The American Journal of Surgery 218 (2019) 899–906

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Disparities in elective surgery for diverticulitis: Identifying the gap in care

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ARTICLE INFO

Article history:
Received 7 February 2019
Received in revised form
28 February 2019
Accepted 2 March 2019

Keywords:
Colorectal surgery
Disparities
Minimally invasive surgery
Complications
Diverticulitis

ABSTRACT

Background: Minimally invasive surgery (MIS) in patients with diverticulitis is advantageous relative to open surgery. We aimed to determine disparities associated with MIS access for diverticulitis and post-operative complications.
Methods: The Florida Inpatient Discharge Dataset was retrospectively queried for patients with diverticulitis undergoing elective surgery between 2013 and 2015. Associations of patient, physician, and hospital characteristics with surgical approach (MIS vs open) and development of complications were calculated in two separate mixed effects logistic regression models.
Results: Of the 5857 patients in the analysis, older, sicker patients, residing in rural areas or with Medicaid insurance had decreased odds of receiving MIS. Being treated by high volume or colorectal surgeons increased the odds of MIS. Decreased complications were present with MIS, in younger, healthier patients, treated by high volume surgeons.
Conclusions: Disparities in Florida are present in patients undergoing elective diverticulitis surgery. MIS access and complications rates are not equal, and MIS is associated with significantly reduced odds of post-operative complications. Improved access to MIS-trained surgeons is a critical step towards improving surgical outcomes for Floridians.

Introduction

Diverticular disease of the colon is among the most common gastrointestinal disorders in Western countries. Upwards of 20% of patients with diverticulosis are at risk of developing diverticulitis in their life time.[1] Approximately 10–20% of patients require surgery for diverticulitis[2] with 15–20% requiring emergent intervention.[3]

Surgical techniques for gastrointestinal surgery have evolved; currently, 59% of colorectal procedures are performed using minimally invasive techniques (laparoscopic or robotic approach).[4] Minimally invasive surgery (MIS) has demonstrated multiple advantages over an open surgical approach.[5] Among them are a shorter length of stay, improved pain management, and lower infection rates.[6] The determinants whether a patient overgoes MIS for their diverticulitis are multiple including: subspecialty training of the surgeon, institution, patient insurance status, education, and area of residence.

The aim of this study was to determine which provider, hospital, and patient characteristics are associated with access to MIS for diverticulitis and how they correlate with potential post-operative complications.

Materials and methods

The Florida Inpatient Discharge Dataset (FIDD), CMS Cost Reports, and the CMS National Plan and Provider Enumeration System (NPPES) were utilized for this study. The FIDD dataset includes de-identified detailed patient data for all inpatient hospital discharges in the State of Florida including patient demographics, insurance,

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https://doi.org/10.1016/j.amjsurg.2019.03.001
0002-9610/

diagnosis, hospital characteristics, and treating physician identifiers.[7] The CMS Cost Reports include information regarding hospital characteristics, utilization data, as well as cost and charge centers.[8] For this work, hospital size and teaching status were collected from the Cost Report. The NPPES provides information regarding physician specialty which is linked to the national provider identifier (NPI). The FIDD and CMS Cost Reports were linked by Medicare provider identification number, and the resulting datasets were linked by NPI to define operating physician specialty. The FIDD dataset was retrospectively queried for all patients diagnosed with and surgically treated for diverticulitis between January 2013 and October 2015. Patients were selected using International Classification of Diseases-9 (ICD-9) codes identifying a diverticulitis diagnosis: 562.11, 562.13. Those patients who had an emergent or urgent admission identifier (n = 6804) were excluded as the process of care as well as the patient needs are likely to promote differences in the pattern of treatment. Furthermore, patients who had multiple procedure types or conversion from MIS to open surgery were excluded as the dataset does not enable identifying timing and physician characteristics to specific surgical procedures when more than one procedure is present. Additionally, operating physician specialties which did not include either general or colorectal surgery were excluded. Fig. 1 summarizes the inclusion and exclusion criteria adopted for this study. Due to the de-identified and publicly available nature of the dataset, this research was categorized as exempt by the Institutional Review Board.

