Original Article

Hospital Quality, Patient Risk, and Medicare Expenditures for Cancer Surgery

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BACKGROUND: Surgical resection is a cornerstone of curative-intent therapy for patients with solid organ malignancies. With increasing attention paid to the costs of surgical care, there is a new focus on variations in the costs of cancer surgery. This study evaluated the potential interactive effect of hospital quality and patient risk on expenditures for cancer resections. **METHODS:** With 100% Medicare claim data for 2010-2013, patients aged 65 to 99 years who had undergone cancer resection were identified. Medicare payments were calculated for the surgical episode from the index admission through 30 days after discharge. Risk- and reliability-adjusted hospital rates of serious complications and mortality within 30 days of the index operation were assessed to categorize high- and low-quality hospitals. **RESULTS:** There was no difference in patient characteristics between the highest and lowest quality hospitals. There were substantial increases in expenditures for procedures performed at the lowest quality hospitals for each procedure. Increased expenditures at the lowest quality hospitals were found for all patients, but they were highest for the highest risk patients. At low-quality hospitals, low-risk patients undergoing pancreatectomy had payments of $29,080, whereas high-risk patients had average payments of $62,687; this was a difference of $33,607 per patient episode. **CONCLUSIONS:** Total episode expenditures for cancer resections were lower when care was delivered at low-complication, high-quality hospitals. Expenditure differences were particularly large for high-risk patients, and this suggests that the selective referral of high-risk patients to high-quality centers may be an effective strategy for optimizing value in cancer surgery. ***Cancer* 2018;124:826-32.** *© 2017 American Cancer Society.*

KEYWORDS: cancer resection, cost containment, episode expenditures, hospital quality, surgical expenditures.

INTRODUCTION

Much attention has been focused on the costs of cancer care because estimates predict a total of $173 billion in annual spending for the care of patients with cancer by 2020.[1] The cost of chemotherapy administration has garnered particular interest and has been the target of bundled payment programs such as the Oncology Care Model for Medicare patients.[2] However, surgical resection is also a cornerstone of curative-intent therapy for patients with solid organ malignancies and can be particularly resource-intensive. To date, surgery for cancer has not been a primary target of cost-containment efforts, but other surgical procedures have been.[3] Because of the tremendous variation in the cost of cancer surgery,[1,4,5] future cost-containment efforts for cancer care are likely to include surgical cancer care.[6-8]

The cost of surgical resection varies by as much as 130% between hospitals.[5] Because inpatient surgical costs are largely driven by the occurrence of postoperative complications,[9-13] cost variation is intimately related to hospital quality.[14] A patient's age, comorbidities, and functional status may also affect the costs of care by affecting both a patient's likelihood of experiencing a complication and the difficulty of subsequent recovery. Previous studies have generally adjusted for such patient factors to focus on hospital comparisons.[8] However, high- and low-risk patients are likely to fare differently even at the same hospital. There may be an interactive effect of hospital quality and patient risk on hospital expenditures, but no prior work has addressed this question in patients undergoing cancer surgery.

To better understand the collective effect of patient risk and hospital quality on surgical costs, we studied elderly Medicare beneficiaries undergoing any of 3 elective cancer resections: colectomy, lung resection, and pancreatectomy. We assessed hospital variation in risk-adjusted Medicare payments for the entire episode of surgical care. We also stratified patients on the basis of their risk for postoperative complications, regardless of hospital effects. Finally, we quantified the interactive effect of hospital quality and patient risk in determining the cost of cancer surgery.

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MATERIALS AND METHODS

Data Source

We used 2010-2013 data from the Medicare Provider Analysis and Review (MEDPAR) file from the Centers for Medicare and Medicaid Services. We used the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes to identify patients undergoing elective colectomy, lung resection, or pancreatectomy for diagnoses of malignancies. We included patients aged 65 to 99 years with continuous Part A and B non–health maintenance organization Medicare coverage for 3 months before and 6 months after the surgical procedure of interest. We excluded patients with a preoperative length of stay greater than 1 day and those undergoing emergent or urgent procedures to capture patients undergoing elective resections. Hospitals were identified by provider number in the MEDPAR file, and additional hospital information was obtained from the American Hospital Association's annual survey.[15] This study was approved by the University of Michigan Institutional Review Board and deemed exempt from review because of the use of secondary data.

