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A new perspective on the value of minimally invasive colorectal surgery—payer, provider, and patient benefits

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Abstract
Background The clinical benefits of minimally invasive surgery (MIS) are proven, but overall financial benefits are not fully explored. Our goal was to evaluate the financial benefits of MIS from the payer's perspective to demonstrate the value of minimally invasive colorectal surgery.
Methods A Truven MarketScan® claim-based analysis identified all 2013 elective, inpatient colectomies. Cases were stratified into open or MIS approaches based on ICD-9 procedure codes; then costs were assessed using a similar distribution across diagnosis related groups (DRGs). Care episodes were compared for average allowed costs, complication, and readmission rates after adjusting costs for demographics, comorbidities, and geographic region.
Results A total of 4615 colectomies were included—2054 (44.5 %) open and 2561 (55.5 %) MIS. Total allowed episode costs were significantly lower MIS than open ($37,540 vs. $45,284, $p < 0.001$). During the inpatient stay, open cases had significantly greater ICU utilization (3.9 % open vs. 2.0 % MIS, $p < 0.001$), higher overall complications (52.8 % open vs. 32.3 % MIS, $p < 0.001$), higher colorectal-specific complications (32.5 % open vs. 17.9 % MIS, $p < 0.001$), longer LOS (6.39 open vs. 4.44 days MIS, $p < 0.001$), and higher index admission costs ($39,585 open vs. $33,183 MIS, $p < 0.001$). Post-discharge, open cases had significantly higher readmission rates/100 cases (11.54 vs. 8.28; $p = 0.0013$), higher average readmission costs ($3055 vs. $2,514; $p = 0.1858$), and greater 30-day healthcare costs than MIS ($5699 vs. $4357; $p = 0.0033$). The net episode cost of care was $7744/patient greater for an open colectomy, even with similar DRG distribution.
Conclusions In a commercially insured population, the risk-adjusted allowed costs for MIS colectomy episodes were significantly lower than open. The overall cost difference between MIS and open was almost $8000 per patient. This highlights an opportunity for health plans and employers to realize financial benefits by shifting from open to MIS for colectomy. With increasing bundled payment arrangements and accountable care sharing programs, the cost impact of shifting from open to MIS introduces an opportunity for cost savings.

Keywords Minimally invasive colorectal surgery · Open colorectal surgery · Healthcare outcomes · Financial benefits · Cost shifting

From the introduction of laparoscopic colorectal surgery, clinical benefits have been apparent [1–6]. The laparoscopic approach was initially more expensive, from the additional operative time, operating room costs, and consumable equipment costs [7, 8]. However, even early in the adoption of MIS, cost offsets related to reductions in length

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of stay (LOS), intensive care unit (ICU) utilization, postoperative complications, and less use of post-discharge nursing facilities were obvious [2, 3, 9]. With increasing experience, the intraoperative efficiency related to operative time and instrumentation improved significantly, resulting in similar or superior total costs with laparoscopic colectomy [9–15]. The combined societal benefits from the lower indirect costs and improved early quality of life were also recognized early in adoption of MIS [7, 16]. Despite these data, the impending transition to bundled payment schemes requires all stakeholders to ascertain the major drivers of clinical and economic efficiency for both MIS and open colectomy. A full assessment requires a risk-adjusted comparison of the short-term outcomes from the index hospitalization, including costs of readmissions, emergency department visits, professional costs from physician visits, and productivity [17].

With the rising costs of healthcare in the USA, there is a need to use all available tools to reduce spending. In 2014, healthcare spending grew 5.3 % from the prior year, to reach $3.0 trillion or $9523 per person, and 17.5 % of the nation's Gross Domestic Product [18]. While the drivers of healthcare cost growth are complex and multifactorial, there is an increasing emphasis on cost reductions and improving quality, including complications, readmissions, and resource use [19–22]. Federally proposed solutions, including bundled payments for inpatient surgery, which combine provider reimbursements into a single payment for the entire surgical episode [23], and merit-based incentive payments, which adjusts physician payment based on factors, include quality metrics and resource utilization [24, 25]. Rather than focusing on outcome issues like readmission, it may be advantageous to compare providers on the cost of care at the population level, allowing providers the opportunity to lower their process costs. This would allow patients and payers to identify clinically and economically efficient providers with greater confidence. Authors focused on the concepts of warranty cost and inefficiency of care have articulated this concept [13, 26]. Surgeons may be able to preempt these impending process changes and reduce their own costs and healthcare consumption by increasing use of MIS for colectomy. With current national utilization of laparoscopy estimated in only ~50 % of eligible cases, there is a great opportunity for expanding MIS and reducing overall costs [27].

