RESEARCH ARTICLE

What drives variation in spending for breast cancer patients within geographic regions?

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Objective: To estimate and describe factors driving variation in spending for breast cancer patients within geographic region.

Data Source: Surveillance, Epidemiology, and End Results (SEER)-Medicare database from 2009-2013.

Study Design: The proportion of variation in monthly medical spending within geographic region attributed to patient and physician factors was estimated using multilevel regression models with individual patient and physician random effects. Using sequential models, we estimated the contribution of differences in patient and disease characteristics or use of cancer treatment modalities to patient-level and physician-level variance in spending. Services associated with high spending physicians were estimated using linear regression.

Data Extraction Method: A total of 20 818 women with a breast cancer diagnosis in 2010-2011.

Principal Findings: We observed substantial between-patient and between-provider variation in spending following diagnosis and at the end-of-life. Immediately following diagnosis, 48% of between-patient and 31% of between-physician variation were driven by differences in delivery of cancer treatment modalities to similar patients. At the end-of-life, patients of high spending physicians had twice as many inpatient days, double the chemotherapy spending, and slightly more hospice days.

Conclusions: Similar patients receive very different treatments, which yield significant differences in spending. Efforts to reduce unwanted variation may need to target treatment choices within patient-doctor discussions.

KEYWORDS

breast cancer, spending, variation

1 | INTRODUCTION

Approximately one in eight women develop breast cancer during their lifetime, making it the most common cancer in women.¹ Total spending for breast cancer treatment is correspondingly large, estimated at \$12.1 billion per year in 2013 and 10% of spending on

cancer.² Due to an aging population and the advent of new and costly treatment options, breast cancer spending is projected to continue to grow.³ In view of this anticipated growth, reducing low-value care is an increasingly important policy priority.⁴ Reducing unnecessary spending has additional benefits for patients, as high out-of-pocket spending can cause patients to forgo treatment, spend less

on necessities including food and clothing, assume debt, and spend savings.⁵⁻⁸

Prior studies have illustrated variation in breast cancer health care expenditures across regions and centers in the United States.^{9,10} Yet an exclusive focus on regional variation can mask substantial differences at the local level,¹¹ as individual health status and disease characteristics affect treatment choices that providers make with their patients, and patient and physician preferences play a role in determining spending as well. Variation between patients and between providers within local areas is not well understood.

Understanding the level and drivers of variation in spending within geographic areas is important to developing and targeting policies to increase the affordability and value of cancer care. Some spending variation will be due to patient-level treatment differences, even when the outcomes are comparable. For example, the choice of mastectomy over breast-conserving surgery—which have comparable patient outcomes in early stage breast cancer^{12,13}—has been shown to lower overall costs because of the decreased need for adjuvant radiation.^{14,15} Other differences in practice patterns between physicians, such as the use of staging investigations or higher cost radiation treatment techniques, can also increase expenditures.^{16,17} The level of within-region spending variation and the extent that it is explained by between-patient or between-physician differences informs whether policy should target physician-patient level decision-making, vs physician or system-level change. Moreover, because there is significant variation in health care spending throughout the breast cancer trajectory,¹⁸ distinguishing the factors that drive variation in spending in the first year after diagnosis from those in the last year of life may aid efforts to reduce cost and improve care.

To provide a more granular understanding of the key drivers of spending for patients with breast cancer and to inform policies aiming to improve the value of care, we analyzed between-patient and between-physician variation in medical spending within geographic regions during the first year following a breast cancer diagnosis and, for those who died of breast cancer, in their final year of life. We then examined how much of the between-patient and between-provider spending variation was explained by characteristics of the patient, of the patient's cancer, or by cancer treatment modalities received. Finally, to understand residual differences across physicians, we examined differences in intensity of care between high vs low spending physicians.

