S125 - Opioid-free Colorectal Surgery: A Reality that Can Improve Patient & Financial Outcomes in Surgery

Short Title: Opioid-free CRS

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Abstract

Background: Opioids have long been a mainstay for postsurgical pain management, but have associated complications, costs, and contribute to the opioid epidemic. Efforts to reduce its use, such as Enhanced Recovery protocols exist, with laparoscopic approach to surgery being pivotal in this context. Little study has been done on opioid utilization and its impact across surgical approaches. Our goal was to evaluate the impact of opioid utilization on quality measures and costs after open and laparoscopic colorectal surgery.

Methods: The Premier Database was reviewed for inpatient colorectal procedures from 1/1/2014-9/30/2015. Procedures were stratified into open and laparoscopic approaches, then "opioid" and "opioid-free" groups within each approach. Univariate analysis compared demographics, outcomes, and cost by opioid use and approach. In "opioid" groups, consumption and duration were assessed across platforms. Multivariate regression analyzed the association between opioid use and approach on costs and quality outcomes.

Results: 50,098 procedures were evaluated- 40.4% laparoscopic and 59.6% open. 6.6% of laparoscopic and 5.3% of open were "opioid-free". Across both approaches, patients >65 years were most likely opioid-free, while obese and cancer patients were most likely to use opioids. Length of stay was shorter, post-discharge nursing needs and total costs lower in the "opioid-free" group in both approaches (all $p<0.001$). The median daily and total opioid consumption was lower laparoscopic ($p<0.001$), with a shorter duration of use versus open ($p<0.001$). Opioids were 20% more likely open than laparoscopic. Total costs were 16% greater with opioids and

24% more expensive open. Complications were 19% higher with opioids and 66% more likely in open. Readmissions were increased by 14% with both opioids and open surgery.

Conclusions: Opioid-free colorectal surgery can be a reality, and results in significantly improved patient and financial outcomes in both laparoscopic and open cases. Laparoscopy further improves these outcomes. Thus, continued efforts to increase laparoscopy are key for reducing opioids and improving outcomes as we transition to value-based care.

Keywords: Opioids; laparoscopic colorectal surgery; readmissions; complications; healthcare costs; healthcare outcomes

Introduction

There is an opioid epidemic in the United States, and the epidemic continues to worsen. The rate of opioids prescribed, distributed, and deaths from opioid overdoses continue to increase steadily (1–3). In 2016, prescription opioids contributed to 116 fatal overdoses per day (4, 5); these now exceed deaths from car crashes, gun violence, and heroin & cocaine combined (5, 6). In addition to fatal overdose, prescription opioids have the costs of abuse, dependence, diversion of unused medication, and can serve as a gateway to other illegal substances (7–9). Currently, 11.5 million people in the United States are reported to misuse opioid prescriptions annually, more than 2.1 million report a prescription opioid use disorder, and 170,000 try heroin (5). The economic burden of prescription opioid misuse alone has been estimated at $78.5 billion per year, with the total economic impact of the opioid crisis estimated at $504.0 billion annually and growing (9, 10). With this widespread impact, further work to identify the root causes and develop solutions is needed.

Opioid use often begins with treatment of acute postoperative pain, and the inpatient surgical episode can be a ‘gateway’ to the opioid crisis. The reasons for the rampant use are multifactorial, but include the promotion of opioids as non-addictive for pain management by the pharmaceutical companies, with a massive increase in opioid prescribing by providers, the addition of pain as the “5th Vital Sign”, the Joint Commission mandate to include pain and pain under-treatment questions on HCAHPS, and the financial incentives for hospitals to maintain high patient satisfaction scores (11–14). These factors contributed to ubiquitous use among hospitalized patients undergoing surgical procedures, such as colectomy (15).