Hospital Quality Assessment

We used rates of serious complications within 30 days of the index operation as the primary outcome to classify high- and low-quality hospitals. We first identified postoperative complications with *ICD-9-CM* codes for the following categories of complications: anastomotic, cardiac, genitourinary, hemorrhagic, neurologic, obstruction, postoperative shock, pulmonary, splenic injury, thromboembolic, wound infection, and reoperation.[16] As in previous work, we defined serious complications as those associated with a hospital length of stay greater than the 75th percentile for each procedure performed.[10,15,17] To further validate our assignments as high- and low-quality assessments, we determined the 30-day mortality rates for the hospital quintiles.

We then performed a risk and reliability adjustment of the hospital-based rates of complications as described later. Hospitals were sorted into quintiles based on these adjusted complication rates. The hospitals in the lowest quintile of complications were labeled as high-quality hospitals, and those in the highest quintile of complications were labeled as low-quality hospitals.

Patient Risk Assessment

We stratified patients by risk by using a model to predict the likelihood of sustaining a postoperative complication. Patient comorbidity information was captured for conditions present on admission for the index hospitalization. Those in the highest quintile of risk for perioperative complications were labeled as high-risk, and those in the lowest quintile of risk were labeled as low-risk for comparison. We then compared the impact of a patient's preoperative risk of developing a postoperative complication on the total expenditure payments in hospitals of various quality levels.

Payment Data

We used Medicare payment data from the MEDPAR file to accurately reflect episode expenditures. Total episode payments included the index procedure with associated admissions up to 30 days after the discharge date. We included inpatient, outpatient, carrier, home health, skilled nursing facility, and long-stay hospital data. We then collapsed these payment data into 4 categories: index hospitalization, readmissions, physician services, and post–acute care services. Index hospitalization payments included the index admission and postoperative care during the initial hospital episode, and readmission payments covered any additional inpatient admissions during the 30 days after the index operation. Payments for physician services included reimbursements for services provided by physicians or other health professions. Payments for post–acute care services included postdischarge rehabilitation services, postdischarge admissions to skilled nursing facilities, and postdischarge admissions to long-stay hospitals.

Payments were price-standardized to account for variations in Medicare reimbursement based on the geography and care setting. Methods for price standardization were based on techniques described by the Dartmouth Institute.[18,19]

Statistical Analysis

The risk adjustment of complication rates was performed with a multivariate logistic regression model accounting for a patient's age, sex, race, and comorbidities[20,21] and the operation type to calculate a risk-adjusted rate of complications for each hospital. In addition, we included adjustments for minimally invasive techniques, including laparoscopic colectomy and thoracoscopic lung resection. We also included the year of operation in the regression model to account for any possible secular trends. Subsequently, we used hierarchical modeling techniques to reliability-adjust outcomes by accounting for statistical noise.[22] Our final assignment of hospitals to quality quintiles was based on the resulting risk- and reliability-adjusted rates of serious complications.

TABLE 1. Patient Characteristics

	Colectomy	Lung Resection	Pancreatectomy
No. of patients	87,369	66,470	8423
Age, y	77.4	74.3	74.4
Male, %	45.9	48.7	51.35
White, %	88.7	91.3	88.7
Comorbidities, %			
0 or 1	25.8	24.87	21.88
2	24.7	26.57	24.77
≥3	49.6	48.56	53.35
Laparoscopic/thoracoscopic operation, %	40.0	46.6	N/A

Abbreviation: N/A, not applicable.

Hospital and patient characteristics at high- and low-quality hospitals were compared with chi-square and Wilcoxon rank-sum tests. We compared both total Medicare payments and individual payment components, including the index hospitalization, readmissions, physician services, and post–acute care services for the entire surgical episode.

As in previous analyses,[5,10,17,23,24] we used the predicted total payment for each patient as the risk-adjusted payment with a linear mixed model that controlled for a patient's age, sex, and race and 29 Elixhauser comorbidities. We calculated the average risk-adjusted payment for each hospital and then reported the average of these risk-adjusted hospital payments by quality quintiles. We also calculated average risk-adjusted payments by risk groups within each hospital to report payments by risk groups and hospital quality.