2 | DATA AND METHODS

2.1 | Data

We used the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database, which has data from 18 cancer registries in the United States and covers 30% of the US population, to study women diagnosed with invasive breast cancer in 2010 and 2011.¹⁹ We used linked Medicare claims files from 2009 to 2013, which included all inpatient (acute and post-acute), outpatient, physician,

durable medical equipment, and hospice claims for women enrolled in fee-for-service Medicare.

Our sample includes all elderly women (age 66 or older) insured by fee-for-service Medicare. We excluded patients with missing data on key demographic and disease characteristics, patients without Medicare coverage for professional services (Part B), and those diagnosed with cancer within 1 month of their death because there were not enough data to create our study variables. We excluded patients with a prior diagnosis of another form of cancer, as multiple cancers could have impacted their medical care spending patterns. We excluded a small number of patients living in Hospital Referral Regions (HRRs) with fewer than 10 breast cancer patients, as it was not feasible to estimate empirical models within this small sample size. Our final study sample included 20 818 women. Details on sample exclusions are available in Table S1.

For each woman in our sample, we selected claims corresponding to the initial 12 months following diagnosis and termed this period the "initial phase." For patients who died during the study period, we selected claims corresponding to the last 12 months of life, termed the "end-of-life phase". When a patient died <24 months after diagnosis, we assigned the last 12 months to the end-of-life phase and any remaining months to the initial phase. The end-of-life phase analysis excluded patients who had a cause of death other than breast cancer.

2.2 | Study variables

Our primary outcome was total medical spending per patient per month, defined as the per person sum of total allowed amounts across all Medicare claims files, except for outpatient pharmacy (Part D), in each month. We excluded outpatient pharmacy claims, because they were missing for patients not enrolled in a Part D prescription drug plan (46% of our study sample). Total medical spending was measured for the initial month of the patient's diagnosis and all subsequent months. To lessen the influence of outliers, all observations with total medical spending above the 99th percentile were set to the value of the 99th percentile.

Medicare spending is determined using a common fee schedule with adjustments primarily for geographic differences in input and practice costs.^{20,21} We controlled for these geographic adjustments in payment, so that Medicare payments could be used as a resource-weighted measure of utilization. We attributed each patient to the Hospital Referral Region (HRR) where the patient received the plurality of her care and controlled for this geographic variation using HRR fixed effects in all analyses. As a result, residual differences in spending reflect differences in resource utilization within regions and not differences in fees.

Patients were also attributed to the physician most responsible for directing the patient's breast cancer care, which we defined as the surgeon or medical oncologist from whom she received the plurality of her care. Physician attribution for the initial phase of care and end-of-life phase of care was separate, and the attributed physician in the initial (end-of-life) phase was the surgeon or medical

oncologist associated with a claim on more days during the initial (end-of-life) phase of care than any other physician. Patients who did not receive care from either a surgeon or medical oncologist were excluded from the main sample ($N = 550$); excluded patients were more likely to be older, non-white, to have two or more comorbidities, and have more advanced disease. Additional details on attribution and excluded patients are shown in the Tables S2 and S3. As a sensitivity analysis, we included patients without a medical oncologist or surgeon, but who could be attributed to a primary care physician.

We defined two additional categories of independent variables: (a) patient and disease characteristics and (b) cancer treatment modalities. Patient and disease characteristics included age, race (white or non-white), comorbidities (measured by the Charlson Comorbidity index with the Klabunde modification and using medical claims from one year prior to diagnosis),^{22,23} original reason for Medicare eligibility, dual enrollment in Medicaid, enrollment in a Part D plan, average income based on a patients' census tract of residence, cancer stage at diagnosis (Stage 1-4), and type of disease (hormone receptor and HER-2 status). We measured an indicator for whether the patient received any cancer care at a National Comprehensive Cancer Network (NCCN) cancer center or teaching hospital, called cancer facility type. Cancer treatment modalities were measured as binary indicators of treatment with any of the following: breast-conserving surgery, mastectomy, radiation therapy, any chemotherapy, or any biologic therapy (e.g. trastuzumab or bevacizumab). Treatment modalities were measured separately for the initial and end-of-life phases. We also constructed an indicator for having any hospice claims at the end-of-life.