Dependent variables

The dependent variables of interest for this study include MIS vs open surgical procedure as well as surgical complications. Surgical procedure classifications were defined by the ICD-9 codes and included total, partial and segmental colonic resections. If the surgery was accompanied by either a laparoscopic or robotic code indicator the surgery was classified as MIS (laparoscopic: 54.21, 45.80, 45.81, 17.31, 17.32, 17.33, 17.34, 17.35, 17.36, 17.39; robotic: 17.41, 17.42), otherwise it was classified as open (45.71, 45.72, 45.73, 45.74, 45.75, 45.76, 45.79, 45.94, 54.11, 54.19, 45.82, 45.83). Postoperative complications were identified using the Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software codes (CCS) complications of surgical procedures or medical care identified in category 238.[9] We only included those complications strictly associated with surgical complications related to the procedures of interest. Complications were then operationalized as a binary variable indicating the presence of a complication or no-complication.

Independent variables

The following patient specific variables were collected: year of surgery, gender, age, race (White, African American, and Hispanic or Latino), patient payer (Medicare, Medicare managed care, Medicaid, Commercial, Other), Urban vs Rural residence (based on the Florida Department of Health county classification,[10]), region of residence as defined by the Florida Department of Transportation (Northeast, Northwest, Central, West Central, Southeast, Southwest, South), Elixhauser score as comorbidity index including identification of obesity.[10,11] The Elixhauser score represents a comprehensive set of comorbidity measures that was developed for use with administrative inpatient databases[12]; in our analysis it was operationalized into four categories identifying the presence of 0, 1–2, 3–5 or more than 5 comorbidities. Obesity was excluded for the score, and was included as a co-variate due to its importance in choosing surgical technique.[13,14] Hospital characteristics included size and teaching status, while physician characteristics of interest

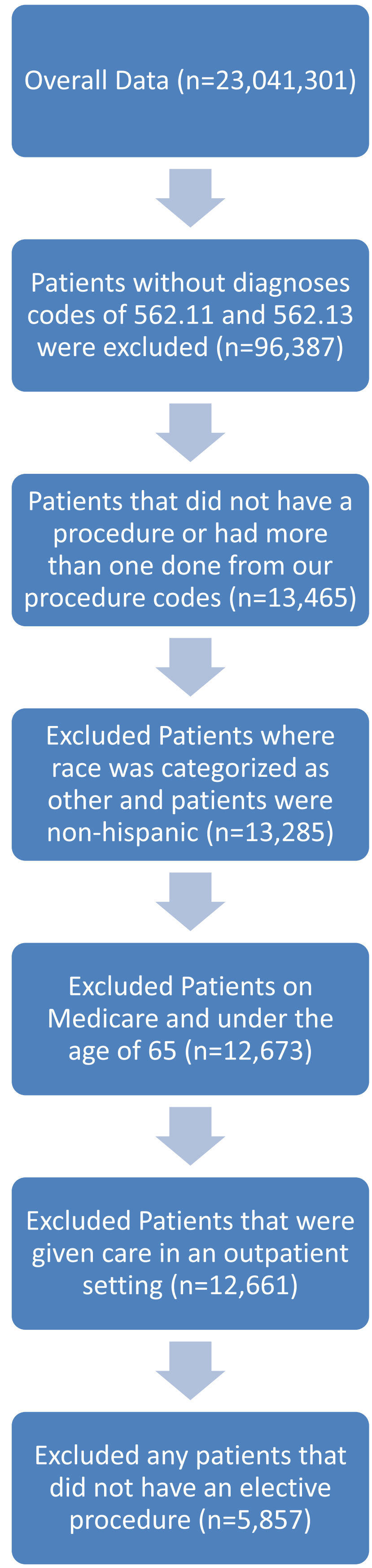

Fig. 1. Inclusion and exclusion criteria adopted for patient selection.

included physician volume and specialty type (general or colorectal surgeon). Hospital size was based upon the number of staffed beds at the hospital and was further categorized into small (less than 100 beds), medium (100–199), and large (greater than 200 beds). Teaching status was categorized by the presence of residency programs. If no residency program was present, the hospital was classified as non-teaching. Surgical volume was defined by the number of surgical cases matching the ICD-9 inclusion criteria for the study by each physician. Finally, the specialty of the physician was defined by the associated NPI for the operating physician. NPI specialty was indicated as colorectal surgeon if any of the specialty identifiers included colorectal surgery. Likewise, if no colorectal surgery identifier was present, any specialty indicating general surgery was utilized to define general surgeons.