RESULTS

We analyzed data on 87,369 patients undergoing colectomy at 3576 hospitals, 66,470 patients undergoing lung resection at 1904 hospitals, and 8423 patients undergoing pancreatectomy at 747 hospitals (Table 1).

Hospital Characteristics

Hospitals were characterized according to their risk- and reliability-adjusted complication rates. For the 3 procedures analyzed, the lowest quality hospitals had complication rates that were 1.5 to 2.2 times higher than the rates of those facilities in the highest quality quintile. As described previously, we determined 30-day rates of mortality for each of the procedures at the high- and low-quality hospitals after their quality designation. For each procedure, the mortality rate was statistically significantly higher at the low-quality institutions (Table 2).

High- and low-quality hospitals had several differences in their characteristics for each of the procedures evaluated. Low-quality hospitals performing colectomy were more often teaching hospitals and larger than high-quality hospitals, whereas low-quality hospitals performing pancreatectomy were more often smaller with fewer operating rooms than high-quality institutions. For lung resections, low-quality hospitals were smaller in terms of bed size and the number of operating rooms, but high-quality hospitals were more often teaching institutions (Table 2).

Patient Characteristics

There was no significant difference in age for patients undergoing any of the 3 procedures evaluated, but there were differences in other demographics when we compared patients undergoing resections at the highest and lowest quality hospitals (Table 3). The total number of patient comorbidities did not differ for pancreatectomy and colectomy between high- and low-quality hospitals, but those undergoing lung resection at the low-quality hospitals were more often multimorbid with 2 or more comorbidities (78% vs 74%; $P < .0001$; Table 3).

High- and Low-Quality Hospital Expenditures

Procedures performed at low-quality hospitals versus high-quality hospitals resulted in 16% to 30% higher total 30-day episode expenditures for all 3 procedures. For average-risk patients undergoing colectomy, low-quality hospitals generated substantially higher episode expenditures than high-quality, low-complication hospitals ($24,406 vs $20,992; $P < .0001$). Larger increases in total episode expenditure differences between low- and high-quality hospitals were found in patients undergoing lung resection ($27,638 vs $21,282; $P < .0001$) and pancreatectomy ($45,731 vs $35,149; $P < .0001$).

We found increases in rates of post–acute care services for patients undergoing colectomy and lung resection at low-quality hospitals (68% vs 65% for colectomy and 68% vs 65% for lung resection) but similar rates between high- and low-quality hospitals after pancreatectomy. Regardless of the rates of post–acute care services, low-quality hospitals generated increased expenditures ($1024 for colectomy, $1643 for lung resection, and $1577 for pancreatectomy). Similarly, low-quality hospitals had higher rates of readmission for each of the 3 procedures (13% vs 12% for colectomy, 13% vs 12% for lung resection, and 25% vs 22% for pancreatectomy). When patients were readmitted, they accrued similar excess expenditures for their readmissions, regardless of the quality of the hospital where their index procedure had been performed (Table 4).

