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Using Merged Clinical and Claims Registry Data to Identify High Utilizers of Surgical Inpatient Care 1 Year after Colectomy

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BACKGROUND: Under bundled payment initiatives, providers will be held financially responsible for patients' acute and post-acute care costs. Certain patients, termed *high utilizers*, use disproportionate shares of resources during 1 year. The aim of this study was to identify high utilizers, describe their costs, and determine whether preoperative characteristics predict high utilizer status.

STUDY DESIGN: Colectomy patients with 1-year follow-up were identified in a linked clinical (American College of Surgeons NSQIP) and administrative (Medicare inpatient claims) dataset (2005 to 2008). Cost of inpatient care was calculated by multiplying patient Medicare charges in each cost center by cost-to-charge ratios from the Medicare cost reports. A mixed-effects logistic model quantified the association between preoperative characteristics and being a high utilizer after elective and emergent colectomies.

RESULTS: One thousand and fifty-five of 10,561 colectomy patients accounted for >50% of the inpatient care cost of the entire cohort during 1 year postoperatively. This top decile of patients were labeled high utilizers and had substantially greater costs in the following cost centers: intensive care ($36,322 vs $0), respiratory ($2,875 vs $22), radiology ($649 vs $29), and cardiology ($5,057 vs $166) (all $p < 0.001$). High utilizers more frequently had emergent index colectomies (43% vs 17%; $p < 0.001$). Patients with American Society of Anesthesiologists class IV and V had 2-fold increased odds of being high utilizers after both elective (odds ratio = 2.72; 95% CI, 1.89–3.90) and emergent colectomies (odds ratio = 2.09; 95% CI, 1.23–3.55).

CONCLUSIONS: Patients in the top cost decile account for the majority of costs in the year after colectomy, disproportionately accumulate those costs in particular cost centers, and can be identified preoperatively. (J Am Coll Surg 2015;221:441–451. © 2015 by the American College of Surgeons)

Providers will increasingly be at risk for the costs of their patients' care over extended time horizons. This is particularly true as care becomes more integrated within accountable care organizations and payers move toward bundled payments across acute and post-acute care.[1] Primary care providers have created programs that provide pre-emptive multidisciplinary comprehensive care for patients termed *high utilizers,* who used a disproportionate amount of resources and successfully reduced visits and costs.[2-4]

Surgical resource use has been described using short-term postoperative readmission,[5,6] reoperation,[7-12] or cost.[13-16] Yet, patients with the highest resource use during an entire year after general surgery have not been described. Strategies could be undertaken perioperatively to address risk factors for high resource use. Preoperative medical evaluation has

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been implemented in limited settings by anesthesiologists. Such efforts may only benefit patients with high risks of complications; for example, preoperative evaluation might not benefit American Society of Anesthesiologists (ASA) class I and II patients.[17,18] Efforts to reduce perioperative care costs could be focused if patients with high odds of being high utilizers in the year after surgery were identified preoperatively. Colectomy patients represent excellent test cases to identify high-utilizer patients in surgery because the procedure is a common operation with a relatively high degree of perioperative resource use.[19-21]

A cohort of Medicare patients undergoing colectomy at American College of Surgeons' (ACS) NSQIP participating hospitals between 2005 and 2008 with 1 year of follow-up were identified to better understand high utilization in surgical patients, as well as patterns of resource use. The primary goals of the study were to describe costs and postoperative events in a high-utilization group and to determine whether observed preoperative characteristics could predict high-utilizer status in the year after colectomy.

METHODS

Data sources

Three data sources were used in this study: a clinical dataset, an administrative claims dataset, and the Medicare Cost Reports. The clinical data source was the ACS NSQIP, which is a voluntary clinical registry that uses dedicated full-time surgical clinical reviewers trained and examined on strict data definitions and processes to collect preoperative demographic and comorbidity variables, as well as procedural and postoperative 30-day outcomes data. The administrative data source was Medicare inpatient claims data, which is officially referred to as the Medicare Provider Analysis and Review File (Medpar). Data elements in this file include demographics, dates of admission and discharge, diagnoses and procedures by ICD-9 code, and charges at the department level (referred to as "cost center"). The Medicare cost reports detail 44 cost centers (eg, operating room) with costs and charges reported by each hospital each fiscal year. The ACS NSQIP was merged with the Medicare inpatient claims data file from 2005 to 2008 using indirect patient identifiers and a deterministic linkage algorithm as described previously.[22]

The inclusion criteria for this study were Medicare beneficiaries 65 years and older undergoing colectomy, defined by CPT codes in the Appendix (available at: http://www.journalacs.org), at 1 of the 212 participating ACS NSQIP hospitals from 2005 until the end of 2008. Of the initial 18,409 patients eligible, 97 patients were excluded because wage-adjusted cost-center level cost-to-charge ratios could not be obtained from their hospitals (36 hospitals in total). Next, 7,751 patients were excluded because they had <1 year of follow-up postoperatively in the Medicare inpatient claims data file.