In the acute inpatient setting, opioids add the additional risk of opioid related adverse events (ORAE), which are reported in approximately 20% of cases, and significantly increase complications, length of stay, and costs (15–18). Furthermore, among opioid-naïve patients, persistent use after surgery occurs in 6-10% (19–21). Thus, the postoperative period provides an opportunity to prevent chronic opioid use and its associated costs (22). Enhanced recovery after surgery (ERAS) protocols embrace the strategy of opioid and ORAE reduction with multimodal pain management, and the evidence supporting its efficacy in colorectal surgery is strong (17, 23–25). A laparoscopic approach is a cornerstone of ERAS, and the two elements work in synergy to optimize outcomes, costs, and surgical value (22, 26–29). While use of a laparoscopic technique is an inpatient element in most ERAS protocols, little study was been performed on the impact of a laparoscopic compared to open approach on postoperative opioid utilization and associated outcomes.

Our goal was to evaluate the impact of opioid utilization across quality measures and costs after open and laparoscopic colorectal surgery. Our hypothesis was that increasing laparoscopic colorectal surgery is a value proposition to reduce opioid use and its associated costly complications. As the US shifts to a value based care model, these inpatient strategies to reduce opioid consumption may improve both clinical and financial outcomes.

Methodology and Materials

A review of the Premier Inpatient Database™ was performed to identify patients undergoing an elective colorectal resection with an inpatient admission between 1/1/2014 through 9/30/2015.

The data source covers over 45 million inpatient visits, representing approximately 1 out of every five inpatient discharges in the US. The data sources contains a day-stamped log of all billed items including procedures, medications, laboratory, diagnostic and therapeutic services at the individual patient level in addition to the standard data elements available in most hospital discharge files (30). Hospitals included in the database are a national representation in terms of regional distribution, urban versus rural hospital, teaching versus non-teaching institutions, and hospital bed size. Discharge-level data includes information on patient and provider characteristics, International Classification of Diseases 9th revision Clinical Modification (ICD-9-CM) diagnosis and procedure codes, hospital resource utilization such as specific device usage, medications and laboratory services, and charges/cost data on all entries.

Laparoscopic and open cases were identified by International Classification of Diseases Ninth Edition (ICD-9) procedure codes in the primary position of the claim. Cases with Diagnostic Related Group (DRG) codes 329, 330, and 331 and ICD-9 procedure codes for colectomy (open: 45.71, 45.72, 45.73, 45.74, 45.75, 45.76, 45.79, 45.82, 45.83 and laparoscopic: 17.31, 17.32, 17.33, 17.34, 17.35, 17.36, 17.39, 45.81) or CPT / HCPCS Codes for colectomy (open: 44140, 44141, 44143, 44144, 44145, 44146, 44150, 44151, 44155, 44156, 44157, 44158, 44160, 45113, 45121 and laparoscopic: 44204, 44205, 44206, 44207, 44208, 44210, 44211, 44212) were included in the analysis. Cases were excluded if the patients were less than 18 years of age or if the procedure was performed with robotic assistance (identified using ICD-9 add-on procedure codes 17.41, 17.42, 17.43, 17.44, 17.45, 17.49 or Current Procedural Terminology/Healthcare Common Procedure Coding System (CPT) code S2900). In addition, to ensure cases were appropriate for with laparoscopic or open surgery, metastatic cancer cases (identified from metastatic ICD-9 diagnosis codes on the inpatient surgery claim) were excluded.

Data fields evaluated included the surgical approach (open or laparoscopic), demographics, length of stay (LOS), overall complications (identified by ICD-9-CM codes, Appendix 1), readmission episode within 30 days of discharge, daily opioid consumption, total opioid consumption, days of opioid consumption, and the average cost across the open and laparoscopic cohorts for the inpatient episode. The opioids included in the analysis included all formulations of alfentanil hydrochloride, dilaudid fentanyl, fentanyl citrate, hydrocodone bitartrate, hydromorphone, levorphanol, meperidine, methadone, morphine, oxycodone, oxymorphone, propoxyphene, remifentanil, sufentanil, tapentadol, and tramadol. Total opioid consumption was defined in morphine equivalent dose (MME) based on total opioid consumption converted to MME based on the Centers for Disease Control MME published conversion factors (31, 32). Costs were defined as the total direct costs (fixed and variable) to the healthcare system. Total fixed cost included those that did not relate directly to or vary with the activity (volume) of the department such as depreciation, management, repair and maintenance and overhead. Total variable costs include those that related directly to or varied with the activity (volume) of the department such as supplies and hands on patient care.