2.3 | Analysis of variation in spending

Assessment of the contribution of differences between patients and differences between physicians to the variance in total spending was estimated using multilevel regression models with individual patient and individual physician random effects:

$$\text{Spend}_{ipt} = \alpha + \text{Patient}_{ip} + \text{Physician}_p + \text{HRR}_r + \text{Time}_t + \varepsilon_{ipt} \quad (1)$$

$$\text{Patient}_{ip} \sim N(0, \sigma_p^2) \quad \text{Physician}_p \sim N(0, \sigma_p^2) \quad \varepsilon_{ipt} \sim N(0, \sigma_{ipt}^2)$$

where Spend measures total spending per patient i , physician p , and month t . Patients were nested within physicians. To allow evaluation of variation in spending within geographic areas and time periods, rather than between regions and time, HRR and Time were vectors of Hospital Referral Region (HRR) and time fixed effects (the latter including calendar quarter of diagnosis, count of months since diagnosis or months prior to death respectively, and, for end-of-life models only, a measure of the number of quarters between patient diagnosis and death) and were included as covariates in all models. Models were run separately for the initial phase and for the end-of-life phase. All statistical analysis was completed using Stata (Version 14); StataCorp, College Station, TX.

For each phase of care, we calculate the proportion of variation in spending due to patient and physician components as the proportion that the variation explained by that component represents of total variance:

$$\begin{aligned} \text{\% variation spend due to component } c \\ = \text{\%Var}_c = \frac{\hat{\sigma}_c^2}{(\hat{\sigma}_{ip}^2 + \hat{\sigma}_p^2 + \hat{\sigma}_{ipt}^2)} \end{aligned} \quad (2)$$

where $c \in (ip, p)$ and $\hat{\sigma}_c^2$ is estimated from (1). Since total variation (i.e., the denominator in (2)) is large in this population, we also report the standard deviation in spending for each component, which can be interpreted as the predicted additional spending for patients or physicians with spending one standard deviation above the mean:

$$\text{Spend due to component driven variation} = \sqrt{\hat{\sigma}_c^2} \quad (3)$$

2.4 | Factors associated with between-patient and between-physician variation

2.4.1 | Patient/disease characteristics or binary cancer treatment choices

Patient and physician-level variation in spending (σ_c^2) may be associated with differences in observable characteristics of patients and their disease (e.g. patients with more co-morbid conditions or those with HER2+ are associated with greater spending), or by differences in decisions to have cancer treatments (e.g. breast-conserving surgery vs mastectomy). We sequentially estimated:

$$\begin{aligned} \text{Spend}_{ipt} = \alpha + \gamma X_{ip} + \delta Z_{ip} + \text{Patient}_{ip} \\ + \text{Physician}_p + \text{HRR}_r + \text{Time}_t + \varepsilon_{ipt} \end{aligned} \quad (4)$$

first, adding to Equation (1) only X_{ip} a vector containing the covariates measuring patient and disease characteristics, then a second specification which also includes Z_{ip} a vector containing indicator variables for cancer treatment modalities, and finally a specification including the indicator for NCCN/teaching hospital facility type.

Each of these sequential models produced a revised estimate of the component-specific variance $\hat{\sigma}_c^2$ (e.g. for both patient and physician components), which measures the component-driven variation in spending *not* associated with the added covariates. We thus calculate and report the proportion of component-specific variance that is explained by added covariates:

$$1 - \frac{\hat{\sigma}_c^2}{\hat{\sigma}_c^2} \quad (5)$$

Output from all models is presented in the Appendix S1.

2.4.2 | Cancer treatment intensity

Variance in spending explained by between-physician differences, but not associated with the covariates in (4), (e.g. $\hat{\sigma}_p^2$), may be associated with intensity within cancer treatment choices or other services that reflect physician behavior. Our final analyses assessed whether

greater intensity of cancer care was associated with higher spending physicians.