Primary end point derived from Medicare inpatient claim and Medicare cost reports

The primary end point was high-utilization status; defined as patients in the top decile of total cost in the 1 year after the index colectomy. Cost was calculated by deriving patient cost from charges using cost-to-charge ratios then summing the patients' costs of inpatient care during 1 year after colectomy. The Medicare cost reports were used to create cost-to-charge ratios. The Medicare cost reports detail 44 cost centers (eg, operating room) with costs and charges reported by each hospital each fiscal year. These 44 cost centers were aggregated into 12 cost centers for each hospital and fiscal year to ensure reliable estimates.[23] Total cost in each of these 12 cost centers were divided by total charges in the same cost center for each hospital and fiscal year, creating cost-to-charge ratios specific to each hospital, fiscal year, and cost center. Extreme outliers in the 12 cost centers' cost-to-charge ratios were observed and cost-to-charge ratios were winsorized to the 2.5th and 96th percentile for each cost center.[23]

The patient charges in the Medicare inpatient claims data file were reported by 32 cost centers for each encounter in the year after colectomy. These patient charges were mapped onto the 12 cost centers in the Medicare Cost Reports and were multiplied by the patients' hospital's fiscal year, cost-center–specific, cost-to-charge ratios to obtain patient costs disaggregated to 12 cost centers for each encounter.[24] All costs were inflated to the 2013 US dollar using the Medicare Market Basket Index. Regional differences in wage were adjusted for using the regional wage index.

Disaggregated cost center costs for each encounter were summed to calculate the total costs of inpatient care in the 1 year after the index colectomy. Patients were ranked based on their total costs of inpatient care and divided into deciles with a high utilizer defined as patients in the top decile of cost. Deciles were used because they are standard nonparametric cut-off points and >50% (52%) of total costs for this entire cohort were accounted for by patients in the highest cost decile (Fig. 1).

Secondary resource use measures derived from Medicare inpatient claims

Readmission was defined based on the presence of a related readmission within 1 year of the index surgery. Two clinician reviewers reviewed the principal diagnoses

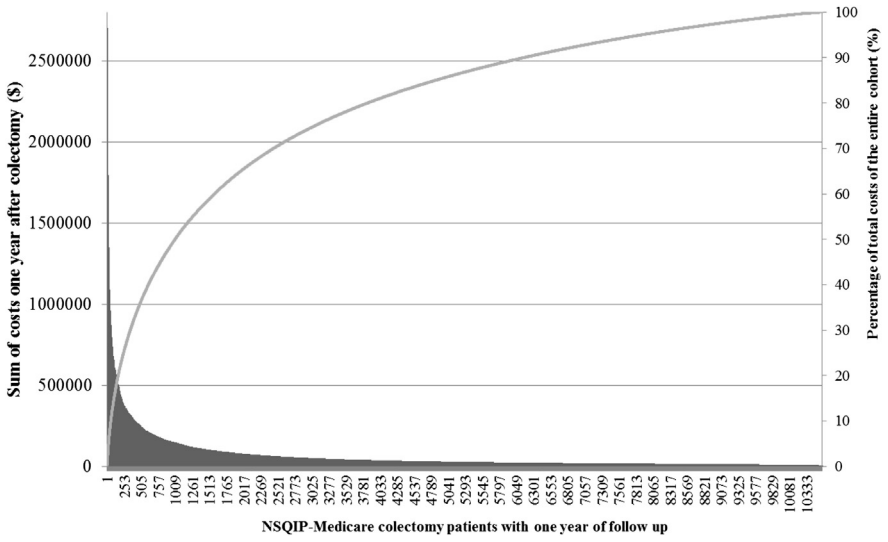

Figure 1. Cumulative percentage of cost in patients ranked in descending order of total cost of colectomy care in the year after colectomy. More than 50% of total costs for entire patient cohort were accounted for by the patients in the top decile of patient costs.

associated with readmissions. Readmissions with principal diagnoses unrelated to the index operative principal diagnosis (eg, cholecystitis, traumatic injury) were excluded.

Reoperation was defined based on the presence of a reoperation within 1 year of the index surgery in 1 of the 6 ICD-9 procedure code data fields in an inpatient encounter recorded in the Medicare inpatient claims file. Procedures were excluded if they occurred before, on the same day, or 1 day after the ACS NSQIP index surgery date. This was done to avoid counting the index operation as a reoperation.[22] The reoperations identified in Medicare inpatient claims were then subdivided into categories of surgical procedures based on organ system, that is, colon resection, ostomy creation, small bowel resection. Two clinician reviewers excluded specific categories of procedures if they were used for screening rather than therapy, or if they could be performed outside of conventional procedural infrastructure, such as at the bedside. The excluded categories of procedures were burr hole creation, percutaneous abdominal drainage, percutaneous thoracic drainage, percutaneous feeding tube placement, endoscopic, colonoscopic, laryngoscopic, and endovascular procedures.