The goal of the study was to evaluate the clinical and financial benefits of MIS from the payer's perspective to demonstrate the overall value of minimally invasive colorectal surgery. Our hypothesis was the reduction in complications and readmissions with MIS would result in an overall benefit to the entire healthcare system.

Methods and materials

We performed a retrospective claim data analysis using the 2012 and 2013 Truven Healthcare MarketScan commercial claim data. MarketScan contains the annual enrollment and paid claims generated by approximately 50 million commercially insured lives covered by the benefit plans of large employers, health plans, and governmental and public organizations nationwide. The study population was full-time employees or dependents of full-time employees, not in capitated and unknown plan types and with eligibility in all months of 2012, and at least 1 month in 2013, as well as pharmacy coverage during all months of eligibility. Patients were included if between 18 and 64 years of age with at least one 2013 claim for colectomy with discharge dates between January 1, 2013 and November 30, 2013. MIS and open colectomy cases were identified using International Classification of Diseases Ninth Edition (ICD-9) procedure codes in the primary position of the claim (Table 1). Cases were excluded if the colectomy was performed with robotic assistance, identified using ICD-9 add-on procedure codes 17.41–17.45 and 17.49 or Current Procedural Terminology/Healthcare Common Procedure Coding System (CPT) code S2900. To ensure, cases were most directly comparable, where either surgery type (open or MIS) could be an option, the following exclusions were also made:

1. Inpatient cases that are not coded with Diagnosis Related Group (DRG) codes 329, 330 or 331.
2. Metastatic cancer cases, which are typically not considered eligible to shift to MIS. These cases were identified based on the presence of metastatic ICD-9 diagnosis codes on the inpatient surgery colectomy claims of patients with colorectal cancer or any of these patients' claims in the 6 months prior to and 1 month after the colectomy surgery (Table 2).
3. Emergent inpatient colectomy cases as we assume that only a small portion of emergent open cases would be eligible for shifting to MIS. We classified claims as emergency (as opposed to elective) based on evidence of an emergency room visit associated with admission based on an ER professional claim on day of admission or day prior to admission.
4. Cases coded as both MIS and open on the index procedure claim (Table 1).

All claims associated with the inpatient colectomy stay and 30 days following discharge were evaluated. The claims were grouped into major service categories using ICD-9 procedure codes, CPT codes, revenue codes, place of service codes, and DRGs. Data fields evaluated include the incidence, demographics, length of stay, 30-day

Table 1 Codes used for colectomy identification

Purpose	Open	MIS
ICD-9 procedure codes for colectomy identification	45.71, 45.72, 45.73, 45.74, 45.75, 45.76, 45.79, 45.82, 45.83	17.31, 17.32, 17.33, 17.34, 17.35, 17.36, 17.39, 45.81
CPT codes to identify cases coded as both open and MIS	44,140, 44,141, 44,143, 44,144, 44,145, 44,146, 44,150, 44,151, 44,155, 44,156, 44,157, 44,158, 44,160, 45,113, 45,121	44,204, 44,205, 44,206, 44,207, 44,208, 44,210, 44,211, 44,212

ICD-9 procedure codes were required to be in the primary position of the claim

MIS minimally invasive surgery, *CPT* current procedural terminology, *ICD-9* international classification of diseases ninth edition