We used the multi-level models in (4) to estimate predicted physician average per patient spending that was adjusted for differences in patient demographic and disease characteristics, provision of cancer treatment modalities, and time and region fixed effects. This adjusted average per patient spending was estimated separately for each phase of care.

We then sorted physicians into quintiles based on this adjusted average per patient spending and examined differences in utilization and spending outcomes associated with quintiles using linear regression:

$$\text{Outcome}_{ipt} = \alpha + b\text{Quintile}_{ip} + \gamma X_{it} + \delta Z_{ip} + \text{HRR}_r + \text{Time}_t + \epsilon_{ipt} \quad (6)$$

Outcomes were measures of treatment intensity and included inpatient utilization (average patient days per month), office visits (number per month), imaging (number of patient days with an imaging procedure excluding those to identify stage), hospice (patient days), chemotherapy spending, and Herceptin spending for patients with HER2+ disease. We only measured use of Herceptin and not use of other biologic drugs, because 91% of claims for Biologic drugs were for Herceptin. We include Quintile, a linear term that measures the quintile of the patient's physician, to test for trend in utilization and spending outcomes across quintiles. Standard errors were clustered on physician. Differences in treatment intensity by physician quintile were estimated separately for the initial year following diagnosis and for patients being treated in the last year of life. All outcomes were measured per month, except for days in hospice which was measured per patient. We report results as predicted values based on these regressions; additional methodologic detail included in the Appendix S1.

3 | RESULTS

The study cohort included 20 818 women with a diagnosis of breast cancer. The average age at diagnosis was 76 years, 13.1% of the sample was non-white, and 81.5% of the sample had a Charlson comorbidity index score of 0 or 1. At diagnosis, 94.5% had Stage 1-3 disease and 5.5% had Stage 4 disease; 9.6% of patients had documented HER2+ disease. Detailed sample characteristics are presented in Table S2.

Unadjusted monthly medical spending for patients with breast cancer varies considerably throughout the 12 months following diagnosis, with significantly higher spending in the first 6 months (Figure 1), and throughout the last year of life, where spending increases substantially during the final 2 months of life (Figure 2).

3.1 | Analysis of variation in spending

During the initial year following diagnosis, average monthly spending for patients was \$2966 (standard deviation \$4418) (Table 1).

Between-patient differences explained 14% of the variation in total spending (i.e., %Var_t = 14%), while between-physician differences explained 4% of spending variation (i.e., %Var_{ip} = 4%). To put these percentages into context, we estimated that a patient with monthly spending one standard deviation greater than average spent an additional \$1538, while a physician at one standard deviation above average spent \$845 more per patient than average.

In the last year of life, average monthly spending per patient was \$5768 (standard deviation \$9613). Between-patient differences explained 11% of variation in spending (i.e., %Var_t = 11%), and between-physician differences explained 1% of variation in spending (i.e., %Var_{ip} = 1%). The standard deviation of between-patient and between-physician spending was \$2946 and \$862, respectively.

3.2 | Factors associated with between-patient and between-physician variation

3.2.1 | Patient/disease characteristics or binary cancer treatment choices

Figure 3 shows the extent to which variation in spending between-patients and between-physicians is explained by observable patient/disease characteristics or by the receipt of particular treatments. Patient demographics and disease characteristics explained 33% of the between-patient variation ($\hat{\sigma}_{ip}^2$ in the left-panel in Figure 3) during the initial year after diagnosis and 24% of the same during the last year of life. Controlling for patient demographic and disease characteristics, the receipt of cancer treatment modalities drove 48% of between-patient variation during the initial year after diagnosis, but only 14% during the last year of life. Almost two-thirds (61%) of between-patient variation in spending in the last year of life was not associated with patient/disease characteristics, with binary decisions to have particular treatments, or with being treated at a teaching or NCCN facility.