Secondary resource use measures derived from American College of Surgeons National Surgical Quality Improvement Program

All clinical complications were defined based on the presence of the clinical complication in the ACS NSQIP data. The complications analyzed included surgical site infection (superficial, deep and organ space), prolonged ventilation, pneumonia, sepsis, reintubation, urinary tract infection, deep vein thrombosis, wound disruption, renal failure, bleeding requiring transfusion, cardiac arrest, pulmonary embolism, cerebrovascular accident, myocardial infarction, and coma (all within 30 days postoperatively and as defined in ACS NSQIP). Overall morbidity was a dichotomous composite variable recorded as "present" if the patient had any of the following complications; surgical site infection (superficial, deep, and organ space), prolonged ventilation, pneumonia, sepsis, reintubation, urinary tract infection, deep vein thrombosis, wound disruption, renal failure, bleeding requiring transfusion, cardiac arrest, pulmonary embolism, cerebrovascular accident, myocardial infarction, coma, or peripheral nerve injury. Peripheral nerve injury was excluded from individual analysis because it was extremely rare, but was included in the composite variable.

Statistical analysis

Patient preoperative characteristics were compared between high utilizers and non—high utilizers. The ACS NSQIP postoperative complications and rates of different types of reoperations occurring within 1 year postoperatively in Medicare inpatient claims data were compared between high utilizers and non—high utilizers using chi-square tests. Total hospital length of stay and cost estimates were log-transformed and compared between high utilizers and non—high utilizers using the Wilcoxon-rank sum test.

Patients were stratified into elective and emergent cases. Patient characteristics associated with being a high utilizer on bivariate analysis were included in a mixed-effects

multivariate logistic regression. Procedure-mix was included in the multivariate regression by using 3 dichotomous indicator variables for partial colectomy, laparoscopic colectomy, and their interaction term; *partial laparoscopic colectomy*. All data management and analyses were performed using SAS software, version 9.3 (SAS Institute). The RAND IRB approved this study.

RESULTS

After the exclusions described, there were total of 10,561 patients identified as having undergone a colectomy with a minimum of 1-year follow-up at 1 of 176 hospitals in the ACS NSQIP Medicare linked dataset. There were 1,055 patients in the top decile of costs labeled as high utilizers, with a median cost of inpatient care during 1 year of $234,085, with an interquartile range of $174,737 to $360,830. Of the high utilizers, 64% had a reoperation and 54% were readmitted within 1 year after colectomy (Fig. 2). The remaining 9,506 patients in this cohort were designated as non−high utilizers.

Most notably, high utilizers were more frequently patients who underwent index colectomy emergently (42.6% vs 16.7%; $p < 0.001$) (Table 1). Additionally, high utilizers had high rates of comorbidity; 8.9% of high utilizers had congestive heart failure (CHF) vs 2.2% of non−high utilizers ($p < 0.001$). In addition, high utilizer were more likely to be acutely ill; 13.5% of high utilizers had been on steroids vs 5.2% of non−high utilizers ($p < 0.001$); and 9.9% of high utilizers had had surgery in the previous 30 days compared with 2.3% of non−high utilizers ($p < 0.001$).

The unadjusted rate of ACS NSQIP postoperative overall morbidity was significantly higher in patients identified as high utilizers compared with non−high utilizers (64.3 vs 27.4%; $p < 0.001$) (Table 2). High utilizers had a 7-fold higher frequency of several ACS NSQIP postoperative complications in particular; prolonged ventilation (35.9 vs 5.0%; $p < 0.001$). High utilizers had a 6-fold higher rate of wound disruption (8.0% vs 1.4%; $p < 0.001$). High utilizers had a 5-fold higher rate of pneumonia (20.8% vs 4.2%; $p < 0.001$) and reintubation (18.4% vs 3.4%; $p < 0.001$).

However, 35.7% of high utilizers did not have an ACS NSQIP postoperative complication. Of these high utilizers who did not have an ACS NSQIP postoperative complication, 67.9% were readmitted and 61.0% had a reoperation within that year after colectomy, suggesting certain postoperative events were not captured in the linked dataset. Patients who did not have an ACS NSQIP complication and were not readmitted had a median length of stay of 13 days among high utilizers (interquartile range 8 to 22 days) compared with 6 days among non−high utilizers (interquartile range 4 to 9 days).

