

# Economic Burden of Postoperative Ileus Associated With Colectomy in the United States

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## ABSTRACT

**BACKGROUND:** Postoperative ileus, a transient impairment of gastrointestinal motility, is a common cause of delay in return to normal bowel function after abdominal surgery. Colectomy surgery patients who develop postoperative ileus could have greater health care resource utilization, including prolonged hospitalization, compared with those who do not develop postoperative ileus. Very few studies have assessed the impact of postoperative ileus on resource utilization and costs using retrospective analysis of administrative databases.

**OBJECTIVE:** To assess health care utilization and costs in colectomy surgery patients who developed postoperative ileus versus those who did not.

**METHODS:** A retrospective cohort study design was used. Adult patients with a principal procedure code for colectomy (ICD-9-CM procedure codes 45.71–45.79), discharged between January 1, 2004, and December 31, 2004, were identified from the Premier Perspective database of inpatient records from more than 500 hospitals in the United States. The colectomy patients were further classified for the presence of postoperative ileus, identified by the presence, in any diagnosis field on the administrative patient records, of a code for paralytic ileus (ICD-9-CM code 560.1) and/or digestive system complications (ICD-9-CM code 997.4) during the inpatient stay. Code 997.4 was used to account for cases in which postoperative ileus would be reported as a complication of anastomosis, as could be the case in colectomy surgeries. Hospital length of stay (LOS) and hospitalization costs were compared using t-tests. Multivariate analyses were performed with log-transformed LOS and log-transformed cost as the dependent variables. Patient demographics, mortality risk, disease severity, admission source, payment type (retrospective/prospective), and hospital characteristics were used as covariates.

**RESULTS:** A total of 17,876 patients with primary procedure code for colectomy were identified, of whom 3,115 (17.4%) patients were classified for presence of postoperative ileus (including paralytic ileus only [ $n = 1,216$ ; 6.8%], digestive system complications only [ $n = 383$ ; 2.1%], or both [ $n = 1,516$ ; 8.5%]). A majority of the colectomy patients with and without postoperative ileus, respectively, were male (54.1% vs. 50.3%,  $P < 0.001$ ), Caucasian (70.5% vs. 69.3%,  $P = 0.170$ ), and aged 51–64 years (51.1% vs. 49.7%,  $P = 0.143$ ). The mean [SD] hospital LOS was significantly longer in patients with postoperative ileus (13.8 [13.3] days) compared with patients without postoperative ileus (8.9 [9.5] days;  $P < 0.001$ ). Presence of postoperative ileus was found to be a significant predictor of LOS ( $P < 0.001$ ) in the regression model, controlling for covariates. Female gender ( $P = 0.002$ ), greater severity level ( $P < 0.001$ ), and hospital bed size of more than 500 ( $P = 0.013$ ) were other significant predictors of hospital LOS. Presence of postoperative ileus was found to be a significant predictor of hospitalization costs ( $P < 0.001$ ), controlling for covariates.

**CONCLUSION:** Postoperative ileus in colectomy patients is a significant predictor of hospital resource utilization.

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## What is already known about this subject

- Postoperative ileus is a temporary impairment of gastrointestinal motility that commonly occurs after abdominal surgery. Although the literature regarding the incidence of postoperative ileus is limited, the incidence rates appear to vary by the type of surgery, with reported incidence rates ranging from 15%-25% in patients undergoing colectomy.
- The etiology of postoperative ileus is understood to be multifactorial with potential causes including inflammation from surgical manipulation, inhibitory neural reflexes, and the use of opioids.
- Although a few pharmacoeconomic studies have been published on postoperative ileus using hospital chart data, no cost study to our knowledge has used large multihospital databases and focused specifically on colectomy surgeries.

## What this study adds

- Mean (SD) hospital length of stay (LOS) for colectomy patients with postoperative ileus was 13.8 (13.3) days total, compared with 8.9 (9.5) days total for colectomy patients without postoperative ileus.
- Mean (SD) per stay hospitalization costs for colectomy patients with and without postoperative ileus were, respectively, \$25,089 (\$35,386) and \$16,907 (\$29,320).
- In multivariate regression models adjusted for covariates, presence of postoperative ileus was found to be a significant predictor of hospital LOS (29% increase, 95% CI = 26.0%-31.0%) and costs (15.5% increase, 95% CI = 13.3%-17.7%) in patients undergoing colectomy surgery.

