Published in final edited form as:

Dis Colon Rectum. 2015 December ; 58(12): 1164–1173. doi:10.1097/DCR.0000000000000433.

Readmission after resections of the colon and rectum: predictors of a costly and common outcome

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Abstract

Background—Readmission rates are a measure of surgical quality and an object of clinical and regulatory scrutiny. Despite increasing efforts to improve quality and contain cost, 6–25% of patients are readmitted after colorectal surgery.

Objective—Define predictors and costs of readmission following colorectal surgery.

Design—Retrospective cohort study of elective and non-elective colectomy and/or proctectomy patients in the Healthcare Cost and Utilization Project Florida State Inpatient Database 2007–2011. Readmission defined as inpatient admission within 30 days of discharge. Univariate analyses of sex, age, Elixhauser score, race, insurance type, procedure, indication, readmission

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Disclaimers: None

Financial Disclosures: None

Previous Presentations: Oral Presentation, New England Surgical Society 95th Annual Meeting, September 12–14, 2014, Stowe, VT

Author Contributions:

Conception and design, or acquisition of data, or analysis and interpretation of data – LAB, LHM, CJY, ZC, ATC, DAN, JFT

Drafting the article or revising it critically for important intellectual content – LAB, LHM, CJY, ZC, ATC, DAN, JFT

Final approval of the version to be published – LAB, LHM, CJY, ZC, ATC, DAN, JFT

diagnosis, cost, and length of stay. Multivariate analysis performed by logistic regression. Sensitivity analysis of non-emergent admissions.

Settings—Florida acute care hospitals

Patients—Colectomy and proctectomy patients 2007–2011

Intervention(s)—None

Main Outcome Measure(s)—Readmission, cost of readmission

Results—93,913 patients underwent colectomy. 14.7% were readmitted within 30 days. From 2007 to 2011, readmission rates remained stable (14.6% to 14.2%, trend $p=0.1585$). After multivariate adjustment, patient factors associated with readmission included non-white race, age <65, and a diagnosis code other than neoplasm or diverticular disease ($p<0.0001$). Patients with Medicare or Medicaid were more likely to be readmitted than those with private insurance ($p<0.0001$). Patients with longer index admissions, those with stomas and those undergoing all procedures other than sigmoid or transverse colectomy were more likely to be readmitted ($p<0.0001$). High volume hospitals had higher rates of readmission ($p<0.0001$). Most common reason for readmission was infection (32.9%). Median cost of readmission care was \$7,030 (IQR \$4,220, \$13,247). Fistulas caused the most costly readmissions (\$15,174; IQR \$6,725, \$26,660).

Limitations—Administrative data, retrospective design

Conclusions—Readmissions rates after colorectal surgery remain common and costly. Non-private insurance, inflammatory bowel disease, and high hospital volume are significantly associated with readmission.

Keywords

Colon; Rectum; Resection; Outcomes; Readmission

Introduction

Hospital readmissions are frequent and expensive. An unplanned readmission occurs within 30 days of discharge for 19.6% of Medicare beneficiaries, at an annual cost of more than \$17 billion.¹ Among colorectal surgery patients, readmission is similarly common, with estimated rates reported from 6–25%.² Identifying patients likely to be readmitted after colorectal surgery remains challenging.

In this study, we use a large, all-payer database of inpatient admissions to analyze individual, procedure, and hospital predictors of readmission following colorectal surgery and calculate the associated cost.

Materials and Methods

Design

This study is a retrospective review of data from the Healthcare Cost and Utilization Project (HCUP) Florida State Inpatient Database (SID). The SID is an all-payer inpatient discharge administrative database assembled by the HCUP, part of the Agency for Healthcare

Research and Quality (AHRQ).³ The database includes patient, hospital, diagnosis, and procedure characteristics. Through use of a unique visit link, patients can be followed across time and institutions, with cost data available.

Using ICD-9 procedure codes, all discharge records with colon and rectum resections performed on patients between 18 and 95 years old during 2007 to 2011 were identified. Patients who did not survive to discharge were removed from the cohort. Resections included in the analysis were right colectomy (17.33, 17.32, 45.72, 45.73), transverse colectomy (17.34, 45.74), left colectomy (17.35, 45.75), sigmoidectomy (17.36, 45.76), total colectomy (45.8), abdominoperineal resection (APR) (48.5), low anterior resection (48.62, 48.63), and other colectomy (17.31, 17.39, 45.71, 45.79, 48.61, 48.64, 48.65, 48.69).