Reoperations were also significantly more common among high utilizers compared with non−high utilizers

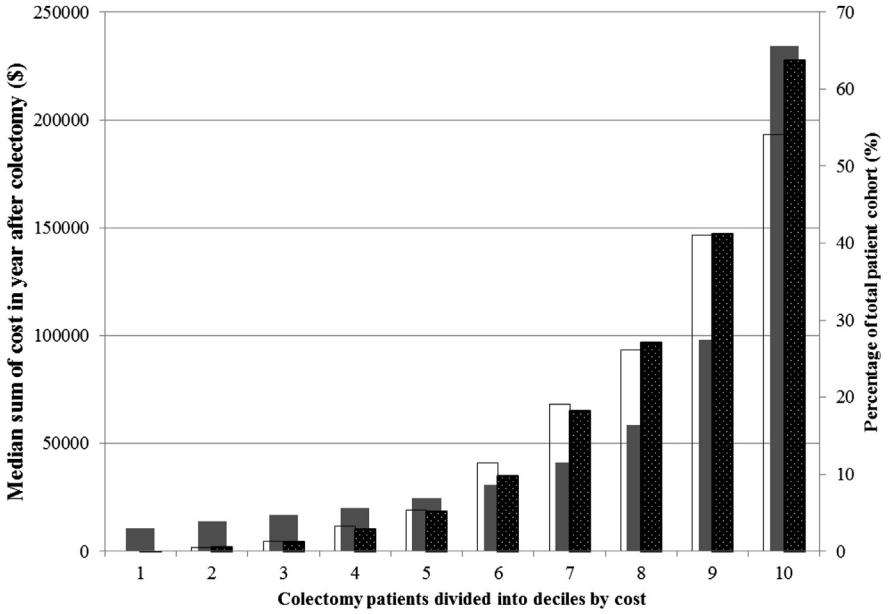

Figure 2. Stratifying colectomy patients into deciles by 1-year patient costs. Median cost, readmission, and reoperation rates by patient cost decile. Patients in top decile defined as high utilizers in remainder of article and tables. Gray bar, median cost; white bar, readmission; black bar, reoperation.

Table 1. Preoperative and Procedural Characteristics of High Utilizers vs Non–High Utilizers

	High utilizers (n = 1,055)		Non–high utilizers (n = 9,506)		
Preoperative and procedural variables	**n**	**%**	**n**	**%**	**p Value***
Demographics					
Male sex	482	45.6	4,126	43.4	0.17
Age, y, category					0.26
65 to 74	454	43.0	4,169	43.9	
75 to 84	469	44.4	3,983	41.9	
85 or older	133	12.6	1,353	14.2	
Diagnosis					0.11
Diverticulitis	146	13.8	1,373	14.5	
Other	103	9.8	562	5.9	
Fistula	20	1.9	179	1.9	
Hemorrhage	17	1.6	61	0.6	
Infectious enteritis	59	5.6	166	1.8	
Noninfectious enteritis	33	3.1	197	2.1	
Benign neoplasm	41	3.9	1,323	13.9	
Obstruction/perforation	355	33.6	4,636	48.8	
Vascular insufficiency	193	18.3	739	7.8	
Malignant neoplasm	89	8.4	269	2.8	
Emergency case	450	42.6	1,586	16.7	<0.001
Functional status					<0.001
Independent	643	60.9	8,150	85.7	
Partially dependent	219	20.7	1,001	10.5	
Fully dependent	194	18.4	354	3.7	
American Society of Anesthesia class					<0.001
I and II	158	15.0	3,253	34.2	
III	539	51.0	5,132	54.0	
IV and V	359	34.0	1,117	11.8	
Metabolic conditions					
BMI kg/m^2					0.79
<18.5	92	8.7	617	6.5	
18.5–24	349	33.1	3,312	34.8	
25–29	319	30.2	3,292	34.6	
30–34	168	15.9	1,523	16.0	
35–39	74	7.0	517	5.4	
≥40	54	5.1	244	2.6	
Diabetes					0.02
No diabetes	822	77.8	7,788	81.9	
Non–insulin dependent	143	13.5	1,196	12.6	
Insulin dependent	91	8.6	521	5.5	
Cardiovascular conditions					
Congestive heart failure	94	8.9	211	2.2	<0.001
Percutaneous coronary intervention in previous 30 days	125	11.8	852	9.0	0.002
Cardiac surgery	153	14.5	1,022	10.8	0.0002
Pulmonary conditions					
COPD	193	18.3	887	9.3	<0.001
Smoker	138	13.1	968	10.2	0.004
Ventilator dependency	119	11.3	143	1.5	<0.001

(Continued)

Table 1. Continued

Preoperative and procedural variables	High utilizers (n = 1,055) n	%	Non–high utilizers (n = 9,506) n	%	p Value*
Hematologic and immunologic conditions					
Radiotherapy	23	2.2	174	1.7	0.43
Chemotherapy	32	3.0	148	1.6	0.0005
Disseminated cancer	63	6.0	440	4.6	0.05
Transfusion	41	3.9	122	1.3	<0.001
Bleeding disorder	196	18.6	792	8.3	<0.001
Steroid use	142	13.5	492	5.2	<0.001
Liver conditions					
Esophageal varices	6	0.6	14	0.2	0.003
Ascites	93	8.8	312	3.3	<0.001
Renal conditions					
Renal failure	43	4.1	111	1.2	<0.001
Dialysis	37	3.5	51	0.5	<0.001
Acuity of illness					
Weight loss in previous 6 months	85	8.1	543	5.7	0.002
Open wound	91	8.6	256	2.7	<0.001
Surgery in previous 30 days	105	9.9	221	2.3	<0.001
Impaired sensorium	94	8.9	179	1.9	<0.001
Do not resuscitate status	38	3.6	209	2.2	0.004
Sepsis					<0.001
No sepsis	645	61.1	8,243	86.7	
Systemic inflammatory response syndrome	192	18.2	784	8.3	
Sepsis and septic shock	219	20.7	478	5.0	