Postoperative ileus is a transient impairment of bowel motility following surgery. It can occur following surgical disruption of the abdominal cavity but may also occur following surgery at other sites.<sup>1,2</sup> Postoperative ileus is characterized clinically by abdominal distension, decreased or absent bowel sounds, constipation, and inability to advance oral intake. Gradual recovery of gut function occurs sequentially by gut segment, with the colon recovering last.<sup>1,3</sup> In abdominal surgery such as colectomy, this process of postoperative bowel recovery typically lasts 3–5 days.<sup>4</sup>

The pathogenesis of postoperative ileus is thought to involve multiple mechanisms.<sup>2</sup> Neural reflexes that inhibit intestinal motility via several different pathways are thought to play a role in the pathogenesis of postoperative ileus.<sup>5-7</sup> Inflammation in

the gut wall characterized by activation of resident macrophages in response to manipulation is also considered to play a role in postoperative ileus, and several inflammatory mediators have been implicated in its evolution.<sup>8-11</sup> Opioid drugs used for postoperative analgesia may also contribute to postoperative ileus by decreasing intestinal motility via stimulation of  $\mu$ -opioid receptors in the gut.<sup>12,13</sup>

Postoperative ileus has a profound impact on outcomes. Increased morbidity associated with postoperative ileus includes nausea and vomiting, increased pain, and prolonged time to oral intake of nutrition necessary for wound healing and immune function.<sup>1,13</sup> Risk of aspiration and increased time to mobilization may lead to pulmonary complications. These consequences of postoperative ileus are associated with greater resource utilization including prolonged hospitalization.<sup>14,15</sup>

Because dysmotility of the gut may be a factor in delaying hospital discharge following abdominal surgery, several strategies have been developed to speed the return of gut function.<sup>16</sup> Accelerated postoperative care including early oral feedings, avoidance of nasogastric intubation, and early ambulation may hasten restoration of gut function, reduce morbidity, and shorten hospital stay.<sup>2,16-18</sup> Less invasive surgery using laparoscopy is effective in reducing time to return of gut function and duration of hospital stay and has been shown to be safe even in patients undergoing colectomy for colon carcinoma.<sup>19-22</sup> Additional techniques that can be combined in a multimodal approach to prevent and manage postoperative ileus include opioid-sparing analgesia, use of regional anesthesia techniques, and administration of laxatives.<sup>2,6,23,24</sup> Currently available prokinetic agents have not been proven effective in the treatment or prevention of postoperative ileus;<sup>1</sup> however, alvimopan, a new pharmacologic agent that antagonizes the effects of opioid analgesia on the gut, has been shown to be helpful in restoring gastrointestinal function and reducing time to hospital discharge.<sup>25,26</sup>

Although these efforts have been successful in shortening hospital stay and reducing costs, they have some limitations. Laparoscopic surgery remains inappropriate for some patients and unavailable at some centers.<sup>20,22</sup> In addition, conversion from laparoscopic-assisted to open colectomy is required in some patients; a meta-analysis of 26 studies reported a conversion rate of 14% (range=0%-42%).<sup>22</sup> In addition, even among patients who receive accelerated postoperative care to minimize postoperative ileus following bowel resection, postoperative ileus still occurs in many patients; postoperative ileus-related morbidity was reported in 15% of 727 patients who received accelerated postoperative care following open bowel resection.<sup>27</sup> Therefore, the clinical and economic consequences of postoperative ileus remain a concern in spite of current preventive and management efforts.

Limited recent data are available that elucidate the economic impact of postoperative ileus in patients undergoing colectomy surgeries. This lack of information, as well as availability of newer techniques for addressing postoperative ileus, suggest that older

estimates should be updated.<sup>15</sup> In this retrospective database analysis, we studied the impact of postoperative ileus on health care utilization and costs in patients who underwent open or laparoscopic colectomy. The main objective of our study was to quantify the incremental impact of postoperative ileus on health care utilization, including hospital length of stay (LOS) and hospitalization costs, in patients undergoing colectomy surgery in the United States. We conducted the economic analysis from a hospital perspective using a large hospital alliance database.

## Methods

### Data Source

A retrospective cohort study was conducted using data from the Premier Perspective database. This repository of hospital administrative data includes approximately one-sixth of all hospitalizations in the United States and was developed for quality and utilization benchmarking. It contains a total of 2.5 billion patient daily service records, and approximately 45 million records are added each month. Annually, nearly 5 million hospital discharges are processed and recorded in the Perspective database. In addition to the data elements available in most standard hospital discharge files, the Perspective database also contains a date-stamped log of all billed items including procedures, medications, laboratory, and diagnostic and therapeutic services at the individual patient level. The Uniform Billing (UB)-92 discharge form provides data on demographic characteristics, discharge diagnoses, and discharge status (including death, but not its cause). Patient records in the database used for this study were de-identified in compliance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA). Records relating to a common hospital discharge were linked using a non-personal identifier assigned by the data provider that prevented subject identification and the linking of identifiers to subjects.

The data undergo quality checks, and cost information is reconciled with the hospitals' financial statements. The data are used by hospitals to compare their clinical and financial performance against the performance of their peers. The Premier Perspective database is used in the Centers for Medicare & Medicaid Services Hospital Quality Incentive Demonstration Project, which links reimbursement of hospitals to the quality of patient care and outcomes of care for selected procedures or conditions.<sup>28</sup> Dollar amounts used in the present study's analyses represent either costs as recorded in procedural cost accounting systems in 70%-80% of hospitals or estimated costs based on a ratio of cost to charges in the remaining 20%-30%.