Table 2 Codes used for cancer identification

Purpose	ICD-9 diagnosis codes
Colorectal cancer identification	153.0, 153.1, 153.2, 153.3, 153.4, 153.5, 153.6, 153.7, 153.8, 153.9, 154.0, 154.1, 154.8, 209.10, 209.13, 209.14, 209.15, 209.16, 230.3, 235.2
Metastatic cancer identification	196.0, 196.1, 196.2, 196.3, 196.5, 196.6, 196.8, 196.9, 197.0, 197.1, 197.2, 197.3, 197.4, 197.5, 197.6, 197.7, 197.8, 198.0, 198.1, 198.2, 198.3, 198.4, 198.5, 198.6, 198.7, 198.81, 198.82, 198.89

ICD-9 procedure codes were required to be in the primary position of the claim

MIS minimally invasive surgery, *CPT* current procedural terminology, *ICD-9* international classification of diseases ninth edition

readmissions, service utilization, and average allowed cost for open and MIS colectomy. Incidence was defined as the frequency of colectomies, calculated as the number of members with colectomies divided by the total number of members in the study population. Complications during the inpatient colectomy episode were identified as by a complication ICD-9 code in any position of the claim.

Costs were defined as paid claims/reimbursement to the healthcare system, including all facility and professional payments incurred during the inpatient stay and within the 30 days after discharge. The 2013 commercial claim data were reviewed for the difference in payer costs between MIS and open colectomies. Readmissions and their cost contribution within 30 days of the colectomy discharge were considered. To adjust for readmission outlier costs, we capped each 30 day readmission allowed amount at $100,000. To compare the costs between open and MIS colectomies, adjustment was made for potential explanatory variables, including age, gender, comorbidities, presence of cancer, and US census region. To adjust for regional reimbursement differences when comparing the cost of open to MIS cases, a regional adjustment to the contribution of costs from each region was made. The adjustment was made for both the post-procedure 30 days and the procedure costs. The adjustment was based on each member's place of residence by ten major regions: Pacific, East South Central, West South Central, Mountain, New England, South Atlantic, West North Central, East North Central, Middle Atlantic, and Unidentified (2 % of cases were in this region). The MIS costs were adjusted to reflect the same contribution of cases per region. To adjust for differences in contribution of cancer cases when comparing the cost of open to MIS cases, the MIS cancer case contribution was adjusted to reflect the same contribution as the open cancer case contribution. We used a federally certified risk adjustment methodology developed by the US Department of Health and Human Services (HHS) to account for differences in age, gender, and comorbidity when comparing the cost of open and MIS colectomies. The methodology uses a hierarchical condition category (HCC) system to categorize diagnosis codes by severity for calculating "metal-level" risk scores (i.e., platinum, gold, silver, bronze, and catastrophic) [28]. The risk scores are intended to predict cost in the subsequent year. Using 2012 MarketScan data, we identified the HHS–HCC gold metal-level risk score for each individual using 12 months of claims data prior to the colectomy admission date. The gold metal level was chosen as it best reflects the average risk score for a commercially insured population. Using individual risk scores, we calculated the mean risk score for each colectomy.

Linear regression was used to model the relationship between post-procedure 30-day costs and the risk score for each colectomy. The ratio between the open and MIS post-procedure 30-day costs was calculated and then adjusted by multiplying this ratio by the existing MIS costs, including the adjustments for regional and cancer differences and readmission outliers.

As the study population was derived from a de-identified national database and did not involve human subjects, it

was exempt from our institution's Institutional Review Board approval.

Results

There were a total of 4615 elective colectomies identified that met the inclusion criteria in the 2013 index year, 2054 (44.5 %) open and 2561 (55.5 %) MIS. The open and MIS cohorts were well matched in gender with just over 50 % of both open and MIS cases performed on males ($p = 0.8653$). Before risk adjustment, the mean age (49.9 open vs. 50.6 MIS, $p = 0.0246$), mean HHS–HCC gold metal-level risk score ($p < 0.001$), proportion of patients with cancer (27.2 % open vs. 28.9 % MIS, $p = 0.0443$), and case distribution across the 10 geographic regions ($p < 0.001$) were statistically significantly different across the open and MIS cohorts. During the inpatient stay, the open group had a significantly higher rate of ICU utilization (3.9 % open vs. 2.0 % MIS, $p < 0.001$). The rates of overall complications per colectomy inpatient claim (52.8 % open vs. 32.3 % MIS, $p < 0.001$) and colorectal-specific complications per colectomy inpatient claim (32.5 % open vs. 17.9 % MIS, $p < 0.001$) were also significantly higher in the open colectomy group. The resulting LOS was significantly longer open compared to the MIS group (6.39 vs. 4.44 days, $p < 0.001$). Complete demographics and details from the inpatient episode are in Table 3. The colorectal-specific complications are in Table 4.