All preoperative variables derived from American College of Surgeons NSQIP.
*p Values from chi-square test.

(Table 3). High utilizers had a >40-fold higher frequency of tracheostomy (13.9% vs 0.3%; $p < 0.001$). High utilizers had a 10-fold higher frequency of ostomy creation (11.7% vs 1.2%; $p < 0.001$). High utilizers had a 9-fold higher frequency of wound debridement (13.1% vs 1.4%; $p < 0.001$), and open vessel ligation (1.8% vs 0.2%; $p < 0.001$). High utilizers had a 8-fold higher frequency of small bowel resection (15.4% vs 1.9%; $p < 0.001$), percutaneous drainage (13.7% vs 1.8%; $p < 0.001$) and ureteral revision (4.6% vs 0.6%; $p < 0.001$).

High utilizers had significantly greater length of total hospital stay at index colectomy (21 vs 7 days; $p < 0.001$) (Table 4). Total initial index admission costs were 6-fold higher ($146,957 vs $22,853; $p < 0.001$). Readmission costs were >7-fold higher among high utilizers ($173,192 vs $24,775; $p < 0.001$) compared with non–high utilizers. Ninety percent of total costs for the entire cohort were accrued by 172 days postoperatively (Fig. 3). Only 50% of total costs in the year after colectomy were accrued at the index admission for high utilizers compared with 89% of costs in non–high utilizers.

Although all costs were greater in high utilizers, the magnitude of the difference varied among cost centers. Intensive care unit cost center showed the largest discrepancy between high utilizers and non–high utilizers ($36,322 vs $0). Additionally, respiratory ($2,875 vs $22), radiology ($649 vs $29), and cardiology ($5,057 vs $166) were >20-fold higher in high utilizers (all $p < 0.001$). Room and board ($123,849 vs $12,311), laboratory ($9,547 vs $775), pharmacy ($17,267 vs $1,222), and rehabilitation therapy ($1,762 vs $124) were >10-fold higher in high utilizers (all $p < 0.001$).

Patients were stratified by whether they underwent elective or emergent colectomy and two separate regressions were run to identify clinical variables associated with being a high utilizer in each scenario. A handful of variables were associated with being a high utilizer in both elective and emergent scenarios. One preoperative variable was associated with >2-fold increased odds of being a high utilizer in both elective and emergent cases (Table 5); ASA class IV and V (odds ratio [OR] = 2.72; 95% CI, 1.89–3.90 and OR = 2.09; 95% CI, 1.23–3.55, respectively). Several preoperative variables were associated with at least a 1.5-fold increased odds of being a high utilizer in both elective and emergent cases including CHF (OR = 1.81; 95% CI, 1.12–2.94 and OR = 1.74; 95% CI, 1.14–2.68, respectively), steroid use (OR = 1.76; 95% CI, 1.23–2.51 and OR = 1.53; 95%

Table 2. American College of Surgeons National Surgical Quality Improvement Program Postoperative Complications in Colectomy High-Utilizers Compared with Non–High Utilizers

	High utilizers (n = 1,055)		Non–high utilizers (n = 9,506)		
ACS NSQIP complications	**n**	**%**	**n**	**%**	**p Value***
No ACS complications	377	35.7	6,904	72.6	<0.001
Overall morbidity†	679	64.3	2,601	27.4	<0.001
Surgical site infection	276	26.1	1,101	11.6	<0.001
Prolonged ventilation	379	35.9	471	5.0	<0.001
Pneumonia	220	20.8	399	4.2	<0.001
Sepsis	175	16.6	450	4.7	<0.001
Reintubation	194	18.4	326	3.4	<0.001
Urinary tract infection	116	11.0	402	4.2	<0.001
Deep vein thrombosis	86	8.1	185	2.0	<0.001
Wound disruption	84	8.0	135	1.4	<0.001
Renal failure	61	5.8	125	1.3	<0.001
Bleeding requiring transfusion	51	4.8	79	0.8	0.005
Cardiac arrest	22	2.1	110	1.2	0.002
Pulmonary embolism	16	1.5	86	0.9	<0.001
Cerebrovascular accident	17	1.6	56	0.6	0.001
MI	12	1.1	61	0.6	0.07
Coma	12	1.1	28	0.3	<0.001

*p Values from chi-square test.
†Overall morbidity as defined in the Methods.
ACS, American College of Surgeons.