### Patient Selection Criteria

To be eligible for analysis, a patient was required to meet the following criteria:

- An inpatient discharge during 2004
- Aged 18 years or older
- A principal procedure code for open or laparoscopic excision

of the large intestine (colectomy) *International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] codes 45.71-45.79 (Table 1)

The colectomy patients were further classified on the basis of presence or absence of a diagnosis code for postoperative ileus, recorded in any diagnosis field in the administrative record, during the inpatient stay for the colectomy procedure. Diagnosis codes for postoperative ileus included paralytic ileus (ICD-9-CM code 560.1) and/or digestive system complications not elsewhere classified (ICD-9-CM code 997.4). The digestive system complications code (ICD-9-CM 997.4) was included in addition to the code for paralytic ileus (ICD-9-CM 560.1) because code 997.4 includes within it the “complications of intestinal anastomosis.” An anastomosis is a surgical connection between two structures. It usually means a connection that is created between tubular structures, such as blood vessels or loops of intestine, as is the case for colectomy surgeries, in which parts of the colon are removed and the remaining sections are reconnected surgically. Since the primary cohort population for this study consists of patients who had undergone colectomy surgery, code 997.4 could be used to code postoperative ileus as a complication resulting from anastomosis for these patients. Hence, the code was included in an attempt to get a comprehensive estimate of postoperative ileus in this population, even though a significant overlap between the 2 codes was expected in our study results. LOS for patients who expired in the hospital was calculated as the time between date of admission and date of death.

### Adjustment for Severity and Mortality Risk

In order to control for confounding factors such as severity of condition and comorbidities, which could impact hospital LOS, All Patient Refined Diagnosis Related Groups (APR-DRGs) were used as covariates. APR-DRGs are a joint development of 3M Health Information Systems and the National Association of Children’s Hospitals and Related Institutions and are used by the Agency for Healthcare Research and Quality (AHRQ) for risk adjustment. APR-DRGs expand the basic DRG structure by adding 2 sets of subclasses to each base APR-DRG.<sup>29</sup>

Each set consists of 4 subclasses and addresses patient differences relating to severity of illness and risk of mortality. Severity of illness is defined as the extent of physiologic decompensation or organ system loss of function. Risk of mortality is defined as the likelihood of dying. Since severity of illness and risk of mortality are distinct patient attributes, separate subclasses are assigned to a patient for each attribute. The 4 severity of illness subclasses and the 4 risk of mortality subclasses are numbered sequentially from 1 to 4 indicating, respectively, minor, moderate, major, and extreme severity of illness or risk of mortality. The underlying clinical principles of APR-DRGs are that the severity of illness and risk of mortality of a patient are highly dependent

**TABLE 1** Description of ICD-9-CM Procedure Codes

ICD-9-CM Procedure Code	Description of Procedure Code
45.71	Multiple segmental resection of large intestine
45.72	Cecectomy
45.73	Right hemicolectomy
45.74	Resection of transverse colon
45.75	Left hemicolectomy
45.76	Sigmoidectomy
45.79	Partial excision of large intestine

ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*.

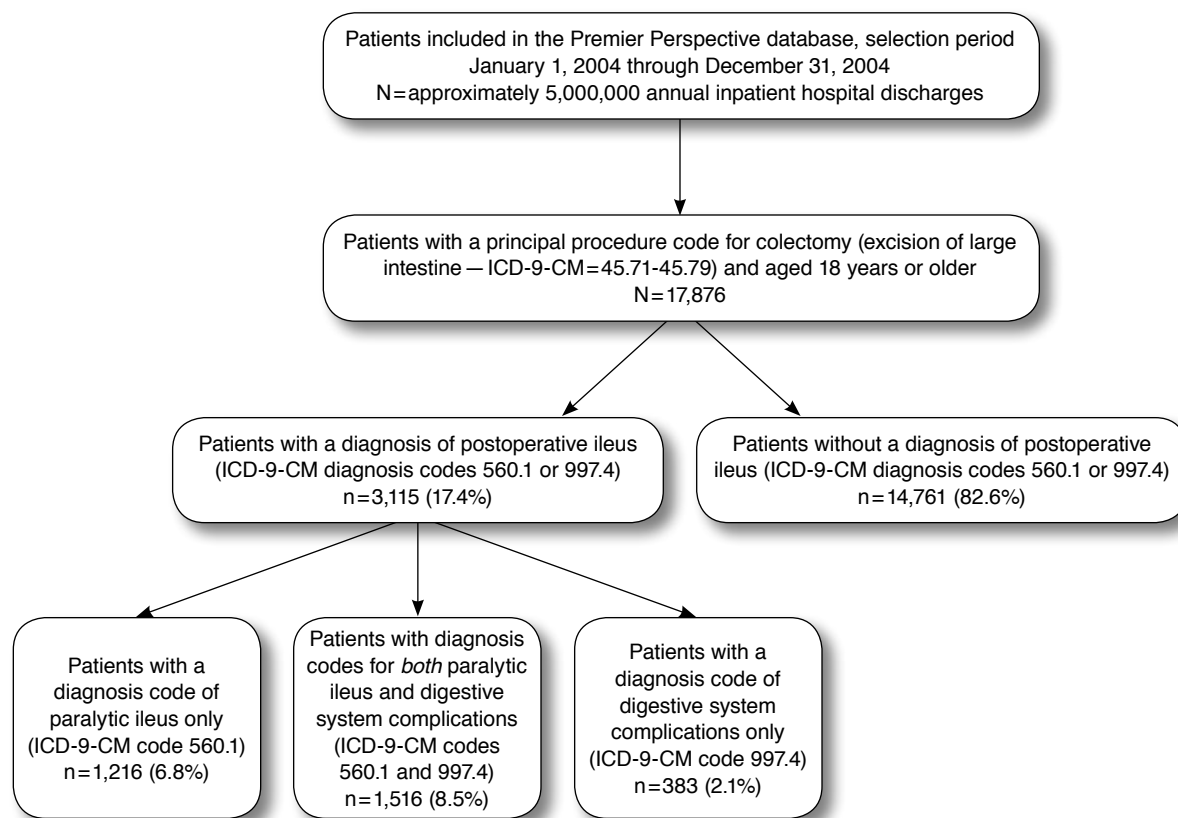
on the patient’s underlying clinical problems, and that patients with high severity of illness or risk of mortality are usually characterized by multiple serious diseases or illnesses.<sup>30</sup> In the APR-DRGs, the assessment of the severity of illness or risk of mortality of a patient is specific to the base APR-DRG to which a patient is assigned. In other words, the determinations of the severity of illness and risk of mortality are disease-specific.<sup>30</sup>