After adjusting for age, comorbidities, incidence of malignant cases, and geographic region, the average allowed facility and professional surgical procedure costs were significantly lower for MIS than open colectomies, even given the equal distribution of patients across DRG's using our adjustment of cases. The MIS cohort also had significantly lower total average costs for the inpatient stay ($33,183 MIS vs. $39,585 open, $p < 0.001$), including lower facility ($27,960 MIS vs. $33,945 open, $p < 0.001$) and professional ($5223 MIS vs. $5639 open, $p = 0.0012$) components for the episode of care. Post-discharge, open cases had significantly higher readmission rates (11.54 per 100 cases vs. 8.28 per 100 cases; $p = 0.0013$), higher average readmission costs ($3055 vs. $2514; $p = 0.1858$), and higher 30 day post-discharge costs than MIS ($5699, vs. 4357; $p = 0.0033$). Overall, the total allowed costs, including the inpatient episode and all associated costs for 30 days post-discharge, were significantly lower with MIS than open colectomy ($37,540 vs. $45,284, $p < 0.001$). The overall cost difference was $7744 per patient. Table 5 demonstrates full details for the allowed costs.

Discussion

With the current healthcare crisis, there is a need for ways to reduce healthcare costs and improve healthcare quality. Laparoscopic colorectal surgery has evolved to be cost-effective, from lower indirect costs during the surgical episode offsetting the direct costs [7, 11–14]. However, there may be additional financial benefits from the index hospitalization and post-discharge healthcare costs with minimally invasive colectomy. In this study, we sought to evaluate the clinical and financial benefits of MIS from the payer's perspective to demonstrate the overall value of minimally invasive colorectal surgery. We found the overall rate of MIS for colectomy in eligible cases was only 55 % nationwide, indicating that further clinical and economic efficiency may be possible by accessing providers who have more fully adopted MIS. After adjusting groups to ensure the open and MIS were comparable, there was a reduction in ICU utilization, complications, length of stay, and average total costs during the inpatient episode using minimally invasive colectomy. Post-discharge, MIS cases had lower readmission rates, lower readmission costs, and lower 30 day post-discharge costs. Overall, MIS was associated with lower total costs than open surgery, including payer costs in a commercially insured working age population.

This work is a novel addition to the current literature as no prior study has evaluated the potential cost savings from the payer's perspective across open and MIS cases that could feasibly be performed through a minimally invasive approach, including the allowable costs for the anchor and post-anchor periods. The data also support earlier assessments of MIS versus open colectomy suggesting a shift of more patients with both a lower frequency of complications, as well as a lower cost to manage those complications [29]. In our analysis, we found the anchor average cost difference between open and MIS was $6402–$5986 for facility fees and $416 for professional fees. The 30 day post-anchor average allowed cost difference was $1342, and total average allowed episode cost difference was $7744, all in favor of MIS. This overall cost difference of $7744 per patient could result in significant overall benefit to the healthcare system by increasing use of MIS for colectomy. While not evaluating the same endpoints, our findings concur with a recent study looking at health care utilization, including office, outpatient, emergency department visits, and inpatient services 90 and 365 days after the index colectomy procedure [17]. The authors reported a cost savings with laparoscopic colectomy for the inpatient episode of $7405 ($24,196 laparoscopic vs. $31,601 open) and 90 days post-discharge of $4096 ($4176 laparoscopic vs. $8272 open). With the growing emphasis on reducing