CI, 1.07–2.19, respectively), surgery in previous 30 days (OR = 1.82; 95% CI, 1.05–3.14 and OR = 1.94; 95% CI, 1.32–2.84, respectively), and preoperative sepsis/septic shock (OR = 1.72; 95% CI, 1.22–2.42 and OR = 1.45; 95% CI, 1.06–1.99, respectively).

DISCUSSION

This study defined surgical high utilizers as colectomy patients in the highest cost decile who accounted for >50% of the inpatient care cost of the entire cohort 1 year after colectomy. These high utilizers had extremely high rates of particular complications and reoperations, such as prolonged ventilation and tracheostomy. High utilizer patients had substantially greater costs in particular cost centers, notably: intensive care, respiratory, radiology, and cardiology. This suggests that particular complications like respiratory failure might be associated with being a high utilizer. Preoperative patient characteristics

Table 3. Most Frequent Types of Postoperative Reoperations in High Utilizers Compared with Non–High Utilizers

	High utilizers (n = 1,055)		Non–high utilizers (n = 9,506)		p Value*
Reoperations	**n**	**%**	**n**	**%**	
Laparotomy	263	24.9	334	3.5	<0.001
Small bowel resection	163	15.4	178	1.9	<0.001
Colon resection	146	13.8	177	1.9	<0.001
Percutaneous drainage	145	13.7	169	1.8	<0.001
Hernia repair	123	11.7	201	2.1	<0.001
Wound debridement	138	13.1	136	1.4	<0.001
Ostomy	124	11.7	112	1.2	<0.001
Tracheostomy	147	13.9	30	0.3	<0.001
Ureteral revision	49	4.6	54	0.6	<0.001
Open vessel ligation	19	1.8	20	0.2	<0.001
Hepatectomy	12	1.1	40	0.4	0.002
Lymphadenectomy	7	0.7	24	0.3	0.02

Reoperations occurring within 1 year of colectomy captured in the Medicare claims file.
*p Values from chi-square test.

Table 4. Resource Utilization in High-Utilizers Compared with Non–High Utilizers

Resource utilization	Median	High-utilizers (n = 1,055), IQR	Median	Non–high utilizers (n = 9,506), IQR	p Value*
Total hospital length of stay, d	21	10–38	7	5–11	<0.001
Total costs, $	234,085	174,737–360,830	24,690	16,057–44,158	<0.001
Total index costs	146,957	52,097–213,746	22,853	15,528–38,150	<0.001
Total readmission costs	173,192	103,617–323,836	24,775	13,016–47,534	<0.001
Cost center costs, $[†]					
Room and board	123,849	82,988–199,520	12,311	7,404–22,433	<0.001
Anesthesia	561	141–1,294	255	132–440	<0.001
ICU	36,322	7,698–66,002	0	0–3,885	<0.001
Laboratory	9,547	5,841–16,097	775	359–1,790	<0.001
Supply	9,569	2,803–20,103	2,392	1,159–4,258	<0.001
Pharmacy	17,267	8,202–30,859	1,222	615–2,679	<0.001
Respiratory	2,875	246–9,229	22	0–303	<0.001
Rehabilitation therapy	1,762	556–3,727	124	0–402	<0.001
Radiology	649	109–1,751	29	0–161	<0.001
Operating room	8,896	4,241–17,725	3,517	2,492–4,992	<0.001
Cardiology	5,057	2,290–9,958	166	0–1,070	<0.001
Other ancillary	4,960	1,942–10,702	284	0–1,146	<0.001

*p values from Wilcoxon rank sum test.
[†]Twelve cost centers or departments where costs are attributed using the Medicare Cost Reports as described in the text.[23]
IQR, interquartile range.

such as ASA class, CHF, surgery in the previous 30 days, steroid use, and sepsis were associated with higher odds of being a high utilizer after both elective and emergent colectomies. This could be interpreted as patients with more preoperative signs of acute (sepsis) and chronic decompensation (ASA class and CHF) had higher odds of being high utilizers postoperatively. Several of these preoperative signs could be addressed by waiting, such as surgery in previous 30 days and steroid use, or are treatable, such as sepsis.