The right-panel of Figure 3 examines between-physician variation in spending, $\hat{\sigma}_p^2$. The demographic and disease characteristics of the patient population treated by a physician (e.g., whether certain physicians see sicker patients), explained 54% of between-physician variation in the initial year of treatment and 16% of the same in the last year of life. Controlling for patient demographic and disease characteristics, provision of cancer treatment modalities drove 31% of between-physician variation in spending in the year following diagnosis, but did not drive any of the variation in spending explained by between-physician differences in the last year of life. Receipt of cancer treatment at a NCCN center or teaching facility explained 8% of between-physician variation in spending for patients at the end-of-life.

3.2.2 | Cancer treatment Intensity

A considerable proportion of the between-physician variance in spending was not driven by observed patient/disease characteristics or by cancer treatment modalities (Figure 3, right-side panel). Table 2 presents results from our analysis of whether this residual between-physician variation, $\hat{\sigma}_p^2$, was associated with cancer-related treatment intensity.

FIGURE 1 Average monthly spending per patient per month, first 12 months post diagnosis, by stage at diagnosis
Source: Authors' analysis of Surveillance, Epidemiology, and End Results (SEER)-Medicare linked data 2010-2013.

FIGURE 2 Average monthly spending per patient per month, last year of life, by stage at diagnosis
Source: Authors' analysis of Surveillance, Epidemiology, and End Results (SEER)-Medicare linked data 2010-2013.

In the first year following diagnosis (top panel of Table 2), predicted monthly spending for patients with the same observed disease characteristics and cancer treatment modalities was 70% higher for physicians in the highest vs lowest spending quintile (\$4115 vs \$2418, respectively, $P < 0.001$). One of the largest differences in treatment intensity across quintiles was the number of inpatient days. High spending physicians had patients with more inpatient days (77% more for quintile 5; 38% more for quintile 4) than physicians in the lowest spending quintile treating similar patients. Among patients who had chemotherapy in the initial phase,

physicians in the two highest spending quintiles were associated with 45%-54% greater chemotherapy spending than physicians in the lowest spending quintile treating similar patients.

In the final year of life (bottom panel of Table 2), predicted monthly spending for patients associated with physicians in the highest spending quintile was 2.36 times greater than for patients associated with physicians in the lowest spending quintile (\$11 783 vs \$3506, $P < 0.001$). Among patients receiving any chemotherapy, physicians in the highest quintile were associated with chemotherapy spending that was over two times as

TABLE 1 Proportion of variance in medical spending driven by patient and physician factors

	Average monthly spending (Std deviation)	Percent variation in patient monthly spending driven by:		For patient with spending one standard deviation above mean, dollars of spending driven by:	
		Patient factors	Physician factors	Patient factors	Physician factors
Initial year post diagnosis	\$2966 (\$4418)	14%	4%	\$1538	\$845
Final year of life	\$5768 (\$9613)	11%	1%	\$2946	\$862

Notes: Estimates based on regression models of monthly patient spending including patient and provider random effects and fixed effects for month of phase, calendar quarter, and the HRR where the patient received the plurality of her care. Model results presented in Tables S5 and S6.

Source: Authors' analysis of Surveillance, Epidemiology, and End Results (SEER)-Medicare linked data 2010-2013.

high vs physicians in the lowest quintile treating similar patients. Physicians in the highest spending quintile were also associated with 73% more office visits, 73% more non-staging imaging scans, over twice as many inpatient hospital days per month, and greater use of hospice than physicians in the lowest spending quintile. There were no significant differences across quintiles in spending on radiation or Herceptin.

Results from sensitivity analyses that included women in the end-of-life phase who could only be attributed to a primary care physician were similar to the main results (Table S7).