### Statistical Analysis

Descriptive statistics were calculated for demographic (age, race, and gender) and health care characteristics (admission type, admission source, hospital payer type). Hospital LOS, all-cause 30-day readmission rates, and costs for the postoperative ileus and non-postoperative ileus groups were compared using t-tests and chi-square tests as appropriate. In order to assess the incremental hospital days and costs associated with postoperative ileus after accounting for covariates, multivariate regression analyses were performed with log-transformed LOS and costs as dependent variables and presence of postoperative ileus as a key independent variable. Since the distributions of the hospital LOS and costs are positively skewed, natural logarithmic transformations were performed to normalize the data, which is essential to fulfill the assumptions of multivariate regression analysis.

For the LOS model, regression (mixed linear) modeling using the SAS (SAS Institute Inc., Cary, NC) procedure “PROC MIXED” was used to account for the correlation that can be expected among patients treated in a particular hospital and to explore the effects of both hospital characteristics and patient characteristics on LOS. For the cost model, regression modeling using the SAS procedure “PROC REG” was used. Patient demographics (age, gender, and race), APR-DRG mortality risk, APR-DRG case severity, admission source (physician, health maintenance organization [HMO], transfer, emergency room [ER], and other), payment method (retrospective vs. prospective, which includes managed care capitated and Medicaid managed care capitated arrangements), and hospital characteristics (bed size, teaching vs. nonteaching, and urban vs.

**FIGURE 1** Patient Selection for Colectomy Surgery Patients



ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.

rural) were used as covariates in both models. The natural antilogarithms of the parameter estimates were obtained. Specifically, the percentage increase or decrease predicted in the dependent variable by a 1-unit increase in any independent variable is obtained using the formula  $(e^{\text{estimate}} - 1) \times 100$ , where  $e$  is a constant approximately equal to 2.718. All analyses were performed using SAS version 9.1.

## Results

A total of 17,876 patients with a primary procedure code for colectomy were identified, of whom 3,115 (17.4%) patients had a secondary diagnosis of postoperative ileus, including paralytic ileus only ( $n=1,216$ , 6.8%), digestive system complications only ( $n=383$ , 2.1%), and both paralytic ileus and digestive system complications ( $n=1,516$ , 8.5%; Figure 1). A majority of the colectomy patients with and without postoperative ileus, respectively, were male (54.1% vs. 50.3%,  $P<0.001$ ), Caucasian (70.5% vs. 69.3%,  $P=0.170$ ), and aged 51-64 years (51.1% vs. 49.7%,  $P=0.143$ ; Table 2).

## Admission and Discharge Characteristics

A significantly lower proportion of patients who developed postoperative ileus compared with those who did not were in category level 1 (minor) for APR-DRG severity (8.0% vs. 38.4%, respectively,  $P<0.001$ ) and APR-DRG mortality (47.6% vs. 60.2%,  $P<0.001$ ; Table 3). A majority of the colectomy surgery patients in both cohorts had elective surgery, but the elective proportion of admissions was smaller in the group of patients who subsequently developed postoperative ileus than those who did not (49.9% vs. 57.7%, respectively,  $P<0.001$ ). The admission type was classified as “emergency” for a significantly greater proportion of patients who subsequently developed postoperative ileus than patients who did not (33.0% vs. 28.7%,  $P<0.001$ ). A majority of the patients in both the ileus and no ileus groups had physician referral as the admission source (59.5% vs. 64.7%, respectively,  $P<0.001$ ).