Univariate analysis was performed to compare the demographic, outcome variables, and costs, using Chi-square tests, Mann-Whitney, or Kruskal-Wallis tests, as appropriate for categorical and continuous variables across the laparoscopic and open approaches. The adjusted inpatient cost and the factors associated with total inpatient costs were estimated by using a generalized estimating equation (GEE) multivariable model with gamma distribution. The controlling factors included age at surgery, gender, race, comorbidity measures, emergency operation, pre-existing chronic pain syndrome (with the assumption that these patients had pre-existing opioid use - identified by diagnostic codes 338.29 Chronic Pain; 338.21 Chronic Pain due to trauma; 338.28 Chronic Pain postoperative; 338.4 Chronic Pain syndrome), and hospital characteristics including bed size, teaching status, urban versus rural and region. Multivariate logistic regression analysis was performed to assess the factors associated with Opioid use (expressed in Adjusted Odds ratios). All statistical analyses were performed using SAS Version 9.4 (SAS Institute Inc., Cary NC).

The study did not involve human subjects, the data were de-identified, and compliant with the Health Insurance Portability and Accountability Act (HIPAA), thus this study was exempt from Institutional Review Board (IRB) approval (45 CFR §46.001(b) (4)).

Results

During the study period, 50,098 cases were included in the analysis- 40.4% were laparoscopic (n=20,264) and 59.6% open (n=29,834) cases. In the laparoscopic cohort, 93.4% received opioids, while 6.6% were opioid-free. In the open cohort, 94.7% received opioids, while 5.3% were opioid-free. Our surrogate for pre-existing opioid use, chronic pain, revealed 2.3% of the laparoscopic and 4.8% of open patients reported pre-existing chronic pain. Patient and hospital demographics are detailed in Table 1. There were significant differences for certain variables in the opioid and opioid-free groups for both the laparoscopic and open cohorts. The oldest patients (>65 years) were most likely to be opioid-free in both approaches (p<0.0001). Patients with the comorbidities of obesity (p=0.0247 laparoscopic, p=0.0468 open) and cancer (p=0.0287 laparoscopic, p=0.0259 open) were more likely to use opioids. In addition, across both surgical procedures, Medicare patients (p<0.0001), patients in the smallest (bed size <200) and largest (bed size>=500) hospitals (p<0.0001), and those in the Midwest region were more "opioid-free" (p<0.0001). Compared to non-teaching hospitals, patients who received treatment in teaching hospitals were more likely "opioid-free" in laparoscopic group (8.7% teaching vs. 5.2% non-teaching, (p<0.0001), but there were no significant differences in the open group. There were no significant differences in gender for opioid use in either surgical approach.

The postoperative outcomes are seen in Table 2. In both the laparoscopic and open approaches, opioid-free patients had significantly shorter LOS than opioid patients (mean 4.78 days vs. 5.56 days laparoscopic and 8.56 days vs. 9.70 days open; both p<0.0001). Opioid-free patients also had significantly lower complication rates than opioid patients in the laparoscopic (p=0.0004) and open approaches (p<0.0001). Opioid-free patients were more likely to be discharged home without post-discharge nursing needs for both approaches (p=0.0002 laparoscopic, p=0.0001 open). The total costs for the hospital episode were significantly lower in the opioid-free cohort in both laparoscopic and open cases (p<0.0001). There were no significant differences in readmission rates for opioid and opioid-free cohorts in either surgical approach. In the patients receiving opioids during the hospital stay, laparoscopic patients had a significantly lower MME/day and total MME for the episode of care, as well as significantly fewer days on opioids than open patients (all p<0.0001) (Table 3).