Statistical analysis

The study population was described by means and percentages in relation to MIS and Open surgical procedure type, as well as with association to post-surgical complications. Continuous and categorical variables were assessed by Kruskal-Wallis and Pearson $\chi 2$ respectively. In order to best understand the association between patient, physician and hospital characteristics, a mixed effects model was utilized which accounts for nesting of patients by physician and physician by hospital. Two separate logistic regression models were utilized. The first utilized MIS vs Open approaches as the dependent variable, and the second utilized presence of complication. All tests of significance were 2-sided, and both parameter estimates (regression coefficients) as well as p-values were reported. The level of statistical significance was set at p-value < 0.05. Analyses were performed using SAS version 9.4 (SAS Institute Inc.).

Results

A total of 5857 patients treated at 182 hospitals were included in the analysis after the application of the inclusion and exclusion criteria. The overall patient and hospital characteristics are summarized in Table 1 for MIS vs open surgical procedures and Table 2 for complications. Median age was 61 years, 58.1% of patients were female and 41.9% were male. The distribution of race was 76.5% White, 3.8% African American and 19.7% Hispanic or Latino. Patient payer was largely represented by Commercial insurance (52.4%) and Medicare (24.9%). The majority of patients had an Elixhauser score between 0 and 2 (79.3%) and the overall median length of stay (LOS) was 5.0 days. Hospital size tended to be large (80.9%), while the distribution of teaching and non-teaching hospitals was similar, 50.3% vs 49.7%, respectively. When looking at the providers' specialty, 69.4% were general surgeons and 30.6% completed advanced training in colorectal surgery.

The results of the multivariate models for MIS and complications are summarized in Tables 3 and 4, respectively. Regarding MIS, patients who were older (OR 0.815, 95% CI 0.736–0.901, p < 0.001), resided in rural areas (OR 0.631, 95% CI 0.413–0.963, p = 0.033), had insurance coverage by Medicaid compared to Commercial insurance (OR 0.620, 95% CI 0.413–0.930, p = 0.021) and who had an Elixhauser score >2 compared to 0 (3–5: OR 0.535, 95% CI 0.421–0.681, p<0.001 and >5: OR 0.266, 95% CI 0.147–0.481, p < 0.001), had decreased odds of receiving MIS. Conversely, as the number of colorectal procedures for diverticulitis performed by a surgeon increases (OR 1.067, 95% CI 1.011–1.127, p = 0.018) the odds of receiving MIS increases as well; likewise, being treated by a surgeon that has completed colorectal training (OR 1.476, 95% CI 1.022–2.132, p = 0.038) increases the odds of MIS being used. Among the different regions of Florida compared with Northeast Florida, only South Florida (OR 3.033, 95% CI 1.331–6.910, p = 0.008) had a significantly different odds of receiving MIS. Finally, women (OR 1.188, 95% CI 1.013–1.393, p = 0.034) had increased odds of being treated with MIS. Obesity, instead, was neither significantly associated with receiving MIS nor developing post-operative complications.

The second multivariate model was related to presence of post-surgical complications. There was a decrease in the odds of a complication over time (2013 vs. 2014: OR 0.787, 95% CI 0.642–0.965, p = 0.021; and 2013 vs. 2015: OR 0.696, 95% CI 0.556–0.871, p < 0.001). Treatment by a surgeon with a greater surgical volume (OR 0.930, 95% CI 0.895–0.966, p = 0.002) or receiving MIS (OR 0.616, 95%CI 0.509–0.746, p < 0.001) also were associated with reduced odds of developing a complication. A 10-year increase in the patient's age (OR 1.168, 95% CI 1.036–1.316, p = 0.011) or an Elixhauser score >0 compared to 0 (1–2: OR 1.486, 95% CI 1.173–1.881, p = 0.001, 3–5: OR 2.775, 95% CI 2.105–3.659, p<0.001, >5: OR 5.298, 95% CI 3.118–9.003, p < 0.001) were both associated with greater odds of developing complications.

Discussion

Minimally invasive surgery is a preferred approach for diverticulitis requiring elective surgery, as it is associated with better post-operative outcomes when compared to open surgery.[3,6,15,16] This retrospective Florida state-wide analysis aimed to evaluate factors associated with receiving MIS for diverticulitis, and factors associated with post-surgical complications. This study demonstrated two principal findings. First, as expected, MIS is associated with decreased odds of developing a post-operative complication. Second, there are specific patient characteristics placing them at risk of having decreased access to MIS.