Patients who developed postoperative ileus were less likely than those without postoperative ileus to be discharged home

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**TABLE 2** Patient Demographics

Characteristic	With Postoperative Ileus		Without Postoperative Ileus		P Value <sup>a</sup>
	n	%	n	%	
	3,115		14,761		
Age (years) mean [SD]	52.7	[12.8]	52.4	[12.8]	<0.001
Age group (years)					
18-35	324	10.4	1,558	10.6	0.800
36-50	860	27.6	4,248	28.8	0.189
51-64	1,592	51.1	7,331	49.7	0.143
65-80	273	8.8	1,334	9.0	0.628
81 or older	66	2.1	290	2.0	0.576
Gender					
Female	1,430	45.9	7,335	49.7	0.001
Male	1,685	54.1	7,426	50.3	
Race					
Caucasian	2,196	70.5	10,222	69.3	0.170
African American	424	13.6	1,743	11.8	0.005
Hispanic	111	3.6	655	4.4	0.029
Other	384	12.3	2,141	14.5	0.002

<sup>a</sup>P value for Pearson chi-square tests (age group, gender, race) or t-test (age) of differences between groups of patients with and without postoperative ileus.

after surgery (67.2% vs. 77.4%, respectively,  $P < 0.001$ ) and more likely to be discharged to another institution (7.7% vs. 4.9%,  $P < 0.001$ ) or to home health care (21.7% vs. 15.0%,  $P < 0.001$ ; Table 3). The all-cause 30-day hospital readmission rate was significantly higher for patients with postoperative ileus than for those without (0.9% vs. 0.3%, respectively,  $P < 0.001$ ).

### Hospital and Payer Characteristics

A majority of the colectomy surgeries in the groups with and without postoperative ileus, respectively, were performed in non-teaching hospitals (61.5% vs. 62.0%), urban hospitals (83.1% vs. 85.8%), and hospitals with more than 100 beds (96.2% in both groups; Table 4). A majority of admissions in both groups were reimbursed by a noncapitated managed care payment source (61.2% vs. 62.3%). In both groups, the majority of patients were in hospitals located in the Midwest (36.8% vs. 37.0% for patients with and without postoperative ileus, respectively) and South (38.7% vs. 33.0%).

### Hospital Length of Stay and Costs

Mean [SD] hospital LOS in days was significantly higher in colectomy patients with postoperative ileus than in patients without (13.75 [13.33] vs. 8.85 [9.49], respectively,  $P < 0.001$ ; Table 5). The median LOS in the postoperative ileus group was 10 days compared with 6 days in the non-postoperative ileus group. Results were similar for all APR-DRG severity levels. Mean [SD] hospitalization costs were significantly higher for colectomy patients

**TABLE 3** Admission and Discharge Characteristics

Characteristic	With Postoperative Ileus		Without Postoperative Ileus		P Value <sup>a</sup>
	n	%	n	%	
	3,115		14,761		
APR-DRG severity level <sup>b</sup>					
Level 1	250	8.0	5,675	38.4	<0.001
Level 2	1,389	44.6	5,380	36.4	<0.001
Level 3	974	31.3	2,381	16.1	<0.001
Level 4	502	16.1	1,325	9.0	<0.001
APR-DRG risk of mortality level <sup>b</sup>					
Level 1	1,483	47.6	8,891	60.2	<0.001
Level 2	797	25.6	3,525	23.9	0.043
Level 3	529	17.0	1,499	10.2	<0.001
Level 4	306	9.8	846	5.7	<0.001
Admission source					
Physician referral	1,852	59.5	9,544	64.7	<0.001
HMO referral	79	2.5	364	2.5	0.819
Transfer from health care facility	65	2.1	246	1.7	0.103
Emergency room	1,059	34.0	4,283	29.0	<0.001
Other	60	1.9	324	2.2	0.347
Admission type					
Emergency	1,029	33.0	4,231	28.7	<0.001
Urgent	464	14.9	1,787	12.1	<0.001
Elective	1,555	49.9	8,521	57.7	<0.001
Other	67	2.2	222	1.5	0.009
Discharge status					
Discharged home	2,094	67.2	11,418	77.4	<0.001
Transferred to other institution	241	7.7	721	4.9	<0.001
Discharged to home health care	676	21.7	2,220	15.0	<0.001
Expired	93	3.0	376	2.5	0.164
Other	10	0.3	26	0.2	0.101
All cause 30-day readmission rate	29	0.9	38	0.3	<0.001

<sup>a</sup>P value for Pearson chi-square tests of differences between the groups of patients with and without postoperative ileus.

<sup>b</sup>APR-DRGs are a valid and reliable measurement system developed specifically to measure inpatient severity and risk of mortality.<sup>29,30</sup>

APR-DRG = All Patient Refined Diagnosis Related Group; HMO = health maintenance organization.

with postoperative ileus than patients without, overall (\$25,089 [\$35,386] vs. \$16,907 [\$29,320], respectively,  $P < 0.001$ ) and for the first (lowest) 3 severity levels. Among patients at APR-DRG severity level 4 (extreme severity), the cost difference was not statistically significant ( $P = 0.068$ ).