In the adjusted regression analysis, when evaluating factors associated with opioid use, open surgery cases were 1.2 times more likely than laparoscopic cases to have opioid use (OR=1.18, 95% CI 1.083-1.287, p=0.0002) (Table 4). With the independent impact of operative approach on opioid utilization confirmed, both operative approach and opioid use were evaluated in the model for their impact on the quality measures (Table 5). Total hospital inpatient costs were 16% greater with opioids (95% CI 1.13-1.18, p<0.0001) and 24% more expensive open than laparoscopic (95% CI 1.23-1.25, p<0.0001). Complications were 19% higher with opioid use (95% CI 1.19-1.21, p=0.04) and 66% more likely with open surgery (95% CI 1.59-1.74, p<0.0001). Readmissions were increased by 14% with both opioid use (95% CI 1.00-1.31, p=0.05) and open surgery (95% CI 1.30-1.49, p<0.0001).

Discussion

With the escalating epidemic of opoid usage, all methods to reduce its use and their associated costs are necessary (15–18, 22). We sought to evaluate the impact of opioid utilization across quality measures and costs after open and laparoscopic colorectal surgery. We found that there are currently a small percentage of colorectal surgical admissions that are opioid free- more laparoscopic than open. Opioid-free procedures had shorter LOS, lower rates of postoperative complications and post-discharge nursing utilization, and lower costs. When opioids were used, laparoscopic procedures used lower doses and had a shorter duration of use. Open cases were independently associated with opioid use, and the combination of opioid use with an open procedure resulted in greater risk of complications, readmissions, and costs.

More than 50 million Americans undergo inpatient surgery annually, and opioids remain the primary modality for inpatient acute pain management (33, 34). Our work is the first to survey the current state of opioid use in inpatient colorectal surgery, finding 93.44% of laparoscopic cases and 94.7% of open cases. In a previous national review of common inpatient procedures from 2009-2010, Kessler, et al. reported 98.6% of surgical patients received opioids during the hospitalization (15). The authors did not stratify opioid use or postoperative outcomes by surgical approach. However, the small reduction in opioid use despite the attention and use of ERAS highlights the need for alternative methods to reduce use.

More focus is being placed on the role of the acute inpatient surgical event to address the opioid crisis, which can be a gateway to continued use, abuse, and diversion of prescription opioids (19–21). The overall prevalence of prolonged (more than 90 day) opioid usage has been reported in 6-10% of opioid-naïve postsurgical patients, with a rate of over 14.4% in gastrointestinal surgery specifically (35). Thus, the inpatient period provides an opportunity to reduce opioid use and its associated costs (19–22). Laparoscopic colorectal surgery has been shown to improve postoperative outcomes, especially in conjunction with an ERAS protocol (22, 26–29). The value proposition from expanding laparoscopic colorectal surgery has been demonstrated to improve quality measure- significantly lowering readmissions, complications, mortality, and total costs compared to open surgery (36). Here, we found the combination of a laparoscopic and opioid-sparing approach in colorectal surgery further improved quality measures, with significantly lower costs, length of stay, complications, and readmission rates than open cases with opioid use. Given these findings, the laparoscopic approach could add further benefit in fighting the opioid epidemic and improving surgical quality.

Our works agrees with existing literature supporting the adverse impact of prescription opioid use on healthcare utilization after surgery (37–39). However, studies to date have focused on patients that were on opioids *before* surgery. An evaluation of 200,005 elective abdominal surgeries between 2009 and 2012 from the Truven database found 8.8% of patients used opioids preoperatively. Preoperative opioid use significantly increased postoperative healthcare utilization though longer lengths of stay, greater post-discharge nursing needs, higher readmission rates, and overall greater expenditures at 90-. 180- and 365- days following surgery compared to opioid-naïve patients (40). Cron, et al. analyzed elective abdominopelvic surgeries from 2008 to 2014 from a single center within the Michigan Surgical Quality Collaborative database, finding 21% of surgical patients used opioids preoperatively. Compared with opioid-naïve patients, these had 9.2% higher costs, 12.4% longer length of stay, and were more likely to have complications and readmissions. Given these outcomes, further study could focus on the impact of the laparoscopic approach on outcomes for patients on preoperative opioids.