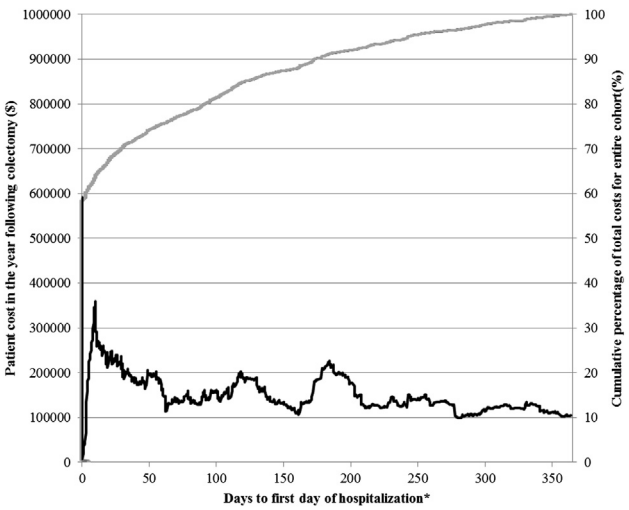

Figure 3. Time to cost incurred. Black line, mean cost per 100 patients at each cross-sectional time point. Gray line, cumulative percentage of total cost of the entire cohort. *Day to first hospitalization was equal to the days to the first readmission if the patient was readmitted or 0 if the patient had no readmission after index admission.

Identifying high utilizers preoperatively allows the health system to address as many risk factors as possible before colectomy and, therefore, could decrease costs and reduce complication rates postoperatively. There are 2 strong examples of such perioperative optimization reducing complication rates. The first is in cardiac surgery where the stabilization of decompensated heart failure before surgery has led to increased survival.[25] The second is in anesthesiology, where preoperative medical evaluation has decreased morbidity, mortality, and length of stay.[17,18,26] The ACS NSQIP complications for which preoperative medical clearance is usually performed—MI and stroke—were not the most common complications among high utilizers.[27] This might be because current systems have already optimized these patients as a result of highly publicized guidelines, or the fact that these occurrences were rare.[27,28] There are new preoperative optimization programs being tested, such as prehabilitation, that seek to improve patient baseline health before surgery to minimize more common, costly complications.[29]

Perioperative optimization might not be necessary for all patients. Two studies have suggested that only patients ASA class III and higher benefit from perioperative optimization.[17,18] This study provides additional insight about who

Table 5. Preoperative and Procedural Variables Associated with Being a High Utilizers for Elective and Emergent Colectomies

		95% CI*				95% CI*		
Preoperative and procedural variables	**Odds ratio***	**Lower**	**Upper**	**p Value***	**Odds* ratio**	**Lower**	**Upper**	**p Value***
Demographics								
Age, y, category								
65 to 74, reference								
75 to 84	1	0.81	1.22	0.96	0.83	0.64	1.09	0.19
85 or older	0.71	0.52	0.98	0.04	0.61	0.42	0.9	0.01
Diagnosis								
Diverticulitis, reference								
Other	1.43	0.94	2.18	0.09	0.88	0.54	1.42	0.59
Fistula	1	0.55	1.83	0.99	1.15	0.24	5.43	0.86
Hemorrhage	1.66	0.57	4.84	0.35	1.46	0.61	3.5	0.4
Infectious enteritis	1.4	0.62	3.16	0.41	1.48	0.88	2.49	0.14
Noninfectious enteritis	0.97	0.52	1.79	0.92	1.14	0.49	2.66	0.76
Benign neoplasm	0.58	0.38	0.88	0.01	0.88	0.18	4.3	0.88
Obstruction/perforation	0.91	0.69	1.22	0.54	1.11	0.69	1.79	0.67
Vascular insufficiency	1.94	1.29	2.9	0.001	1.38	0.94	2.03	0.1
Malignant neoplasm	1.16	0.55	2.47	0.69	0.89	0.57	1.41	0.62
Functional status								
Independent, reference								
Partially dependent	1.49	1.12	1.97	0.01	1.35	0.98	1.85	0.06
Fully dependent	2.03	1.22	3.38	0.01	1.83	1.22	2.76	0.004
American Society of Anesthesiologists class								
I and II, reference								
III	1.83	1.44	2.31	<0.0001	1.62	0.98	2.66	0.06
IV and V	2.72	1.89	3.9	<0.0001	2.09	1.23	3.55	0.01
Metabolic conditions								
BMI, kg/m^2								
<18.5	0.88	0.58	1.33	0.53	0.99	0.66	1.48	0.96
18.5 to 24, reference								
25 to 29	0.87	0.7	1.09	0.24	1.18	0.86	1.62	0.3
30 to 34	1.03	0.78	1.35	0.86	1.14	0.76	1.71	0.53
35 to 39	1.23	0.83	1.83	0.31	1.49	0.89	2.52	0.13
≥40	1.18	0.68	2.02	0.56	3.84	2.13	6.92	<0.0001
Diabetes								
No diabetes, reference								
Non-insulin dependent	1.01	0.77	1.33	0.94	1.28	0.89	1.84	0.18
Insulin dependent	1.13	0.78	1.62	0.52	0.67	0.43	1.05	0.08
Cardiovascular conditions								
Congestive heart failure	1.81	1.12	2.94	0.02	1.74	1.14	2.68	0.01
Pulmonary conditions								
COPD	1.14	0.85	1.54	0.37	1.36	0.99	1.86	0.06
Ventilator dependency	1.16	0.55	2.47	0.69	0.89	0.57	1.41	0.62
Hematologic and immunologic conditions								
Radiotherapy	1.59	0.9	2.79	0.11	0.59	0.16	2.17	0.41
Chemotherapy	1.63	0.87	3.05	0.12	0.95	0.47	1.93	0.89
Transfusion	0.86	0.35	2.15	0.75	1.1	0.62	1.96	0.75
Bleeding disorder	1.15	0.83	1.59	0.39	1.28	0.96	1.71	0.1
Steroid use	1.76	1.23	2.51	0.002	1.53	1.07	2.19	0.02