Age and comorbidities are relevant characteristics for patients undergoing surgery. The results of this study demonstrate that older patients are less likely to receive MIS for diverticulitis and are at greater risk of developing post-operative complications. In addition, a higher comorbidity score was also associated with reduced odds of receiving MIS and increased odds of having a complication. These findings are consistent with the known literature.[17,18] However, obesity was neither associated with receiving MIS nor with higher complication rate. Multiple studies have described that the elective laparoscopic approach is safe for morbidly obese patients.[13,19–21] Hotouras et al.[22] in particular presented a systematic review on the impact of obesity and BMI on post-operative outcomes of elective laparoscopic colorectal procedures; they confirmed that laparoscopic approach is overall feasible in obese patients, although different results may be achieved based on the hospital volume. Obesity, in this study like in most administrative databases,[23] is likely to have been under-coded, so the actual obese population might be larger than reported.

Along with patient-specific variables, geographical setting may affect outcomes on different levels. In our study, patients living in rural areas are less likely to receive MIS. This finding may be due to several factors. First, advanced high volume centers are not common in rural areas, and the availability of minimally invasive, and in particular robotic, equipment may be limited. Additionally, high volume minimally invasive surgeons are likely concentrated in the metropolitan or urban setting, making the ratio of open surgeries higher in rural hospitals.[24] Nevertheless, this does not mean that patients residing in rural areas should move to urban center to receive treatment; on the contrary, more tailored training programs and extended resources allocation should be planned to overcome those barriers that may affect the framework in which rural surgeons operate.[25–27] Conversely, South Florida is associated with

Table 1
Descriptive statistics by surgery type.

	MIS (N = 3668)	Open (N = 2189)	Total (N = 5857)	p value
Gender				0.430[1]
Female	2118 (62.2%)	1287 (37.8%)	3405 (58.1%)	
Male	1550 (63.2%)	902 (36.8%)	2452 (41.9%)	
Age				<0.001[2]
N	3668	2189	5857	
Mean (SD)	59.1 (12.6)	63.0 (12.8)	60.6 (12.8)	
Median	60.0	65.0	61.0	
Q1, Q3	51.0, 68.0	54.0, 72.0	52.0, 70.0	
Range	(22.0–93.0)	(23.0–99.0)	(22.0–99.0)	
Race				<0.001[1]
Missing	78	39	117	
White	2590 (59.0%)	1801 (41.0%)	4391 (76.5%)	
Black or African American	129 (58.6%)	91 (41.4%)	220 (3.8%)	
Hispanic or Latino	871 (77.1%)	258 (22.9%)	1129 (19.7%)	
Elixhauser Score				<0.001[1]
0	1266 (69.0%)	570 (31.0%)	1836 (31.3%)	
1-2	1813 (64.5%)	996 (35.5%)	2809 (48.0%)	
3-5	556 (50.4%)	548 (49.6%)	1104 (18.8%)	
More than 5	33 (30.6%)	75 (69.4%)	108 (1.8%)	
Length of Stay (Days)				<0.001[2]
N	3668	2189	5857	
Mean (SD)	4.6 (2.9)	7.4 (9.4)	5.6 (6.3)	
Median	4.0	6.0	5.0	
Q1, Q3	3.0, 5.0	4.0, 8.0	3.0, 6.0	
Range	(1.0–50.0)	(1.0–354.0)	(1.0–354.0)	
Year				0.038[1]
2013	1301 (61.0%)	831 (39.0%)	2132 (36.4%)	
2014	1311 (62.4%)	791 (37.6%)	2102 (35.9%)	
2015	1056 (65.1%)	567 (34.9%)	1623 (27.7%)	
Patient Payer				<0.001[1]
Medicare	790 (54.1%)	670 (45.9%)	1460 (24.9%)	
Medicare Managed Care	495 (57.0%)	373 (43.0%)	868 (14.8%)	
Medicaid	126 (57.5%)	93 (42.5%)	219 (3.7%)	
Commercial	2112 (68.8%)	958 (31.2%)	3070 (52.4%)	
Other	145 (60.4%)	95 (39.6%)	240 (4.1%)	
Patient County				0.065[1]
Missing	72	51	123	
Rural	143 (57.2%)	107 (42.8%)	250 (4.4%)	
Urban	3453 (63.0%)	2031 (37.0%)	5484 (95.6%)	
Obesity				0.113[1]
No	3165 (63.0%)	1856 (37.0%)	5021 (85.7%)	
Yes	503 (60.2%)	333 (39.8%)	836 (14.3%)	
Patient Region				<0.001[1]
Missing	72	51	123	
Southwest Florida	482 (54.3%)	405 (45.7%)	887 (15.5%)	
Northeast Florida	365 (61.0%)	233 (39.0%)	598 (10.4%)	
Northwest Florida	188 (45.9%)	222 (54.1%)	410 (7.2%)	
Southeast Florida	675 (62.4%)	407 (37.6%)	1082 (18.9%)	
Central Florida	517 (59.2%)	356 (40.8%)	873 (15.2%)	
South Florida	829 (83.1%)	169 (16.9%)	998 (17.4%)	
West Central Florida	540 (60.9%)	346 (39.1%)	886 (15.5%)	
Hospital Size				<0.001[1]
Small	209 (60.6%)	136 (39.4%)	345 (5.9%)	
Medium	407 (52.4%)	369 (47.6%)	776 (13.2%)	
Large	3052 (64.4%)	1684 (35.6%)	4736 (80.9%)	
Teaching Hospital				<0.001[1]
Missing	91	53	144	
No	1679 (59.1%)	1160 (40.9%)	2839 (49.7%)	
Yes	1898 (66.0%)	976 (34.0%)	2874 (50.3%)	
Surgeon Volume				<0.001[2]