In the multivariate regression model of hospital LOS on postoperative ileus and covariates, presence of postoperative ileus was found to be a significant predictor ( $\beta = 0.254$ , 95% confidence interval [CI] = 0.235-0.274,  $P < 0.001$ ), associated with

**TABLE 4** Hospital and Payer Characteristics

Characteristic	With Postoperative Ileus		Without Postoperative Ileus	
	n	%	n	%
	3,115		14,761	
<b>Primary payer</b>				
Managed care: capitated	73	2.3	324	2.2
Medicaid managed care: capitated	3	0.1	17	0.1
Charity	17	0.5	87	0.6
Commercial: indemnity	462	14.8	2,385	16.2
Direct employer contract	26	0.8	148	1.0
Indigent	24	0.8	71	0.5
Managed care: not capitated	1,907	61.2	9,192	62.3
Medicaid managed care: not capitated	43	1.4	237	1.6
Medicaid fee for service	239	7.7	919	6.2
Other	66	2.1	320	2.2
Other government payers	65	2.1	267	1.8
Self-pay	179	5.7	738	5.0
Unknown	0	0.0	7	0.0
Workers compensation	11	0.4	49	0.3
<b>Hospital region</b>				
Northeast	329	10.6	2,580	17.5
South	1,206	38.7	4,873	33.0
West	435	14.0	1,838	12.5
Midwest	1,145	36.8	5,470	37.1
<b>Hospital total beds</b>				
0-100	117	3.8	560	3.8
101-500	1,729	55.5	8,583	58.1
> 500	1,269	40.7	5,618	38.1
<b>Hospital type</b>				
Rural	528	17.0	2,091	14.2
Urban	2,587	83.0	12,670	85.8
<b>Teaching status</b>				
Non-teaching	1,915	61.5	9,150	62.0
Teaching	1,200	38.5	5,611	38.0

a 29% increase (95% CI=26.0%-31.0%, approximately 1.6 days when 29% is applied to the antilog of the intercept) in hospital LOS (Table 6). Female gender ( $P=0.002$ ), greater severity level ( $P<0.001$ ), and hospital size greater than 500 beds ( $P=0.013$ ) were other significant predictors of hospital LOS. In the multivariate regression model of hospital cost, presence of postoperative ileus was found to be a significant predictor ( $\beta=0.144$ , 95% CI=0.125-0.163,  $P<0.001$ ), associated with a 15.5% increase (95% CI=13.3%-17.7%) in hospital costs (\$1,461). APR-DRG severity level ( $P<0.001$ ), APR-DRG mortality risk level ( $P<0.001$ ), hospital size, admission source, and admission to a teaching hospital were other significant predictors of hospital costs (Table 6).

## Discussion

Our study results indicate that postoperative ileus occurs in approximately 17% of the colectomy surgeries performed in the hospitals in the Premier Perspective database, which represents approximately one-sixth of hospital discharges in the United States. The rates of postoperative ileus vary from 4%-75% in studies reported in the literature for abdominal surgeries.<sup>15,31-33</sup> The rates of postoperative ileus found in this database seem to be similar to those reported in other studies that have used ICD-9-CM codes for identification of cases of postoperative ileus in colectomy patients. In a study by Goldstein et al., the incidence of postoperative ileus in abdominal surgeries was reported to be 8.5%, with the highest incidence in large and small bowel resection (14.9% and 19.2%, respectively).<sup>15</sup> In a pooled analysis of clinical studies of a drug aiming to prevent postoperative ileus in patients following bowel resection surgery, the rate of postoperative ileus was approximately 15% in patients treated with placebo.<sup>27</sup>

While comparing across studies in the literature, it is important to emphasize the variability in the definition of the term "postoperative ileus." The postoperative ileus rate of 17% in colectomy patients found in our study is lower than those reported in studies that have used narrative information in patient charts or a pre-defined cutoff time to recovery of bowel function in addition to ICD-9-CM codes. In a retrospective cohort review of patient chart records at a major academic center in the United States, the rates of prolonged postoperative ileus in 40 hemicolectomy patients was found to be 24.5%.<sup>31</sup> In addition to ICD-9-CM codes, that study used additional criteria to identify postoperative ileus, including documentation of postoperative ileus in the narrative section of the chart, confirmation or identification of postoperative ileus by radiological studies such as obstruction series or abdominal or pelvic computed tomography scans, and prolonged return of gastrointestinal function, including lack of bowel sounds, delayed flatus, and no bowel movement, abdominal distention, nausea, or vomiting. In a study reported in a meeting abstract, Benedict et al. reported that the incidence of postoperative ileus, defined as greater than 5 days of time to recovery of normal bowel function, was 52%-75% in patients after colonic surgery in Germany.<sup>33</sup>

In the present study, we found that postoperative ileus predicts an increase of 29% in the average hospital LOS. Similar results have been reported for total abdominal surgeries and some types of colectomy surgeries, hemicolectomy in particular.<sup>15,27,31</sup> LOS is an important outcome as a marker for resource consumption. In a study evaluating the association of postoperative ileus with hospital LOS in abdominal surgeries using the National Inpatient Sample (NIS) database, hospital LOS in patients with postoperative ileus was 2.35 to 3.00 days longer on average compared with patients without postoperative ileus.<sup>32</sup> In clinical studies of bowel resection patients, the average LOS has been reported to be 6.6 days.<sup>27</sup> In a study of abdominal surgeries, the average hospital