(Continued)

Table 5. Continued

Preoperative and procedural variables	Odds ratio*	95% CI*		p Value*	Odds* ratio	95% CI*		p Value*
		Lower	Upper			Lower	Upper	
Liver conditions								
Esophageal varices	3.8	0.92	15.72	0.06	2.45	0.14	41.81	0.43
Acuity of Illness								
Surgery in previous 30 d	1.82	1.05	3.14	0.03	1.94	1.32	2.84	0.001
Sepsis								
No sepsis, reference								
Systemic inflammatory response syndrome	1.72	1.22	2.42	0.002	1.45	1.06	1.99	0.02
Sepsis and septic shock	0.93	0.51	1.69	0.8	1.59	1.11	2.28	0.01

All preoperative variables derived from American College of Surgeons NSQIP.
*Odds ratio, CI, and p value from hierarchical multivariate logistic model controlling for procedure CPT code and all the patient characteristics listed.

should be targeted. The next step is to determine exactly what the multidisciplinary perioperative optimization of these high utilizer patients should entail. Functional status, steroid use, recent surgery, and even sepsis, are temporary and will change given lifestyle, medical management, or simply time. Functional status can be improved through innovative prehabilitation programs.[30-37] Patients who recently were on steroids could be weaned and treated with alternative medications that do not have such influence on wound healing and subsequently taken for elective surgery. In other words, much of the risk factors are a function of when we operate. Trials where delayed colectomies are offered for patients who had a recent surgery, recently used steroids, or meet systemic inflammatory response syndrome criteria could help elucidate whether such strategies are safe and feasible. Not all patients may be eligible, but perhaps, like in cardiac surgery, the greatest advancement could be rethinking when we offer patients surgery.

This study has several limitations. First, it might be limited in external generalizability because the sample was restricted to Medicare beneficiaries at ACS NSQIP hospitals, which are somewhat biased toward large academic centers. Second, censoring bias of the long-term costs might be a concern because patients with potential follow-up of 1 year who passed away were included in the study. Third, unfortunately, these data do not contain process measures so the successful use of process measures to limit preventable complications cannot be studied. Fourth, costs from the hospital perspective were taken because the goal of this study was to identify factors that would assist hospitals in targeting care to patients who use a disproportionate amount of inpatient resources. Other stakeholders, such as payers, might also have vested interest in reducing costs of inpatient care.

CONCLUSIONS

This study found that patients in the top decile of cost the year after colectomy accounted for >50% of the cost of the entire cohort. High-utilizer patients had substantially greater costs in 4 cost centers in particular—intensive care, respiratory, radiology, and cardiology. Patients with more signs of acute (sepsis) and chronic decompensation (high ASA class and CHF) had higher odds of being high utilizers after both elective and emergent colectomy. These data can help focus hospitals' attention on surgical patients, who, if adequately treated, could lower hospitals' costs and complication rates.

Author Contributions

Study conception and design: Stey, Liu, Ko
Acquisition of data: Zingmond, Lawson
Analysis and interpretation of data: Stey, Russell, Gibbons, Hall, Needleman, Ko
Drafting of manuscript: Stey, Russell, Zingmond, Gibbons, Hall, Needleman, Lawson, Liu, Ko
Critical revision: Stey, Liu, Lawson, Zingmond, Russell, Gibbons, Hall, Needleman, Ko

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Appendix. Current Procedure Terminology Codes of Operation Included in This Analysis

Procedure	CPT code
Colectomy, partial; with anastomosis	41440
Colectomy, partial; with skin level cecostomy or colostomy	44141
Colectomy, partial; with end colostomy and closure of distal segment (Hartmann type procedure)	44143
Colectomy, partial; with coloproctostomy (low pelvic anastomosis)	44145
Colectomy, partial; with coloproctostomy (low pelvic anastomosis), with colostomy	44146
Colectomy, total, abdominal without proctectomy; with ileostomy or ileoproctostomy	44150
Colectomy, partial; with removal of terminal ileum with ileocolostomy	44160
Laparoscopy, surgical; colectomy, partial, with anastomosis	44204
Laparoscopy, surgical; colectomy, partial, with removal of terminal ileum with ileocolostomy	44205
Laparoscopy, surgical; colectomy, partial, with anastomosis, with coloproctostomy (low pelvic anastomosis)	44207