Table 3 Patient characteristics for colectomy types

	Open	MIS	*p* value
Cases	2054	2561	
Case distribution	44.5 %	55.5 %	
Incidence	0.012 %	0.015 %	
Age			
Mean	49.9	50.6	0.0246*
Median	52.0	52.0	
Range	18–64	18–64	
Distribution			
18–24	3.4 %	2.7 %	<0.001**
25–34	6.7 %	4.2 %	
35–44	14.8 %	14.6 %	
45–54	36.3 %	38.9 %	
55–64	38.9 %	39.6 %	
Average risk score	7.34	3.21	<0.001*
Gender distribution			
Male	50.6 %	50.8 %	0.8653**
Female	49.4 %	49.2 %	
Cases with an ICU stay	3.9 %	2.0 %	<0.001**
Average length of stay (days)	6.39	4.44	<0.001*
Total complications per inpatient claim	52.8 %	32.3 %	<0.001*
Colorectal-specific complications per inpatient claim	32.5 %	17.9 %	<0.001*
Regional distribution (census region)			
Pacific	12.3 %	13.8 %	<0.001**
East South Central	10.0 %	7.8 %	
West South Central	8.4 %	8.9 %	
Mountain	6.2 %	5.6 %	
New England	6.4 %	6.1 %	
South Atlantic	20.2 %	21.2 %	
West North Central	5.9 %	5.9 %	
East North Central	19.7 %	18.3 %	
Middle Atlantic	9.4 %	10.9 %	
Unidentified	1.4 %	1.5 %	
Cancer distribution			
Yes	27.2 %	28.9 %	0.0443**
No	72.8 %	71.1 %	

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* *T* test, ** χ test

Table 4 Colorectal-specific complications ICD-9 diagnosis and procedure codes

Code type	Code
ICD-9 diagnosis codes	998.59, 998.6, 557.0, 557.9, 560.1, 560.2, 560.81, 560.89, 560.9, 567.2, 567.21, 567.22, 567.23, 567.29, 567.31, 567.38, 567.39, 567.8, 567.81, 567.82, 567.89, 567.9, 568.81
ICD-9 procedure codes	44.5, 46.41, 46.93

healthcare costs, there is a compelling argument for increasing use of laparoscopy for colectomy even in the limited literature.

To reduce healthcare utilization, there is a drive toward quality improvement, as all parties suffer financial consequences from poor quality health care, with payers hit the

Table 5 Comparison of MIS and open average allowed costs. *Source*: Authors' analysis of 2012–2013 Truven MarketScan database using methodology described

	Open	MIS adjusted[c]	Difference	*p* value
Total average allowed episode costs[a]	$45,284	$37,540	$7744	<0.001
Anchor average cost	$39,585	$33,183	$6402	<0.001
Facility	$33,945	$27,960	$5986	<0.001
Professional	$5639	$5223	$416	0.0012
30 day post-anchor average allowed cost	$5699	$4357	$1342	0.0033
Readmissions per 100 anchor cases	11.54	8.28	3.26	0.0013
Readmission average allowed cost/case[b]	$3055	$2514	$542	0.1858

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[a] Total allowed episode cost includes all claims for the initiating "anchor" surgery case and the 30 days after anchor discharge

[b] Readmission average allowed cost/case reflects the cost of all readmissions spread across all cases—not the average cost of a readmission

[c] MIS average cost calculation for each cohort assumes the same regional and cancer contribution as open cases and MIS average cost reflects an adjustment for the difference in 2012 HHS–HCC gold risk score between open and MIS patients

hardest [30]. Colectomy is a prime target for quality improvement as the procedure accounts for a disproportionate share of the morbidity, mortality, and excess hospital days in surgery [31]. An important, direct relationship between complications, readmissions, costs, and episode payments in colorectal surgery has previously been demonstrated [13, 22, 32, 33]. In order to improve surgical quality, reductions in costs and improvement in these quality outcomes must occur [33]. In our study, we found significantly lower rates of complications-colectomy specific and overall, readmissions, and readmission costs with MIS compared to open colectomy. Subsequent total allowed costs were significantly lower with MIS than open colectomy. Based on this data, increasing utilization of minimally invasive colectomy is a clear tool for increasing quality and reducing costs. With impending penalties for readmissions and complications, implementing this surgeon-controlled quality improvement is increasingly important [34]. The implications of this work are to determine how to shift the remaining 45 % of colectomy patients from open to laparoscopic techniques, in order to realize the potential clinical and quality benefits.