Table 1 (*continued*)

	MIS (N = 3668)	Open (N = 2189)	Total (N = 5857)	p value
N	3668	2189	5857	
Mean (SD)	48.2 (58.6)	26.8 (29.2)	40.2 (50.8)	
Median	29.0	21.0	25.0	
Q1, Q3	16.0, 49.0	12.0, 34.0	14.0, 42.0	
Range	(1.0–251.0)	(1.0–251.0)	(1.0–251.0)	
Surgeon Subspecialty				<0.001[1]
Missing	394	400	794	
General	2109 (60.0%)	1407 (40.0%)	3516 (69.4%)	
Colorectal	1165 (75.3%)	382 (24.7%)	1547 (30.6%)	
Facility Region				<0.001[1]
Southwest Florida	465 (53.7%)	401 (46.3%)	866 (14.8%)	
Northeast Florida	402 (61.1%)	256 (38.9%)	658 (11.2%)	
Northwest Florida	200 (46.6%)	229 (53.4%)	429 (7.3%)	
Southeast Florida	710 (61.5%)	444 (38.5%)	1154 (19.7%)	
Central Florida	513 (59.4%)	351 (40.6%)	864 (14.8%)	
South Florida	825 (84.2%)	155 (15.8%)	980 (16.7%)	
West Central Florida	553 (61.0%)	353 (39.0%)	906 (15.5%)	
Complications				<0.001[1]
No	3293 (65.3%)	1751 (34.7%)	5044 (86.1%)	
Yes	375 (46.1%)	438 (53.9%)	813 (13.9%)	

Comparison Tests: [1]Chi-Square, [2]Kruskal Wallis.

higher use of MIS. We propose that this aspect is related to the higher per-capita income of the region and distribution of highly advanced medical and surgical centers.[28] Literature reported that patient with higher income have greater chance of undergoing MIS for their condition.[29] This may be explained by their easier access to facilities in which MIS is performed more routinely and to diagnostic or screening procedures that allow early and potentially less invasive treatment.

Race and ethnicity have also often been reported as important factors for healthcare disparities.[30,31] However, our analysis did not show any difference in regard to race for either the MIS or complication models. This finding is discordant with the literature, where Lassiter et al.[32] reported that African Americans are less likely to receive laparoscopic colon resection for diverticulitis and are at higher risk of morbidity and mortality. A possible explanation for this difference lies in the studied population. Lassiter's group analyzed patients on a national level, while our dataset includes only patients treated in Florida. Since the distribution of races and ethnicities is not homogeneous in the United States,[33] looking at a subnational level might highlight discrepancies that would be critical to investigate in order to more efficiently reduce healthcare disparities. An interesting finding in our analysis is the proportion of African American patients; although African Americans represent almost 15% of Florida population,[34] only 3.8% of all the patients undergoing elective surgery for diverticulitis in our data set are African American, while they represent 5.78% of the population being treated in an urgent/emergent setting.

In addition to race and ethnicity, other socioeconomic factors, such as insurance status or income, are often associated with barriers to accessing care[30,32,35] especially surgery. We found that Medicaid patients were less likely to undergo MIS for diverticulitis. These findings are particularly relevant since we included only elective procedures. Previous studies have indicated that Medicaid or uninsured statuses were reported to be associated with delayed presentation at hospital and therefore increased emergent admission status, higher complication rate and mortality.[35,36]

Surgeon volume was found to be significant in both multivariate models. Consistent with previous studies,[2,37] a higher surgical volume correlates with increased use of MIS approach and less post-operative complications. A positive association was also observed between surgeons who received colorectal training and the use of MIS, but there was no difference when looking at complications.