Our study adds to the current literature, as the impact of the surgical approach on opioid utilization during the anchor episode has not been previously described. We found the open approach was independently associated with opioid use during the hospital stay, with open cases 20% more likely than laparoscopic to use opioids. In addition, when opioids were used, laparoscopic patients had significantly lower daily and total doses, and fewer days on opioids than open cases. This is important, as patients with higher opioid consumption during the inpatient stay are more likely to report higher use of opioids after discharge (8). Other work looking at the impact of the surgical approach on opioid use concentrated on use after discharge.

In a single institution retrospective review, Stafford, et al. found 91% of patients were discharged on opioids; 4% patients remained on opioids beyond 30 days, and 25% of those remained on opioids at 90 days (41). A minimally invasive approach attenuated the risk of prolonged opioid use (more than 30 days after surgery) (OR 0.6; CI 0.4–0.9). Thus, the benefit of a minimally invasive approach is effective for reducing opioids during the inpatient stay, and the effects appear durable through the postoperative period.

We recognize limitations in the work. First, the data source used was a national administrative database, which offers a large sample size for power, but little detail on the specific data fields evaluated. In particular, we had no data on the use, specific components, and compliance with ERAS pathways, which could influence outcomes. There is also the potential for coding and capture errors, and errors in outcomes based on self-reported information, such as codes for chronic pain and pre-existing opioid use. Regardless of the limitation, this work offers value in showing the current state of opioid use, the feasibility of opioid-free surgery in both open and laparoscopic approaches, and the potential to reduce opioid utilization and improve quality outcomes by expanding laparoscopic colorectal surgery.

In conclusion, opioid-free colectomy can be a reality, and results in significantly improved healthcare utilization and postoperative outcomes in both laparoscopic and open colorectal surgery. Laparoscopy further improves outcomes over open surgery, with improved quality measures, and lower overall costs for the surgical episode. These results highlight the benefit of continued efforts to reduce opioid utilization, improve patient outcomes, and expand utilization of laparoscopy. The initiative to increase laparoscopic colorectal surgery, which adds value and lower costs, could be an effective tool during the transition to value-based payment system.

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Table 1- Patient and Hospital Demographics