The cost difference demonstrated here with MIS could also increase value to physicians and payers with the increasing use of bundled payments. Bundled payment—the reimbursement to providers on the basis of expected costs for an entire episode of care [35]—is a federally funded initiative mandated by the Affordable Care Act to transition Medicare away from fee-for-service payments and toward a single payment for a total episode of care [36]. Under bundled payment and shared saving arrangements, hospitals and physicians split any surplus, giving them a powerful incentive to improve quality, patient outcomes, and reduce utilization. Thus, using MIS, which results in lower total costs for payers, could lead to greater profit for physicians and hospitals under these alternative payment arrangements.

We recognize the limitations in this work. First, the data set only considered commercially insured patients aged 18–64, so Medicare patients, who may be greater consumers of health care, were not included. The MIS and open groups were different in terms of age, comorbidity, incidence of cancer, and geographic region. However, stringent risk adjustment was used to ensure groups were comparable, and exclusions were used to create two cohorts where MIS would be feasible. Coding errors could also be present in a large administrative data source. In this large sample size, we would not expect these to make a significant impact on our results or conclusions. Truven MarketScan does not contain full clinical details, lab results, or diagnostic information contained on medical records, so clinical outcomes cannot be fully evaluated. This limitation was managed by using claims data for complications and readmissions.

In conclusion, we found minimally invasive colectomy offered benefits for patients, payers, and providers. MIS had lower healthcare utilization in terms of ICU stays, facility, and professional fees. MIS also resulted in greater quality than open colectomy, with lower complications, lower readmissions, and shorter lengths of stay. In a commercially insured population, the risk-adjusted allowed costs for MIS colectomy episodes were significantly lower

than open-an overall cost difference of almost $8000 per patient. These data suggest that a system offering MIS preferentially shifts the cost structure across the spectrum of DRG's, resulting in a lower cost for both the index admission and a lower contribution of cost from readmission. This highlights an opportunity for health plans and employers to realize financial benefits by shifting from open to MIS for colectomy. It also offers an opportunity for surgeons to reduce their costs through process improvement with MIS, instead of relying on outcomes, which are not always in out control. With increasing bundled payment arrangements and accountable care sharing programs, the impact of shifting from open to MIS introduces an opportunity for cost savings and quality improvement.

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Compliance with ethical standards

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Appendix

See Table 6.

Table 6 Colorectal-specific and nonspecific complications ICD-9 diagnosis and procedure codes

Code type	Code
ICD-9 diagnosis codes	V58.2, E873.0, E934.7, E876.0, 998.51, 338.18, 338.28, 998.30, 998.31, 998.32, 998.33, 998.2, 998.11, 599.0, 590.10, 590.11, 415.11, 415.19, 453.40, 590.11, 590.2, 590.80, 590.81, 4270, 427.1, 427.2, 427.31, 427.32, 427.41, 427.42, 427.5, 427.60, 427.61, 427.69, 427.81, 427.89, 427.9, 997.1, 428.1, 428.21, 428.23, 428.31, 428.33, 428.41, 428.43, 514, 518.4, 434.91, 997.02, 4350, 453.41, 453.42, 453.8, 453.9, 997.2, 997.71, 997.72, 997.79, 518.81, 518.82, 518.84, 799.1, 481, 485, 486, 997.3, 584.5, 584.6, 584.7, 584.8, 584.9, 586, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 435.1, 435.2, 435.3, 435.8, 435.9, 437.1, 430, 431, 4320, 432.1, 432.9, 99,700, 997.01, 997.09, 997.4, 564.2, 564.3, 564.4, 998.59, 998.6, 557.0, 557.9, 560.1, 560.2, 560.81, 560.89, 560.9, 567.2, 567.21, 567.22, 567.23, 567.29, 567.31, 567.38, 567.39, 567.8, 567.81, 567.82, 567.89, 567.9, 568.81
ICD-9 procedure codes	99.02, 99.03, 99.04, 96.70, 96.71, 96.72, 44.5, 46.41, 46.93

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