Pre-Procedure Characteristics

Patient demographic information collected from discharge records included sex, age, median ZIP code income, insurance type, and race. Patient comorbidity burden was calculated as an Elixhauser score, generated using the HCUP Comorbidity Software, Version 3.7.⁴ The Elixhauser score was specifically designed for use in large administrative datasets and uses ICD-9 codes and Diagnosis-Related Groups to identify comorbidities.⁴

Admission characteristics collected were indication for procedure, urgency of admission (elective or non-elective), year, and procedure performed, as classified above. Indications for the procedure were determined based on all ICD-9 diagnosis codes for the admission. Indications were neoplasm (153.0–153.9, 154.0–15.4, 154.8, V10.05, V10.06, V18.51, 211.3, 211.4, 320.3, 235.2, 235.5, 230.4, 230.5, 230.6), diverticular disease (562.1), other colorectal infection (005.0–005.6, 005.8, 005.9, 008.0–008.69, 008.8, 009.0–009.3), ischemia (557.0–557.1, 557.9), volvulus or obstruction (560.0–560.39, 560.8×, 560.9), inflammatory bowel disease (IBD) (555.0–555.2, 555.9, 556.0–556.6, 556.8–556.9), and gastrointestinal bleed (578.1, 578.9). Any patients with less common indications or without a colorectal-related ICD-9 procedure code identified were assigned an indication of other. Those patients suspected of having stomas post-operatively were identified using ICD-9 procedures codes 46.01, 46.02, 46.03, 46.04, 46.10, 46.11, 46.13, 46.14, 46.43, 46.20, 46.21, 46.22, 46.23, 46.24, 46.31, 46.39, 46.40).

Hospital colon and rectum resection annual volumes were analyzed to categorize volume status. Hospitals were classified into low-, medium- and high-volume tertiles that each included approximately one third of the overall resections.

Patient Outcomes

The primary outcome was readmission within 30 days after discharge. Readmissions were identified using the HCUP Supplemental Variables for revisit analyses, which provide a unique visit link to allow for each patient to be tracked at subsequent inpatient visits across time and multiple institutions.³ The first readmission was defined as any readmission within 30 days after discharged.

The reason for readmission was determined using the principal ICD-9 diagnosis code for the readmission. Reasons were grouped into 13 categories: infection (excluding wound

infections), genitourinary (excluding urinary tract infection), cardiac, pulmonary (excluding pneumonia), thromboembolism, hemorrhage, gastrointestinal or malnutrition, electrolyte disorder or fluid imbalance (including dehydration), ostomy or drain care (including mechanical or infectious complications as well as stoma care), fistula, pain management, ileus, or wound complication (including wound infection). ICD-9 codes included in each category are listed in Appendix 1.

Other patient outcomes recorded were length of stay (LOS) for the initial admission, when resection occurred, and disposition at discharge from the initial admission.

Cost

The charge that the hospital billed for each admission, index and first readmission, were abstracted from the SID. This charge information does not reflect the cost of services provided or the amount reimbursed. To convert billed charge information to approximate costs, we used the supplemental SID HCUP Cost-to-Charge Ratio files.³ These files include hospital-specific cost-to-charge ratios based on all-payer inpatient cost for each hospital as reported to the Centers for Medicare and Medicaid Services (CMS).³ Median cost and interquartile ranges (IQR) were calculated for all cost analyses.

Statistical Analysis

Race, payer, urgency of admission, and discharge disposition categories with a small number of patients were collapsed into aggregate groups. Continuous variables, age, median ZIP income, Elixhauser score, and index admission LOS (above and below the median LOS), were categorized to enhance clinical relevance. Patients with missing characteristics or LOS were removed from the analysis.

Patient, hospital, admission, and procedure characteristics for those patients with readmission and without readmission were compared using chi-square tests. The proportion of readmissions attributable to each readmission reason was calculated as a percentage of all patients with readmissions. For each readmission reason, median values and IQRs were calculated for days to readmission, readmission LOS, and readmission cost. Changes in readmission over the study duration were assessed using Cochran-Armitage trend test. Changes in LOS and cost of readmissions over time were calculated using the Kruskal-Wallis one-way analysis of variance.

Univariate regression modelling of likelihood of readmission was performed. A multivariate regression model predicting readmission was created using all available patient-, hospital-, and procedure-related predictors. A sensitivity analysis of only elective admissions was performed.

Statistical analyses were performed using SAS statistical analysis software, version 9.3 (SAS Institute Inc., Cary, NC). For all analyses, *p* value of less 0.05 was considered statistically significant.

Results

Pre-procedure Characteristics

During 2007 to 2011, 98,215 patients underwent colorectal resection. 4,302 (4.38%) patients died before discharge leaving a cohort of 93,913. 13,955 patients (14.86%) were readmitted within 30 days following discharge. Patient, admission, and hospital characteristics for readmitted and non-readmitted patients are displayed in Table 1. The characteristics of the two groups differ significantly in all categories. The annual number of resections performed decreased over the course of the study, from 19,294 in 2007 to 18,226 in 2011. Among all patients, non-white patients were less likely to undergo resection at a low or high volume center compared to a medium volume center ($p<0.0001$) and more likely to be in the older age group ($p<0.0001$).

Readmissions

From 2007 to 2011, readmission rates remained stable ($p=0.1585$, Figure 1). The most common reasons for first readmission were infection (4,592, 32.91%), and gastrointestinal conditions and malnutrition (1,977, 14.17%) (Figure 2). The least common reasons for first readmission were fistula (189, 1.35%), and ostomy and drain dysfunction (224, 1.61%).