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**TABLE 5** Hospitalization Length of Stay and Cost in Patients Undergoing Open Colectomy Surgery

Severity Level	Outcome Measure	Statistic	With Post Operative Ileus	Without Post Operative Ileus	P Value <sup>a</sup>
All patients		n	3,115	14,761	
	Cost (\$)	Mean [SD] Median	25,089 [35,386] 15,146	16,907 [29,320] 10,836	<0.001
	Length of stay (days)	Mean [SD] Median	13.75 [13.33] 10.0	8.85 [9.49] 6.0	<0.001
APR-DRG severity level 1		n	250	5,675	
	Cost (\$)	Mean [SD] Median	11,451 [4,985] 10,654	9,340 [3,788] 8,628	<0.001
	Length of stay (days)	Mean [SD]	7.6 [3.5]	5.3 [2.3]	<0.001
APR-DRG severity level 2		n	1,389	5,380	
	Cost (\$)	Mean [SD] Median	13,619 [7,656] 11,620	12,589 [6,844] 11,003	<0.001
	Length of stay (days)	Mean [SD]	8.8 [4.6]	7.5 [4.1]	<0.001
APR-DRG severity level 3		n	974	2,381	
	Cost (\$)	Mean [SD] Median	23,030 [14,949] 18,655	20,638 [18,352] 16,489	0.003
	Length of stay (days)	Mean [SD]	14.2 [7.8]	11.8 [8.3]	<0.001
APR-DRG severity level 4		n	502	1,325	
	Cost (\$)	Mean [SD] Median	67,611 [69,975] 47,940	60,146 [80,679] 39,015	0.068
	Length of stay (days)	Mean [SD]	29.9 [25.0]	24.1 [23.6]	<0.001

<sup>a</sup>P value for Pearson chi-square tests (age group, gender, race) or t-test (age) of differences between groups of patients with and without postoperative ileus.

APR-DRG = All Patient Refined Diagnosis Related Group.

LOS was found to be 11.5 days for cases with coded postoperative ileus versus 5.5 days for cases without coded postoperative ileus.<sup>15</sup> Salvador et al. reported that in hemicolectomy patients, the average hospital LOS was 16.6 days (median 15.8 days) in patients with prolonged postoperative ileus compared with 8.6 days (median: 6.8 days) in patients without any evidence of postoperative ileus.<sup>31</sup> The results of our study confirm that postoperative ileus in colectomy patients, including hemicolectomy, could be a significant predictor of hospital LOS, even after controlling for various confounding factors in multivariate analysis. Our study is one of the first to assess the association between postoperative ileus and hospital LOS in colectomy patients in the United States after controlling for other potential confounding factors, such as patient demographics and condition severity.

In addition to prolonged hospital LOS during the index hospitalization, patients developing postoperative ileus are also at higher risk for hospital readmission. The 0.38% rate of 30-day all-cause hospital readmissions found in our study is much lower than those reported in previous studies of abdominal surgeries. Goldstein et al. reported a 30-day readmission rate for postoperative ileus of 3.6% in abdominal surgery patients with postoperative ileus compared with 0.02% in patients without postoperative ileus.<sup>15</sup> Past studies have reported that approximately 10% of patients undergoing colorectal surgery were readmitted within 30 days, and one-third were readmitted for small-bowel obstruction or ileus.<sup>34</sup> Lower readmission rates in our study could be attributed to the restricted sample of colectomy surgery cases in the present study compared with all abdominal surgeries as reported in other previously published studies. Nevertheless, the readmission rates found in our study were higher in patients with postoperative ileus than in those without, which could contribute significantly to increased health care costs.

The total annual national hospital cost attributed to managing coded postoperative ileus in abdominal surgeries has been projected to be \$1.46 billion for both the index hospitalization and any readmissions within 30 days.<sup>15</sup> We found that presence of postoperative ileus is associated with an increase of approximately 15% in hospital costs. Other studies have reported incremental costs associated with postoperative ileus in abdominal surgeries. Sarawate et al. reported that the incremental charges attributable to postoperative ileus were found to range between \$4,118 and \$8,745 per hospitalization in intra-abdominal surgeries.<sup>32</sup> Goldstein et al. reported that the average hospital cost for cases with coded postoperative ileus following abdominal surgeries was \$18,877 compared with \$9,460 for cases without any code for postoperative ileus.<sup>15</sup> Our study confirms that postoperative ileus could be a significant predictor of hospital LOS and costs in patients undergoing colectomy surgery, controlling for covariates.