TABLE 2. Characteristics of High- and Low-Quality Hospitals

	Colectomy				Lung Resection				Pancreatectomy			
	All Hospitals	High-Quality Hospitals	Low-Quality Hospitals	*P*	All Hospitals	High-Quality Hospitals	Low-Quality Hospitals	*P*	All Hospitals	High-Quality Hospitals	Low-Quality Hospitals	*P*
No. of hospitals	3576	716	715		1904	381	380		747	150	149	
No. of patients	87,369	25,070	25,913		66,470	25,962	12,797		8423	3873	1662	
Bed size, %												
<250	40.9	39.2	31.6	<.001	21.4	17.1	24.0	.025	8.7	6.7	9.3	.040
250-500	36.1	40.2	38.3		39.7	38.7	48.1		32.0	24.1	33.5	
>500	23.0	20.6	30.2		38.9	44.2	30.0		59.3	69.2	57.2	
Teaching hospital, %	54.7	54.3	64.2	<.001	92.6	76.7	60.8	.002	90.7	94.2	91.4	.128
Annual total inpatient surgical volume, No.	5446	5146	6748	<.0001	8121	9653	6226	<.0001	11,914	11,492	13,736	.0083
Annual total outpatient surgical volume, No.	8276	8095	9956	.003	11,544	14,346	8683	<.0001	15,640	12,690	18,642	.0088
Annual total surgical volume, No.	13,723	13,240	16,703	.0002	19,666	23,999	14,908	<.0001	27,554	24,182	32,378	.0052
Annual average procedure-specific volume, No.	15.7	17.0	17.0	.915	33.2	49.4	17.6	<.0001	14.7	19.5	8.8	<.0001
Length of stay, d	7.2	6.4	8.1	<.0001	6.9	5.9	8.9	<.0001	12.8	11.0	16.2	<.0001
Risk-reliability–adjusted complication rate, %	10.2	8.4	12.3	<.0001	8.9	6.3	13.8	<.0001	13.4	10.9	17.8	<.0001
Mortality rate, %	4.0	3.8	4.2	<.0001	2.8	2.6	3.2	<.0001	3.8	3.6	4.2	<.0001

Abbreviation: d, days.

Increased utilization of post–acute care services and increased rates of readmissions contributed to the increased episode payments, but the dominant driver of excess expenditures at low-quality hospitals was payment for the index hospitalization. We found that index hospitalization expenses generated 62% to 79% of the increase in expenditures across procedures for low-quality hospitals versus high-quality hospitals (Table 4). For example, a patient undergoing colectomy at a high-quality hospital had an average index hospitalization payment of $14,141, whereas a similar patient at a low-quality hospital generated an index hospitalization payment of $16,255; this resulted in an excess of $2114 per colectomy. More substantial increases were noted for patients undergoing lung resection ($4154) and pancreatectomy ($8378) at low-quality hospitals.

Interaction of Hospital Quality and Patient Risk

Next, we sought to explore whether the impact of hospital quality on expenditures differed with patient risk. Low-quality hospitals generated excess expenditures for all patient risk groups. For example, low-risk patients undergoing colectomy at low-quality hospitals generated $17,001 versus $15,423 per 30-day episode at high-quality institutions. Similarly, we found excess expenditures for low-risk patients undergoing lung resection ($3797) and pancreatectomy ($4357) at low-quality institutions.

Although all patient risk groups incurred higher expenditures at low-quality hospitals, the impact on expenditures for high-risk patients was particularly pronounced. For example, low-risk patients undergoing pancreatectomy incurred 17% higher episode payments at low-quality hospitals ($29,080 vs $24,723; $P < .0001$). High-risk patients undergoing pancreatectomy incurred 40% increases in total episode payments at low-quality hospitals versus high-quality hospitals ($62,687 vs $44,925; $P < .0001$). The episode payment increase for high-risk patients receiving care at low-quality hospitals versus high-quality hospitals was significantly higher in comparison with low-risk patients in similar comparisons (40% vs 17%; $P < .0001$). Similar results were found for patients undergoing colectomy, with increased expenditures at low-quality hospitals (10% increased expenditures for low-risk patients and 18% increased expenditures for high-risk patients; $P < .0001$), and for patients undergoing lung resection (24% increased expenditures for low-risk patients and 29% increased expenditures for high-risk patients; $P < .0001$; Table 5 and Fig. 1).

TABLE 3. Patient Characteristics at High- and Low-Quality Hospitals

	Colectomy			Lung Resection			Pancreatectomy		
	High-Quality Hospitals	Low-Quality Hospitals	*P*	High-Quality Hospitals	Low-Quality Hospitals	*P*	High-Quality Hospitals	Low-Quality Hospitals	*P*
No. of patients	26,070	25,913		25,962	12,962		3873	1662	
Age, y	77.3	77.4	.004	74.4	74.2	.001	74.2	74.6	.025
Male, %	45.9	46.2	.508	47.6	50.6	<.0001	51.9	51.1	.578
White, %	89.6	87.6	<.0001	92.1	91.6	.105	90.1	87.4	.005
Comorbidities, %									
0 or 1	25.4	25.1	.447	26.4	21.9	<.0001	21.7	21.3	.730
2	24.1	25.1	.007	27.3	25.2	<.0001	25.4	24.0	.264
≥3	50.5	49.8	.095	46.3	52.9	<.0001	52.9	54.8	.212
Laparoscopic/thoracoscopic approach, %	40.8	41.7	.031	52.1	39.0	<.0001	N/A	N/A	N/A

Abbreviation: N/A, not applicable.