The median time to first readmission by principal diagnosis ranged from 4 days (IQR 2,10) for dehydration and electrolyte abnormalities to 11 days for ostomy and drain dysfunction (IQR 5, 23). The longest first readmission LOS was for fistula (median 10, IQR 5, 17), while the shortest first readmission LOS was for pain (median 3, IQR 2, 4). Over the course of the study, mean first readmission LOS decreased from 7.6 days in 2007 to 7.0 days in 2011 ($p<0.0016$).

The overall median first readmission cost was \$7,030 (IQR \$4,220, \$13,247). The most costly first readmission reason was fistula (median \$15,174, IQR \$6,725, \$26,660) followed by infection (median \$8,093, IQR \$4,911, \$15,099). The median cost for all other first readmission reasons was less than \$8,000. Over the course of the study, mean first readmission cost remained stable ($p=0.3234$).

Regression Models

The multivariate logistic regression model predicting readmission within 30 days of discharge included year of procedure, patient sex, Elixhauser score, ZIP median income category, age group, insurance type, urgency of admission, race, hospital colorectal resection volume, procedure type, presence of a stoma, procedure indication, disposition at time of discharge, and index admission LOS. Univariate and multivariate odds ratios (ORs) are displayed in Table 2. After adjustment, median ZIP income was no longer a significant predictor of likelihood of readmission. After adjustment, predictors of readmission were resection in 2009, Elixhauser score ≥ 2 , Medicare or Medicaid, non-white race, age <65 years, resection at a high volume institution, all procedure types compared to sigmoid colectomy, the presence of a stoma, indication of ischemia, volvulus or obstruction, IBD, gastrointestinal bleed or other, discharge disposition other than home without services, and index admission LOS greater than 1 week.

Elective Admissions

During the study period, 52,955 patients underwent elective colorectal resections. The readmission rate among elective patients was 12.50% (6,619 patients). The elective resection population was more homogenous, with no significant differences in sex, and race between those readmitted and not readmitted.

The most common reasons for first readmission among elective resection patients were infection (2,153, 32.53%), and gastrointestinal conditions and malnutrition (1,114, 16.83%) (Figure 3). The first readmission reasons with the shortest and longest days to readmission were gastrointestinal conditions and malnutrition (median 5 days, IQR 2, 10), and ostomy and drain care (median 15 days, IQR 6, 24.5), respectively. The most costly reason for first readmission after elective admission was fistula (median \$14,019, IQR \$6,556, \$24,274). The least costly reason for first readmission was electrolyte disorders and fluid imbalance (median \$3,774, IQR \$2,346, \$5,513).

Univariate and multivariate logistic regression models predicting readmission among elective resection patients were performed (Table 3). After adjustment, predictors of readmission among elective patients were Elixhauser score ≥ 2 , non-private payer, age <65 years, resection at a high volume center, any resection other than transverse colectomy or sigmoidectomy, presence of a stoma, resection for ischemia, volvulus or obstruction, IBD, or other indication, discharge disposition other than to home without services, and LOS greater than 1 week.

DISCUSSION

In this study we have used an administrative dataset with readmission files to analyze predictors of readmission after colorectal surgery. We found a readmission rate 14.86% and a median first readmission cost of \$7,030. Some of the predictors of readmission identified in our study are clinically unsurprising. Patients with higher comorbidity, non-sigmoid resections, relapsing conditions, and prolonged LOS were more likely to return to the hospital. These characteristics define a high-risk, complication-prone population. Less predictably, younger age was associated with increased likelihood of readmission. Non-white race was slightly, but significantly associated with readmission. Even when controlling for multiple patient and procedure variables, high hospital caseload was associated with higher rates of readmission.

Reduction in readmission is a clinical, financial, and political priority. In surgery, this equates to minimizing post-operative complications, readying patients for discharge, and assuring adequate outpatient care.

Studies of readmission in colorectal surgery have been performed as institutional reviews, analyzing patient and operative level variables not available in this administrative database. Higher estimated blood loss (EBL), longer operative times, pre-operative weight loss, obesity, contamination of the operative field, and not air-testing anastomoses are associated with colorectal readmissions.^{5–9} Administrative database studies have documented the associations between readmission and non-white race, non-elective operation, longer LOS,

increased comorbidities, and procedure type, but have generated conflicting results regarding the impact of age and sex.^{5,10,11–15} Both large database studies and smaller institutional reviews have found stoma creation and post-operative complications to be associated with readmission.^{5,8–9,10,12–14}

A recently published analysis of readmissions after colorectal resection performed by Damle, et al. identified a 13.7% 30-day readmission rate.¹⁶ Predictors of readmission were longer LOS, presence of a stoma, and discharge to facilities.¹⁶ Readmissions were associated with a doubling of hospital costs.¹⁶ Unlike our study, this analysis was limited to patients undergoing resection at academic hospitals and restricted the indications for procedures.¹⁶ As such, our analysis includes a broader range of practice settings, including patients resected in the community setting without post-colectomy clinical pathways.