4 | DISCUSSION

This paper finds evidence of considerable variation in resource use for patients with breast cancer living in the same geographic region and with similar demographic and clinical characteristics—in both the first year following diagnosis and the last year of life. Although between-patient spending variation is greater than between-physician variation, between-physician variation is important, as the highest spending physicians were associated with 70% more monthly spending per patient during the initial year following diagnosis and with 243% more

FIGURE 3 Determinants of between-patients and between-physician variation in spending* [Color figure can be viewed at wileyonlinelibrary.com]

Note: Each bar represents the variation in spending due to the component in that phase of care, so the left-most bar is variation in spending due to between-patient differences in the initial 12 months post diagnosis. Results based on regression models of patient monthly spending on patient and provider random effects and indicators for time variables (month of phase and calendar quarter), the HRR where patients received the plurality of their care, and that sequentially add patient and disease characteristics, indicators for treatments received, and indicator for any care received at a teaching hospital or NCCN center. Model results presented in Tables S5 and S6.

Source: Authors' analysis of Surveillance, Epidemiology, and End Results (SEER)-Medicare linked data 2009-2013.

TABLE 2 Differences in utilization across physician quintiles

Physician quintiles based on average per patient spending (1 = lowest, 5 = highest)								
	1	2	3	4	5	Statistical significance ^a	Difference quintile 1 vs 4 (%)	Difference quintile 1 vs quintile 1 vs 5 (%)
Initial year of treatment								
Average total spending per patient per month (\$)	2418	2596	2896	3312	4115	***	37	70
Inpatient days per month	0.13	0.14	0.16	0.18	0.23	***	38	77
Office visits per month	0.6	0.62	0.67	0.72	0.83	***	20	38
Imaging days per month (non-staging only)	0.11	0.12	0.12	0.14	0.15	***	27	36
Chemotherapy spending per patient per month (\$) ^b	440	529	549	637	677	***	45	54
Radiation spending per patient per month (\$) ^b	780	827	855	899	946	***	15	21
Herceptin spending per patient per month (\$) ^b	2166	2467	2568	2750	2784	***	27	29
Final year of life								
Average total spending per patient per month (\$)	3506	4405	6588	8544	11 783	***	144	236
Inpatient days per month	0.26	0.32	0.39	0.45	0.64	***	73	146
Office visits per month	0.94	0.92	1.23	1.46	1.63	***	55	73
Imaging days per month (non-staging only)	0.22	0.23	0.27	0.34	0.38	***	55	73
Chemotherapy spending per patient per month (\$) ^b	477	584	750	943	1109	***	98	132
Radiation spending per patient per month (\$) ^b	695	639	878	932	768		34	10
Herceptin spending per patient per month (\$) ^b	1270	1140	1409	2078	1812		64	43
Days between first day of hospice and death ^b	29.83	45.35	40.60	46.85	42.91	*	57	44

Notes: Table reports predicted values from linear regression models with indicator of physician quintile, patient and disease characteristics, treatment modality indicators, and time and geography fixed effects (see Appendix S1 for additional detail). Initial Year: 830 physicians per quintile; Final Year: 261 physicians per quintile; P-values: * <0.05 , *** <0.001 .

^aP-values are based on tests for linear trends across quintiles.

^bAmong people receiving treatment.

Source: Authors' analysis of Surveillance, Epidemiology, and End Results (SEER)-Medicare linked data, 2009-2013.

monthly spending during the last year of life than physicians with the lowest spending. This finding contributes to an emerging literature showing large spending variation within local areas.^{11,24}

Understanding the drivers of this variation is needed, so that policy levers can be targeted to reduce inefficiencies in local-level heterogeneity. Our results suggest that in the first year following diagnosis, some of the observed variation in spending between-physicians is because different types of patients choose to go to different physicians or that physicians specialize in the care of different types of disease, as half of the between-physician variation is driven by patient sorting by demographic/disease characteristics. In contrast, the majority of spending variation due to between-patient differences and of spending variation due to between-physician differences at the end-of-life were largely unexplained by differences in patient demographic/disease characteristics, indicating that patients with similar characteristics are receiving different cancer treatments.