TABLE 4. Payments for Procedures at High- and Low-Quality Hospitals

	Low-Quality Hospitals	High-Quality Hospitals	Difference in Payment	*P*
Colectomy				
Total episode	$24,406	$20,992	$3414	<.0001
Index hospitalization	$16,255	$14,141	$2114	<.0001
Physician services	$3562	$3135	$427	<.0001
Readmission (when present)	$10,171	$10,662	–$491	.194
Post–acute care services (when present)	$4735	$3711	$1024	<.0001
Lung resection				
Total episode	$27,638	$21,282	$6356	<.0001
Index hospitalization	$18,961	$14,808	$4154	<.0001
Physician services	$4708	$4012	$696	<.0001
Readmission (when present)	$11,998	$10,516	$1482	.033
Post–acute care services (when present)	$5022	$3378	$1643	<.0001
Pancreatectomy				
Total episode	$45,731	$35,149	$10,582	<.0001
Index hospitalization	$31,049	$22,671	$8378	<.0001
Physician services	$7140	$6264	$877	.001
Readmission (when present)	$11,290	$10,698	$592	.570
Post–acute care services (when present)	$6313	$4736	$1577	.001

TABLE 5. High- and Low-Risk Patients in High- and Low-Quality Hospitals

	Patient Risk	Low-Quality Hospital	High-Quality Hospital	Difference in Payment	*P*
Colectomy	High	$35,708	$30,394	$5314	<.0001
	Low	$17,001	$15,423	$1578	<.0001
Lung Resection	High	$39,735	$30,908	$8827	<.0001
	Low	$19,863	$16,066	$3797	<.0001
Pancreatectomy	High	$62,687	$44,925	$17,762	<.0001
	Low	$29,080	$24,723	$4357	<.0001

DISCUSSION

Poor hospital surgical quality, as manifested by high complication rates, is directly related to excess costs of care. Previous studies have consistently shown that, for many surgical procedures[13,14] and for cancer surgery in particular,[9] the occurrence of postoperative complications drives expenditures in the inpatient setting and beyond. The notion that certain high-risk patients may both be more prone to complications and experience a more difficult recovery once they occur has clinical face validity but