Readmissions are detrimental to long term patient outcomes. Analysis of over 40,000 colon cancer patients found that 11% were readmitted after colectomy. The adjusted OR of mortality for those patients was 2.44 (95% CI 2.25–2.65), similar to the impact of stage III versus stage I disease.¹⁰ Furthermore, readmissions contribute to disparities in surgical outcomes, with racial minority patients more frequently readmitted after surgery.¹⁷

Our study extends previous work on colorectal surgery readmissions by using administrative data combined with unique variables to allow analysis of revisits. In addition, we analyzed factors including patient race, hospital surgical volume, and socioeconomic and insurance status. We found that non-white race was associated with readmission after multivariate adjustment. Hospital and patient variables are involved in this discrepancy. Black patients are more likely to undergo surgery at low volume hospitals and to have more complicated presentations.¹⁸ Analysis of 250,000 black Medicare beneficiaries undergoing colectomy found that black patients had more comorbidities and were more likely to undergo urgent operation relative to white patients. Black patients were also treated at different hospitals; two-thirds of black patients were treated at 20% of the study hospitals considered “minority-serving hospitals.” Both black and white patients treated at these hospitals were significantly more likely to be readmitted, and hospital variables explained 35% of the racial disparity in post-colectomy readmissions.¹⁷

In our study, patients with non-private insurance were significantly more likely to be readmitted. In particular, Medicaid-insured patients were the most likely to be readmitted. This may reflect difficulty of these patients, relative to privately insured patients, to be seen in outpatient follow-up, obtain supplies or medications, and secure the necessary social support for recovery, and also may be indicative of an increased burden of primary disease or comorbid conditions.

Surprisingly, we identified age less than 65 as associated with readmission after adjustment for other variables. This may be due to a higher acuity of illness in the younger population, particularly those with IBD, as well as an aversion to decline operation on sicker young patients. The use of administrative data prevents adjustment for disease severity within a given diagnosis code. Older patients in extremis or with debilitating chronic illnesses may not be offered surgery due to the expectation of poor outcomes and short life expectancy or

may decline operative intervention while younger patients may be offered or choose a more aggressive management strategy. Additionally, insurance status may play a role. While many younger patients have access to private insurance, those who are most ill are often unable to work and are uninsured or have Medicaid. Both of these may impede their access to preventative and outpatient follow-up services.

In our study, high volume hospitals had higher rates of readmission. This is in contrast to two large studies of surgical readmission among Medicare patients. Tsai et al analyzed over 400,000 Medicare beneficiaries undergoing six surgical procedures, including colectomy, and found readmission rates to be consistently inversely associated with surgical volume.¹⁹ Similarly, Greenblatt's 2010 analysis of patients undergoing colectomy for cancer in the Surveillance, Epidemiology, and End Results (SEER)-Medicare database found higher volume hospitals to be associated with lower rates of readmission.¹⁷ Conversely, large, academic, and safety-net hospitals are more likely to be penalized by the Centers for Medicare and Medicaid Services (CMS) for higher readmission rates.²⁰ Internationally, analysis of greater than 100,000 United Kingdom (UK) colorectal surgery patients found no correlation between hospital or provider caseload and readmission.¹⁵ In our population, high volume centers may be associated readmission rates due to a greater case complexity as referral centers or a patient population more predisposed to readmission. While some degree of complexity is adjusted for by the inclusion of Elixhauser score, procedure type, and indication, these variables do not reflect the range of disease burden and associated risk levels within each individual comorbidity or primary disease category and the spectrum of intraoperative complexity within each procedure code. Further, unmeasured social factors influence whether patients are readmitted and vulnerable population may be overrepresented at urban, higher volume centers. This includes patients with inadequate assistance at home or lack of timely access to a primary care physician who can manage complications before they progress and require inpatient readmission. The discrepancy in the volume effect between our analysis and previous studies may be due to the inclusion of cases regardless of payer, while the above mentioned studies reflect the experience of caring for the Medicare population.

Ultimately, many factors associated with readmission are non-modifiable—race, age, comorbidity, extent of procedure, and indication for procedure. In these higher risk patients, pre-operative optimization and patient selection, especial in the setting of elective resections, should occur. Patients whose initial admissions are complicated may benefit from a longer initial LOS to maximize the likelihood of identifying future complications. Additionally, outpatient follow-up should be more proactive and frequent to identify post-operative complications early so outpatient management is feasible. Similarly, as discharge to a facility or with services is associated with readmission—likely due to frailty or complexity of these patients—further efforts should be made to enhance communication between the surgical team and these care providers after discharge. Finally, Medicare and Medicaid are associated with readmissions for the above mentioned reasons. Improving access to care for these patients could reduce disease severity at the time of presentation and facilitate the outpatient management of post-discharge complications.