Choices among cancer treatment modalities explained nearly half of between-patient spending variation in the first year after diagnosis and nearly one-third at the end-of-life. A key question is whether spending variation is appropriate or inappropriate. Appropriate spending variation may be driven by unobservable patient preferences, such as when there is choice between breast-conserving surgery and mastectomy, or clinical uncertainty, such as at the end-of-life when there is the least evidence to guide decision-making.^{25,26} Other clinical factors, such as whether patients have a BRCA mutation or whether the cancer disease progresses/recurs soon after initial diagnosis, are unobservable in our data and may also lead to appropriate differences in cancer treatment. While higher spending in higher-intensity settings can be a driver of inappropriate spending (i.e., due to supplier-induced demand), we found that treatment at a teaching or NCCN hospital only explained 8% of variation in spending between-physician for patients at the end-of-life, and almost no spending variation otherwise. Patient surveys to determining the mechanisms associated with variation in care and whether it is appropriate is a critical area for future research.²⁷

Binary choices to offer treatment modalities do not explain significant between-physician variation, but the intensity of treatment within these binary treatment choices is also an important component of physician decision-making. We find differences in intensity of use of inpatient hospitalization and chemotherapy for all patients, which suggests that there is variation in physician decision-making about treatment (e.g., which agents to use) for similar patients, even where there are prescribed clinical pathways for treatment. We also find considerable variation in intensity of treatment between-physicians for many other services for patients at the end-of-life, a finding that in other work has been found to be associated with physician beliefs.²⁸ Interestingly, among patients with any hospice care at the end-of-life, higher spending physicians also demonstrated greater spending for hospice services than lower spending physicians. This pattern of care, where use of hospice did not offset more intensive treatment, has also been observed for women with ovarian cancer.²⁹

This analysis can inform efforts to promote appropriate decision-making for physicians with their patients and increase value in cancer care. Payment reforms aimed at changing incentives regarding treatment decision-making (e.g., episode-based payment), should target choice of chemotherapy drug regimens and utilization of inpatient hospitalization. Our results also suggest that policy efforts to reduce unwarranted variation should also be directed at physician-patient interactions. Cancer care pathways, which are evidence-based treatment protocols for patients with specific disease types and stages, could allow patients to better understand the cost consequences of their treatment choices and could help to minimize variation in treatment between patients.³⁰ Decision support for physicians and decision aids for patients could facilitate these difficult conversations regarding treatment choices.

The design and adoption of such interventions may be spurred by the advent of payment reforms for cancer care, such as the Oncology Care Model being tested by the Center for Medicare and Medicaid Innovation and in the private sector.³¹ However, initiatives to reduce variation in cancer spending are not without risks.³² It will be critical to monitor access to care, quality of care, and patient outcomes to ensure that changes in treatment patterns eliminate the provision of low-value care and while preserving spending that is beneficial to patients.

This study has several limitations. Our sample is limited to elderly women with fee-for-service Medicare, so the findings may not generalize to younger women with breast cancer. The sample included in the end-of-life models is small due to the small number of women dying of breast cancer in the short time frame of the study. We did not have data on physician characteristics (e.g., age and tenure of service), and due to the limited sample and the complex nature of how physicians practice across hospitals, we were unable to explore whether between-physician differences are driven by facility characteristics. Finally, the results are not reflective of practice pattern changes since the study period included the launch of new therapeutics (e.g., Perjeta, Kadcyla, etc.). As expected, a substantial degree of the observed spending variation is not explained by observable patient or physician factors, which is expected and consistent with other examinations of cancer in the literature.^{33,34}

There is extensive variation in medical spending for patients with breast cancer, both in the first year following the diagnosis and at the end-of-life. Interventions to reduce unwarranted variation in health care spending for cancer care are critical to improving value, clinical outcomes, and patient well-being. Results from this analysis suggest that interventions targeting the decisions of physicians with their patients about treatment planning, and in particular physician decisions about specific chemotherapy regimens, are opportunities to reduce variation in spending and to increase the affordability and value of cancer care.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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