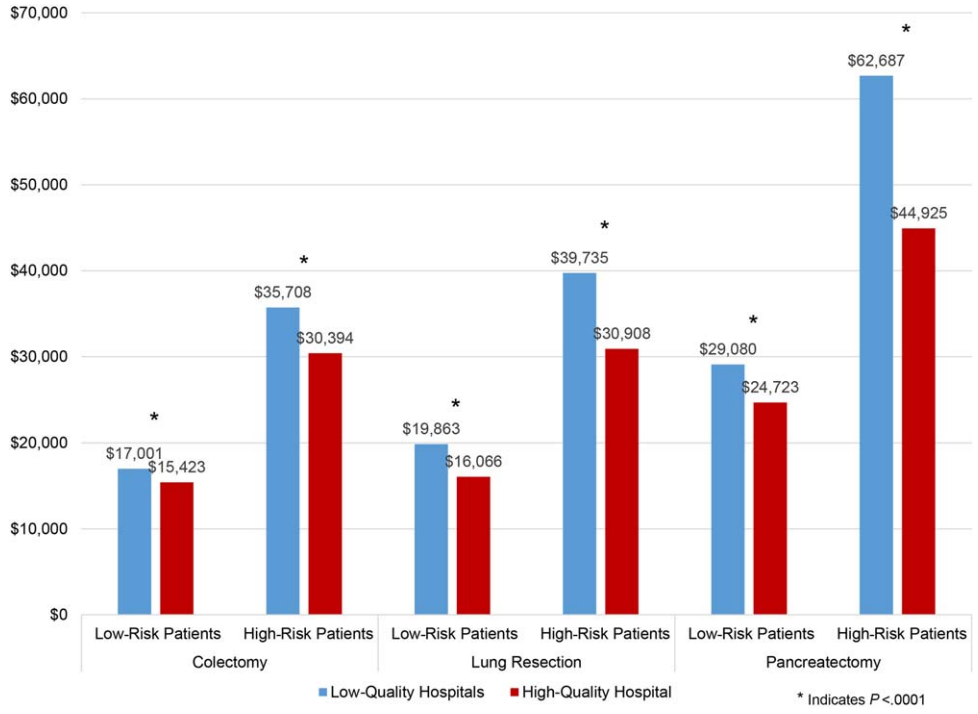

Figure 1. Total episode expenditures for low and high risk patients at low and high quality hospitals.

has not been explored in this context. In this analysis, we found that cancer resections performed at low-quality hospitals generated substantial excess expenditures for all patients. However, excess expenditures were particularly pronounced when high-risk patients underwent surgery at low-quality hospitals. As health systems and policymakers attempt to identify targeted interventions aimed at managing the costs of health care, a focus on high-risk patients receiving care at low-quality institutions may be warranted.

Despite the fixed payment structure of the diagnosis-related group model, we found that there is wide variation in payments for cancer surgery. Whether this is due to higher reimbursement for increased numbers of patients meeting the criteria for outlier payments on account of longer hospital stays or postoperative complications, it highlights large potential savings in the delivery of surgical cancer care. As we have described, a substantial amount of this variation is attributable to preexisting cost differences between hospitals. For example, we found that high-risk patients would disproportionately benefit from directed referral to high-quality centers for oncologic resection. Previous work has suggested selective referral for uncommon procedures on the basis of volume or quality rankings to improve outcomes and reduce costs of surgical care.[25,26] This analysis highlights a particular high-risk subset of the surgical population that would be most likely to benefit from referral with respect to cost for oncologic resection. Identifying this portion of the surgical population can provide a more realistic strategy for selective referral because suggesting referring all patients is not a practical strategy. This immediate solution may improve outcomes and health care spending for these highest risk patients, whereas ongoing quality improvement initiatives at low-quality, higher cost hospitals could expand the network of high-quality hospitals for all patients.

There are several limitations to this analysis. First, this analysis assessed patient risk with administrative data, which may incompletely capture some aspects of preoperative risk such as performance status and frailty. Second, we adopted a payer's perspective on surgical expenditures by assessing actual Medicare reimbursements for care. Our analysis does not address other perspectives on health care costs, such as utilization and opportunity costs within a health system. We used 30-day episode payments, which may not fully represent the longer term care received after surgical resection. We focused on elderly Medicare beneficiaries undergoing 3 surgical resections for cancer diagnoses; therefore, our findings may not be generalizable to younger populations of patients, those undergoing other cancer resections not included in our analysis, or those with private insurance. Finally, we did not include the

cancer stage in our analysis or risk adjustment because this is not accurately reflected in the 2010-2013 MEDPAR file. Because these patients all underwent resection, they were likely diagnosed with localized disease. Prior work has demonstrated that adding cancer-specific staging to outcome assessments using claim data does not provide much benefit for measuring performance.[27] Although a similar analysis has not been performed for surgical costs, we find it highly improbable that the identified cost differences are due to differences in the cancer stage.

In summary, we have found that there is a significant interaction between hospital quality and preoperative patient risk that drives payments for cancer resections. The excess expenditures for procedures performed at low-quality hospitals are exaggerated for high-risk patients. This analysis demonstrates that those patients at highest risk for postoperative complications may stand to benefit most substantially from cost-containment strategies including selective referral to high-quality centers.

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CONFLICT OF INTEREST DISCLOSURES

Justin B. Dimick is a cofounder of ArborMetrix, a company that makes software for profiling hospital quality and efficiency.

AUTHOR CONTRIBUTIONS

Sarah P Shubeck: Conceptualization, methodology, writing–original draft, and writing–review and editing. **Jyothi R. Thumma**: Data curation, formal analysis, and writing–review and editing. **Justin B. Dimick**: Conceptualization and writing–review and editing. **Hari Nathan**: Conceptualization, funding acquisition, methodology, writing–original draft, and writing–review and editing.

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