Our study has several limitations. Analysis of billing code data is subject to errors in patient classification and coding. Furthermore, the limits of the ICD-9 system make it difficult to determine important surgical variables – specifically laparoscopic versus open surgery in early years of our study –, important indications for readmission, particularly anastomotic leak, whether comorbidities and complications predated the surgical procedure, and disease severity. Beyond ICD-9 procedure codes, intraoperative data is not available, including operative time, anatomic challenges, operative technique, intraoperative complications, American Society of Anesthesiologists classification, and stability at the time of procedure completion. With regards to our primary endpoint, although readmission is an increasingly scrutinized metric of surgical quality, it is not uniformly associated with surgical morbidity or mortality.²¹

Despite these limitations, this study expands the current understanding of colorectal surgery readmissions. It highlights established risk factors for readmission, but also identifies less commonly studied factors in colorectal surgery including race, insurance status, and hospital volume. Our study also shows that, despite professional and political pressure for their reduction, colorectal surgery readmissions are not decreasing in frequency and continue to be prolonged and costly. This study highlights the remaining work to be done in preventing surgical complications, identifying patients likely to fail at discharge, improving the transition to outpatient care, and rectifying disparities in surgical outcomes for different patient groups.

Readmission after colorectal surgery is common, and expensive. Despite years of increasing scrutiny of surgical quality and cost metrics, readmissions were no less common over time while becoming longer and tending toward higher costs. These data reflect an ongoing challenge in preventing post-operative complications, identifying patient readiness for discharge, and successfully transitioning patients to outpatient care.

Acknowledgments

Funding Sources:

Howard Hughes Medical Institute Early Career Award, American Surgical Association Foundation Fellowship, American Cancer Society MSRG 10-003-01 (to JFT)

NIH Award K24 DK098311 (to ATC)

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Appendix 1. Readmission reasons by principal ICD-9 diagnosis codes

Reason for Readmission	ICD-9 Codes
Infection	003.1, 005.9, 007.4, 008.45, 008.8, 009.0, 009.1, 009.3, 038.0, 038.10, 038.11, 038.12, 038.19, 038.2, 038.3, 038.40, 038.42, 038.43, 038.49, 038.8, 038.9, 042.047.9, 070.1, 110.3, 112.0, 112.2, 112.4, 112.5, 112.84, 112.85, 112.89, 117.9, 136.3, 282.82, 322.2, 323.9, 324.1, 380.10, 381.0, 421.0, 461.8, 465.9, 466.0, 481, 482.0, 482.1, 482.2, 482.39, 482.41, 482.42, 482.82, 482.83, 482.9,