### Limitations

First, since postoperative ileus was identified by ICD-9-CM codes, postoperative ileus rates could be underestimated. Use of information in patient charts in addition to the ICD-9-CM codes could help to account for the underestimation in future research. Second, billing and coding errors could potentially have occurred. Third, few clinical variables were available for inclusion in the multivariate analyses, thus limiting conclusions about the direct contribution of postoperative ileus on hospital LOS and cost. Multivariate analysis controls only for measured covariates, not for unmeasured confounding factors. Fourth, the proportion of surgeries that were performed laparoscopically is unknown. It is possible that differences in surgical procedures could have an effect on LOS and cost outcomes. Finally, this study failed to

## Economic Burden of Postoperative Ileus Associated With Colectomy in the United States

**TABLE 6** Relationship of Postoperative Ileus With Hospital Length of Stay and Costs

Variable	Hospital Length of Stay (Log-Transformed) as Dependent Variable <sup>a</sup>			Hospital Costs (Log-Transformed) as Dependent Variable <sup>b</sup>		
	Estimate	Antilog Estimate	Pr >  t	Estimate	S.E	Pr >  t
Intercept	1.762	5.83	<0.001	9.149	0.028	<0.001
<b>Postoperative ileus (ref: no postoperative ileus)</b>						
Postoperative ileus	0.254	1.29	<0.001	0.144	0.01	<0.001
<b>Payment type (ref: retrospective)</b>						
Prospective	-0.039	0.96	0.160	-0.046	0.025	0.061
<b>Age (continuous)</b>	0.001	1.00	0.142	-0.000	0.000	0.970
<b>Gender (ref: female)</b>						
Male	-0.022	0.98	0.002	-0.003	0.007	0.627
<b>Race (ref: white)</b>						
African American	0.051	1.05	0.240	0.086	0.011	<0.001
Hispanic	0.131	1.14	0.034	0.104	0.017	<0.001
Other	0.010	1.01	0.816	0.016	0.010	0.116
<b>APR risk of mortality (ref: Level 1)</b>						
Level 2	0.025	1.03	0.307	0.028	0.010	0.004
Level 3	0.048	1.05	0.331	0.112	0.016	<0.001
Level 4	0.227	1.26	0.003	0.428	0.027	<0.001
<b>APR severity level (ref: Level 1)</b>						
Level 2	0.190	1.21	<0.001	0.182	0.009	<0.001
Level 3	0.427	1.53	<0.001	0.462	0.014	<0.001
Level 4	0.787	2.20	<0.001	0.954	0.024	<0.001
<b>Admission source (ref: physician referral)</b>						
HMO referral	-0.044	0.96	0.116	-0.193	0.023	<0.001
Transfer	0.165	1.18	<0.001	0.163	0.028	<0.001
ER	0.064	1.07	<0.001	0.038	0.014	0.006
Other	-0.159	0.85	<0.001	-0.083	0.027	0.002
<b>Admission type (ref: emergency)</b>						
Urgent	0.032	1.03	0.050	-0.001	0.015	0.938
Elective	-0.120	0.89	<0.001	-0.112	0.015	<0.001
Other	-0.016	0.98	0.746	0.018	0.031	0.547
<b>Discharge status (ref: home)</b>						
Other institution	0.396	1.49	<0.001	0.459	0.018	<0.001
Home health	0.222	1.25	<0.001	0.182	0.010	<0.001
Expired	-0.485	0.62	<0.001	0.151	0.026	<0.001
Other	0.019	1.02	0.804	0.123	0.078	0.111
<b>Hospital beds (ref: 100 or less)</b>						
101-200	0.057	1.06	0.098	-0.078	0.021	<0.001
201-300	0.051	1.05	0.125	-0.082	0.020	<0.001
301-400	0.077	1.08	0.023	-0.092	0.020	<0.001
401-500	0.082	1.09	0.026	-0.015	0.021	0.454
Greater than 500	0.091	1.10	0.013	-0.024	0.020	0.225
<b>Hospital type (ref: rural)</b>						
Urban	-0.033	0.97	0.124	-0.017	0.011	0.113
<b>Teaching (ref: nonteaching)</b>						
Teaching	0.007	1.01	0.722	0.061	0.008	<0.001

<sup>a</sup>N=17,896. Goodness of Fit Statistics: -2 Res Log Likelihood: 24192.3, Akaike Information Criterion: 24196.3, Bayesian Information Criterion: 24204.1. Null Model likelihood test chi-square: 664.15, Pr > Chi square: <0.0001.

<sup>b</sup>N=17,896. Adjusted R-square=0.5402, P<0.001.

APR-DRG=All Patient Refined Diagnosis Related Group; ER=emergency room; HMO=health maintenance organization; ref=reference category.



capture the humanistic impact of postoperative ileus on patients, who experience pain and discomfort because of this condition. Lost work productivity due to prolonged hospitalization is another relevant component of indirect costs, which could be important from the perspectives of patients, employers, and society.

### Conclusion

In patients who underwent colectomy surgery, postoperative ileus was associated with a 29% increase in hospital LOS and a 15% increase in hospitalization costs. Prevention of postoperative ileus could potentially yield benefits in reduction in hospital LOS and associated health care costs.

### Authors

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### DISCLOSURES

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Iyer and Saunders were responsible for concept and design, with the assistance of Stemkowski. Saunders performed the majority of data collection, with the assistance of the other authors. Iyer had primarily responsibility for data interpretation and writing of the manuscript, with the assistance of the other authors. Stemkowski and Iyer performed most of the manuscript revisions.

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