Surgical Approach	Laparoscopic					Open				
Opioid use	Yes		No		P-value	Yes		No		P-value
	18,935	93.44%	1,329	6.56%		28,265	94.74%	1,569	5.26%	
Mean Age (years, SD)	60.88	14.93	62.97	15.12	<0.0001	63.24	15.85	65.84	16.2	<0.0001
Age Group (n, %)					<0.0001					<0.0001
18-34	1,083	86	73	14		1,488	88	71	12	
35-44	1,460	96.05	60	3.95		1,904	96.45	70	3.55	
45-54	3,307	94.14	206	5.86		4,114	95.3	203	4.7	
55-64	4,623	93.36	329	6.64		6,363	95.3	314	4.7	
>=65	8,462	92.75	661	7.25		14,396	94.05	911	5.95	
Gender (n, %)					0.03282					0.1095
Female	10,153	93.28	731	6.72		15,196	94.55	876	5.45	
Male	8,782	93.62	598	6.38		13,069	94.96	693	5.04	
Comorbidities (n, %)*										
CHF	746	3.94	65	4.89	0.0873	2,363	8.36	141	8.99	0.3837
CVD	276	1.46	29	2.18	0.036	793	2.81	50	3.19	0.3752
PVD	450	2.38	29	2.18	0.6519	1,246	4.41	73	4.65	0.6467
Hypertension	9,659	51.01	719	54.1	0.0294	16,562	58.6	952	60.68	0.1033
Diabetes Mellitus	3,432	18.13	253	19.04	0.4049	5,925	20.96	350	22.31	0.2033
Obesity	2,938	15.52	237	17.83	0.0247	4,819	17.05	298	18.99	0.0468
COPD	2,696	14.24	206	15.5	0.2042	5,326	18.84	324	20.65	0.0754
Cancer	6,355	33.56	465	34.99	0.0287	8,246	29.17	499	31.8	0.0259
Payers **(**n, %)					<.0001					<.0001
Medicare	8,363	92.73	656	7.27		14,740	94.1	925	5.9	
Medicaid	1,189	94.37	71	5.63		2,438	96.1	99	3.9	
Commercial	8,524	94.57	489	5.43		9,152	95.91	430	4.49	
Others	859	88.37	113	11.63		1,935	94.39	115	5.61	
Hospital Beds (n, %)					<.0001					<.0001
000-099	1,060	93.47	74	6.53		1,391	90.27	150	9.73	
100-199	2,456	89.41	291	10.59		4,031	91.84	358	8.16	
200-299	2,905	96.99	90	3.01		5,495	96.44	203	3.56	
300-399	3,503	95.84	152	4.16		5,335	95.15	272	4.85	
400-499	2,643	96.88	85	3.12		4,220	97.24	120	2.76	
≥ 500	6,368	90.91	637	9.09		7,793	94.36	466	5.64	
Teaching hospital (n, %)	7,283	91.31	693	8.69	<.0001	10,692	94.54	618	5.46	0.215
Urban vs Rural (n, %)					0.2087					0.2087
Rural	2,062	94.07	130	5.93		4,273	95.68	193	4.32	
Urban	16,873	93.37	1,199	6.63		23,992	94.58	1,376	5.42	
Regions (n, %)					<.0001					<.0001
Midwest	3,042	83.8	588	16.2		4,849	87.23	710	12.77	
Northeast	3,368	93.19	246	6.81		4,207	95.9	180	4.1	
South	9,732	95.85	421	4.15		15,237	96.22	598	3.78	

West	2,793	97.42	74	2.58		3,972	98	81	2	

*Comorbidites were calculated as row totals and are not expected to total 100%, as not all patients had comorbidities, and some patients had more than one of the comorbidities

CVD- Cardiovascular Disease; CHF- Congestive Heart Failure: COPD- Chronic Obstructive Pulmonary Disease; PVD_ Peripheral Vascular Disease

Table 2- Postoperative Outcomes

Surgical Approach	Laparoscopic					Open				
Opioid use	Yes		No		p-value	Yes		No		P-value
Length of Stay (Mean, SD)	5.56	4.53	4.78	3.74	<0.0001	9.70	7.66	8.56	7.44	<0.0001
Complications (n, %)	333	25.06	3,962	20.92	0.0004	596	37.99	10,093	35.71	0.0671
Discharge status (n, %)					0.0002					0.0001
Home	15,850	93.25	1,147	6.75		15,746	94.53	911	5.47	
Home with Home Care	1,887	95.74	84	4.26		6,122	95.73	273	4.27	
SNF	817	91.49	76	8.51		3,802	94.48	222	5.52	
Long Term Care/ Other	293	188	18	12		1,831	191	88	9	
Died	88	95.65	4	4.35		764	91.06	75	8.94	
Total cost (Mean, SD)	$16,514	$17,476	$14,383	756	<0.0001	24,534	21,949	20,792	21,047	<0.0001
Readmission (n, %)	1,407	7.43	87	6.55	0.233	3,247	11.49	170	10.83	0.4294

Table 3 Opioid Utilization in milligram morphine equivalent (MME) and Days of Use

Approach	Laparoscopic				Open				
	Mean	SD	IQR	Median	Mean	SD	IQR	Median	p-value
MME/day	52.27	268.35	15.63-53.75	20.05	55.98	194.21	14.67-60.40	28.50	<0.0001
Total MME	194.18	616.41	37.50-194	88.00	306.81	1129.06	56.00-290	131.50	<0.0001
Days on Opioid	3.61	3.38	2.00-4.00	3.00	6.10	5.79	3.00-8.00	5.00	<0.0001