Reason for Readmission	ICD-9 Codes
	485, 486, 490, 507.0, 510.9, 513.0, 536.41, 540.1, 540.9, 555.1, 555.9, 558.2, 558.2, 558.9, 562.11, 562.13, 566, 567.1, 567.21, 567.22, 567.23, 567.29, 567.31, 567.38, 567.89, 567.9, 569.5, 569.61, 572.0, 590.10, 590.80, 595.9, 599.0, 608.4, 614.3, 614.4, 616.4, 682.2, 682.3, 682.5, 682.6, 686.1, 728.86, 730.05, 730.25, 730.26, 730.28, 733.11, 780.6, 780.60, 780.62, 790.7, 995.91, 995.92, 996.61, 996.62, 996.63, 996.66, 996.67, 996.69, 997.31, 998.51, 998.59, 999.31, 999.32
Genitourinary	179, 403.90, 584.5, 584.8, 584.9, 585.6, 585.9, 591, 592.0, 592.1, 593.3, 593.4, 593.5, 593.81, 593.89, 593.9, 594.0, 595.0, 595.2, 595.82, 595.89, 596.0, 596.54, 596.6, 599.60, 599.7, 599.70, 599.71, 599.84, 600.00, 600.01, 600.21, 600.91, 603.9, 604.90, 604.99, 608.83, 608.86, 614.9, 788.1, 788.20, 788.30, 788.99, 867.2, 996.31, 996.64, 996.65, 996.73, 996.76, V56.0, V58.76
Cardiac	397.0, 398.91, 401.9, 402.91, 404.91, 410.01, 410.11, 410.31, 410.41, 410.51, 410.71, 410.72, 410.81, 410.91, 411.0, 413.1, 414.01, 414.02, 414.8, 420.90, 420.99, 423.8, 423.9, 424.1, 425.11, 425.4, 426.0, 426.13, 427.0, 427.1, 427.31, 427.32, 427.41, 427.5, 427.61, 427.69, 427.81, 427.89, 427.9, 428.0, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.41, 428.42, 428.43, 429.83, 785.0, 785, 785.1, 785.4, 786.50, 786.51, 786.52, 786.59, 794.31, 996.04, 996.72, 997.91, V53.32
Pulmonary	491.20, 491.21, 491.22, 492.8, 493.20, 493.22, 493.90, 493.92, 494.0, 494.1, 496, 508.0, 511.0, 511.8, 511.81, 511.89, 511.9, 512.1, 512.8, 514, 515, 516.8, 518.0, 518.3, 518.5, 518.51, 518.52, 518.81, 518.82, 518.83, 518.84, 518.89, 519.09, 519.19, 786.05, 786.09, 799.02, 997.3, 997.39, V46.13, V55.0
Thromboembolism	415.11, 415.19, 444.21, 444.22, 444.81, 444.89, 451.11, 451.19, 451.2, 451.82, 451.83, 451.84, 451.89, 452, 453.2, 453.40, 453.41, 453.42, 453.51, 453.8, 453.82, 453.83, 453.84, 453.86, 459.81, 459.89
Bleeding	280.0, 284.89, 285.1, 285.22, 285.9, 459.0, 530.7, 530.82, 531.00, 531.40, 532.00, 532.20, 532.40, 532.41, 533.40, 534.40, 537.83, 537.84, 562.02, 562.12, 568.81, 569.3, 569.85, 569.86, 578.0, 578.1, 578.9, 596.7, 784.7, 790.92, 997.5, 998.11, 998.12
Gastrointestinal & Malnutrition	261, 262, 263.9, 528.00, 530.0, 530.10, 530.11, 530.12, 530.19, 530.20, 530.21, 530.3, 530.6, 530.81, 530.85, 531.50, 531.90, 532.10, 532.50, 532.90, 532.91, 534.00, 534.90, 535.00, 535.01, 535.11, 535.40, 535.41, 535.50, 535.51, 535.60, 536.2, 536.3, 536.42, 536.49, 536.8, 537.0, 537.3, 555.2, 556.2, 556.3, 556.8, 556.9, 557.0, 557.1, 557.9, 558.1, 560.32, 564.00, 564.09, 564.1, 564.2, 564.3, 564.4, 564.89, 565.0, 565.1, 568.0, 569.1, 569.2, 569.49, 569.71, 569.79, 569.82, 569.83, 569.89, 570, 571.1, 571.2, 571.5, 571.8, 572.2, 572.8, 573.4, 573.8, 573.9, 574.00, 574.01, 574.10, 574.11, 574.20, 574.21, 574.30, 574.40, 574.41, 574.50, 574.51, 574.60, 574.61, 574.90, 574.91, 575.0, 575.10, 575.11, 575.12, 575.8, 575.9, 576.1, 576.2, 576.8, 577.0, 577.1, 577.2, 577.8, 579.3, 579.8, 751.0, 751.3, 783.0, 783.21, 783.7, 787.01, 787.02, 787.03, 787.3, 787.91, 789.5, 789.59, 936, 997.4, 997.49, V55.1, V58.75
Electrolyte Disorders & Fluid Imbalance	275.2, 275.42, 276.0, 276.1, 276.2, 276.50, 276.51, 276.52, 276.6, 276.69, 276.7, 276.8, 276.9, 458.0, 458.29, 458.8, 458.9, 785.59
Ostomy & Drains	569.60, 569.62, 569.69, V55.2, V55.3, V55.4, V58.42, V58.49
Fistula	596.1, 596.2, 569.81, 599.1, 619.0, 619.1, 998.6
Pain	338.18, 338.19, 338.28, 338.29, 338.3, 562.10, 569.41, 569.42, 724.5, 789.00, 789.01, 789.02, 789.03, 789.04, 789.05, 789.06, 789.07, 789.09, 789.30, 789.39
Ileus	560.0, 560.1, 560.2, 560.39, 560.81, 560.89, 560.9
Wound Complication	552.20, 552.21, 552.29, 553.20, 553.21, 553.29, 568.89, 707.03, 707.04, 707.05, 707.07, 707.10, 707.14, 707.15, 707.19, 707.23, 707.8, 997.62, 998.13, 998.30, 998.31, 998.32, 998.33, 998.83, V58.41, V58.77

Readmission rates 2007 to 2011 for all colectomy and proctectomy admissions and only elective admissions

Figure 1.
Readmission rates for all colectomy and proctectomy cases and elective-only cases over time.

First Readmission Principle Diagnoses and Associated Costs

Figure 2.

Principle reasons for first readmissions by volume and cost per readmission for all admissions.

First Readmission Principle Diagnoses and Associated Costs - Elective Admissions Only

Figure 3.

Principle reasons for first readmissions by volume and cost per readmission for elective admissions.

Table 1

Patient, admission, and hospital characteristics of patients undergoing colorectal resection with and without readmission within 30 days following discharge.

	Not Readmitted		Readmitted		p-value
	n	%	n	%	
Total	79,958	85.14%	13,955	14.86%	
Sex					0.0630
Male	36,857	46.10%	6,314	45.25%	
Female	43,101	53.90%	7,641	54.75%	
Elixhauser Score					<0.0001
0-1	30,499	38.14%	3,360	24.08%	
2	49,459	61.86%	10,595	75.92%	
ZIP Income					0.0013
Lower	46,332	57.95%	8,290	59.41%	
Upper	33,626	42.05%	5,665	40.59%	
Age					<0.0001
64	36,730	45.94%	5,675	40.67%	
>64	43,228	54.06%	8,280	59.33%	
Insurance Type					<0.0001
Medicare	43,210	54.04%	8,615	61.73%	
Medicaid	3,469	4.34%	901	6.46%	
Private	27,887	34.88%	3,591	25.73%	
Other	5,392	6.74%	848	6.08%	
Emergent					<0.0001
No	46,336	57.95%	6,619	47.43%	
Yes	33,622	42.05%	7,336	52.57%	
Race					<0.0001
Non-white	17,746	22.19%	3,318	23.78%	
White	62,212	77.81%	10,637	76.22%	
Volume Cluster					0.0025
Low	26,390	33.00%	4,558	32.66%	

	Not Readmitted		Readmitted		p-value
	n	%	n	%	
Medium	27,468	34.35%	4,642	33.26%	
High	26,100	32.64%	4,755	34.07%	
Procedure					<0.0001
Right Colectomy	28,925	36.18%	4,830	34.61%	
Transverse Colectomy	3,005	3.76%	538	3.86%	
Left Colectomy	7,938	9.93%	1,495	10.71%	
Sigmoid Colectomy	23,490	29.38%	3,398	24.35%	
Total Colectomy	1,755	2.19%	741	5.31%	
Abdominoperineal Resection	1,643	2.05%	411	2.95%	
Low Anterior Resection	7,951	9.94%	1,349	9.67%	
Other	5,251	6.57%	1,193	8.55%	
Rectal Procedure (LAR or APR)					0.0414
Yes	9,594	12.00%	1,760	12.61%	
No	70,364	88.00%	12,195	87.39%	
Stoma					<0.0001
Yes	14,622	18.29%	4,275	30.63%	
No	65,336	81.71%	9,680	69.37%	
Indication					<0.0001
Neoplasm	25,278	31.61%	3,449	24.72%	
Diverticular Disease	20,325	25.42%	2,820	20.21%	
Ischemia	1,316	1.65%	456	3.27%	
Volvulus or Obstruction	20,179	25.24%	4,225	30.28%	
Inflammatory Bowel Disease	3,519	4.40%	887	6.36%	
Gastrointestinal Bleed	2,334	2.92%	606	4.34%	
Other	7,007	8.76%	1,512	10.83%	
Discharge to Home					<0.0001
No	30,636	38.32%	8,228	58.96%	
Yes	49,322	61.68%	5,727	41.04%	
Index Admission Length of Stay					<0.0001
1 week or less	44,810	56.04%	5,012	35.92%	

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	Not Readmitted		Readmitted		p-value
	n	%	n	%	
Greater than 1 week	35,148	43.96%	8,943	64.08%	

Table 2

Univariate and multivariate logistic regression model predicting readmission for all colorectal resection patients.

	Unadjusted		Adjusted	
	Odds Ratio	95% Confidence Limits	Odds Ratio	95% Confidence Limits
Year				
2007		Ref-----		Ref-----
2008	1.043	0.986 1.104	1.044	0.986 1.106
2009	1.081	1.022 1.143	1.070	1.011 1.134
2010	1.011	0.955 1.071	1.002	0.945 1.063
2011	0.968	0.913 1.025	0.961	0.905 1.019
Sex				
Male		Ref-----		Ref-----
Female	1.035	0.998 1.073	0.988	0.952 1.026
Elixhauser Score				
0-1		Ref-----		Ref-----
2	1.944	1.866 2.027	1.381	1.318 1.447
ZIP Income				
Lower	1.062	1.024 1.102	0.972	0.936 1.010
Upper		Ref-----		Ref-----
Age				
64	0.807	0.778 0.837	1.200	1.123 1.281
>64		Ref-----		Ref-----
Insurance Type				
Medicare	1.548	1.485 1.614	1.357	1.266 1.454
Medicaid	2.017	1.860 2.187	1.516	1.392 1.651
Private		Ref-----		Ref-----
Other	1.221	1.127 1.323	1.061	0.977 1.153
Emergent				
No		Ref-----		Ref-----
Yes	1.527	1.473 1.584	0.949	0.907 0.992
Race				