IQR- Interquartile range, 25-75 percentiles

Table 4- Adjusted Odds ratio of Opioid use in Open versus Laparoscopic Cases)

	Effect	Point Estimate	95% Confidence Limits	
Surgery	Open vs. Laparoscopic	1.18	1.083	1.287
Age group	Age 18-34 vs. age>=65	1.42	1.121	1.808
	Age 35-44 vs. age>=65	1.90	1.517	2.378
	Age 45-54 vs. age>=65	1.39	1.177	1.633
	Age 55-64 vs. age>=65	1.17	1.009	1.351
Gender	Female vs. Male	0.97	0.892	1.049
Emergency Operation	Yes vs. No	1.41	1.286	1.547
Payer	Medicaid vs. Commercial	0.98	0.814	1.169
	Medicare vs. Commercial	0.84	0.726	0.966
	Self-pay/Other vs. Commercial	0.37	0.311	0.431
Hospital bed size	000-099 vs. > 500	0.74	0.619	0.894
	100-199 vs. > 500	0.88	0.772	0.997
	200-299 vs. > 500	2.10	1.82	2.429
	300-399 vs. > 500	1.35	1.192	1.532
	400-499 vs. > 500	3.27	2.783	3.852
Teaching hospital	Yes vs. No	0.78	0.704	0.855
Rural/urban	Rural vs. Urban	0.98	0.851	1.118
Region	Northeast vs. Midwest	3.59	3.164	4.079
	South vs. Midwest	3.30	3.002	3.636
	West vs. Midwest	5.76	4.812	6.903
Chronic pain	Yes vs. No	1.33	1.057	1.68

Table 5- Multivariate Model for Opioid Use and Approach on Quality Metrics

Opioid-use vs. Opioid-free	OR	95% LCL	95% UCL	P-value
Total Cost	1.16	1.13	1.18	<.0001
Readmission	1.144	0.996	1.314	0.0569
Complication	1.193	1.186	1.210	0.0358
Open vs. Laparoscopic				
Total Cost	1.24	1.23	1.25	<.0001
Readmission	1.394	1.301	1.493	<.0001
Complications	1.664	1.591	1.74	<.0001

Appendix 1 Complications

General Category	**ICD-9-CM Code**
Ileus/ Small Bowel Obstruction (included constipation and PONV)	560.1, 560.2, 560.81, 560.89, 560.9, 997.4, 787.01, 564.3, 564.09, E937.9
Anastomotic Leak. Organ space SSI	569.5, 567.22, 566, 567.21, 567.23, 567.29, 567.89, 567.9, 599.0, 996.64, 567.38
Superficial SSI and wound complications (Hematoma/ Seroma, Wound Infection, Dehiscence)	682.2, 682.8, 682.9, 686.8, 686.9, 998.59, 958.3, 998.30, 998.31, 998.32, 998.33, 998.13, 998.51, 998.59, 998.6, 729.91, 998.12
Clostridium difficile colitis	008.45
Pulmonary Infection	481, 482.0, 482.1, 482.2, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.81, 482.82, 482.83, 482.89, 482.9, 483.0 485, 486, 507.0, 997.31, 997.32, 997.3, 518.5
Deep Venous Thrombosis	453.40, 453.41, 453.42, 453.82, 453.83
Urinary tract infection	599.0, 996.64, 788.2
Dehydration/ Acute renal failure	584.9, 276.51
Bleeding	998.11, 578.9, 285.1, 459.0, 285.1, 998.12, 569.3, 568.81, 569.3
Bleeding Requiring Transfusion	99.00, 99.01, 99.02, 99.03, 99.04, 99.05, 99.06, 99.07, 99.09
Peritonitis	567.38, 567.39, 567.2, 567.21, 567.22, 567.39, 567.8, 567.89, 567.9, 568.81
GI Complication (Fistula)	997.4, 569.81, 593.82, 599.1, 596.1
Delirium/ Confusion/ Accidental Fall	780.09, 293.9, 780.97, E884.4

SSI- Superficial site infection