	Unadjusted		Adjusted	
	Odds Ratio	95% Confidence Limits	Odds Ratio	95% Confidence Limits
Non-white	1.094	1.048	1.103	1.055
White	Ref	Ref	Ref	Ref
Volume Cluster				
Low	Ref	Ref	Ref	Ref
Medium	0.978	0.936	1.043	0.997
High	1.055	1.009	1.133	1.082
Procedure				
Right Colectomy	1.154	1.101	1.192	1.129
Transverse Colectomy	1.238	1.121	1.142	1.030
Left Colectomy	1.302	1.219	1.155	1.079
Sigmoid Colectomy	Ref	Ref	Ref	Ref
Total Colectomy	2.919	2.659	1.842	1.661
Abdominoperineal Resection	1.729	1.543	1.516	1.343
Low Anterior Resection	1.173	1.096	1.300	1.210
Other	1.571	1.461	1.367	1.266
Stoma				
No	Ref	Ref	Ref	Ref
Yes	1.973	1.896	1.333	1.269
Indication				
Neoplasm	Ref	Ref	Ref	Ref
Diverticular Disease	1.017	0.964	1.001	0.943
Ischemia	2.540	2.270	1.467	1.303
Volvulus or Obstruction	1.535	1.462	1.117	1.059
Inflammatory Bowel Disease	1.847	1.702	1.281	1.168
Gastrointestinal Bleed	1.903	1.728	1.223	1.105
Other	1.581	1.481	1.366	1.273
Discharge to Home Without Services				
No	2.313	2.230	1.555	1.486
Yes	Ref	Ref	Ref	Ref
Index Admission Length of Stay				

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	Unadjusted		Adjusted	
	Odds Ratio	95% Confidence Limits	Odds Ratio	95% Confidence Limits
1 week or less	2.275	2.192	1.530	1.460
Greater than 1 week		Ref		Ref

Table 3

Univariate and multivariate logistic regression model predicting readmission for elective colorectal resection patients.

	Unadjusted		Adjusted	
	Odds Ratio	95% Confidence Limits	Odds Ratio	95% Confidence Limits
Year				
2007	Ref-----	Ref-----	Ref-----	Ref-----
2008	1.010	0.932 1.094	1.018	0.938 1.105
2009	1.079	0.996 1.169	1.082	0.997 1.174
2010	0.994	0.916 1.078	1.012	0.931 1.100
2011	0.966	0.890 1.049	0.986	0.906 1.073
Sex				
Male	Ref-----	Ref-----	Ref-----	Ref-----
Female	0.978	0.929 1.030	0.961	0.911 1.014
Elixhauser Score				
0-1	Ref-----	Ref-----	Ref-----	Ref-----
2	1.675	1.587 1.767	1.349	1.271 1.431
ZIP Income				
Lower	1.073	1.019 1.131	1.005	0.952 1.061
Upper	Ref-----	Ref-----	Ref-----	Ref-----
Age				
64	0.869	0.825 0.915	1.149	1.043 1.266
>64	Ref-----	Ref-----	Ref-----	Ref-----
Insurance Type				
Medicare	1.344	1.271 1.422	1.252	1.134 1.382
Medicaid	2.008	1.757 2.294	1.594	1.387 1.832
Private	Ref-----	Ref-----	Ref-----	Ref-----
Other	1.326	1.165 1.510	1.217	1.066 1.390
Race				
Non-white	0.995	0.934 1.060	1.006	0.941 1.075
White	Ref-----	Ref-----	Ref-----	Ref-----
Volume Cluster				

	Unadjusted		Adjusted	
	Odds Ratio	95% Confidence Limits	Odds Ratio	95% Confidence Limits
Low	Ref-----	Ref-----	Ref-----	Ref-----
Medium	1.046	0.977 1.118	1.045	0.976 1.120
High	1.176	1.101 1.256	1.164	1.088 1.247
Procedure				
Right Colectomy	1.174	1.093 1.260	1.115	1.029 1.209
Transverse Colectomy	1.258	1.091 1.451	1.064	0.917 1.234
Left Colectomy	1.306	1.178 1.448	1.143	1.028 1.272
Sigmoid Colectomy	Ref-----	Ref-----	Ref-----	Ref-----
Total Colectomy	3.128	2.726 3.589	1.704	1.451 2.002
Abdominoperineal Resection	2.218	1.948 2.526	1.443	1.256 1.659
Low Anterior Resection	1.474	1.352 1.606	1.280	1.168 1.402
Other	1.755	1.585 1.944	1.321	1.185 1.473
Stoma				
No	Ref-----	Ref-----	Ref-----	Ref-----
Yes	2.543	2.374 2.724	1.542	1.422 1.672
Indication				
Neoplasm	Ref-----	Ref-----	Ref-----	Ref-----
Diverticular Disease	0.834	0.776 0.897	0.981	0.904 1.065
Ischemia	2.365	1.771 3.158	1.392	1.031 1.880
Volvulus or Obstruction	1.418	1.326 1.517	1.115	1.036 1.200
Inflammatory Bowel Disease	1.805	1.612 2.021	1.219	1.066 1.394
Gastrointestinal Bleed	1.641	1.345 2.003	1.157	0.942 1.421
Other	1.484	1.354 1.625	1.364	1.238 1.503
Discharge to Home Without Services				
No	2.317	2.198 2.442	1.501	1.409 1.598
Yes	Ref-----	Ref-----	Ref-----	Ref-----
Index Admission Length of Stay				
1 week or less	Ref-----	Ref-----	Ref-----	Ref-----
Greater than 1 week	2.257	2.140 2.380	1.555	1.461 1.657