Finally, our analysis reported that patients treated with a minimally invasive approach have almost a 40% reduction in the odds of incurring post-operative complications. MIS has been reported safe and feasible, and represents the optimal approach for multiple conditions that require surgery[5,38,39]; when compared to open. MIS is associated with shorter LOS, earlier return to normal function, improved pain management, lower infection rate, blood loss and overall complication rate.[6,40] Such outcomes, especially the significant reduction in complications, highlight the importance of increasing patient access to MIS-trained surgeons.

Limitations of this study include those involved in retrospective analyses, and that our state level database may have limited generalizability to a national level; however, our intention was to look at the state of Florida specifically. While we limit our analysis to elective surgery we are unable to more specifically address patient readmission, recurrence, or pain levels which may more directly indicate the need or timing of surgery. As such, we are limited to categorizing patient admissions as elective or urgent/emergent. Additionally, collected data did not allow for risk adjustment of complications for disease severity in the multivariate model. The exclusion of urgent/emergent procedures, as well as the inclusion of the Elixhauser comorbidity scale partially balanced this limitation; however, it could represent a confounder as a more severe condition may require a more extended procedure and therefore a higher risk of complications. Ultimately, there is a likelihood that obesity is under-reported in this dataset based upon the limited number of patients identified as obese in our descriptive statistics. As a result, our analysis may be biased toward the null on any association with obesity. Despite these limitations, we believe this study reports a valuable, state-specific analysis of patient and hospital characteristics associated with access to MIS and likelihood of post-operative complications for patients undergoing elective surgery for diverticulitis.

In conclusion, disparities in the Florida healthcare system are present for patients undergoing elective surgery for diverticulitis.

Table 2
Descriptive statistics by complications.

	No (N = 5044)	Yes (N = 813)	Total (N = 5857)	p value
Gender				0.840[1]
Female	2935 (86.2%)	470 (13.8%)	3405 (58.1%)	
Male	2109 (86.0%)	343 (14.0%)	2452 (41.9%)	
Age				<0.001[2]
N	5044	813	5857	
Mean (SD)	60.1 (12.7)	63.4 (12.7)	60.6 (12.8)	
Median	61.0	65.0	61.0	
Q1, Q3	51.0, 70.0	55.0, 73.0	52.0, 70.0	
Range	(22.0–99.0)	(24.0–93.0)	(22.0–99.0)	
Race				0.001[1]
Missing	101	16	117	
White	3754 (85.5%)	637 (14.5%)	4391 (76.5%)	
Black or African American	181 (82.3%)	39 (17.7%)	220 (3.8%)	
Hispanic or Latino	1008 (89.3%)	121 (10.7%)	1129 (19.7%)	
Elixhauser Score				<0.001[1]
0	1688 (91.9%)	148 (8.1%)	1836 (31.3%)	
1-2	2438 (86.8%)	371 (13.2%)	2809 (48.0%)	
3-5	849 (76.9%)	255 (23.1%)	1104 (18.8%)	
More than 5	69 (63.9%)	39 (36.1%)	108 (1.8%)	
Length of Stay (Days)				<0.001[2]
N	5044	813	5857	
Mean (SD)	5.0 (5.7)	9.8 (8.4)	5.6 (6.3)	
Median	4.0	8.0	5.0	
Q1, Q3	3.0, 6.0	5.0, 11.0	3.0, 6.0	
Range	(1.0–354.0)	(1.0–105.0)	(1.0–354.0)	
Year				0.002[1]
2013	1787 (83.8%)	345 (16.2%)	2132 (36.4%)	
2014	1822 (86.7%)	280 (13.3%)	2102 (35.9%)	
2015	1435 (88.4%)	188 (11.6%)	1623 (27.7%)	
Patient Payer				<0.001[1]
Medicare	1209 (82.8%)	251 (17.2%)	1460 (24.9%)	
Medicare Managed Care	728 (83.9%)	140 (16.1%)	868 (14.8%)	
Medicaid	191 (87.2%)	28 (12.8%)	219 (3.7%)	
Commercial	2711 (88.3%)	359 (11.7%)	3070 (52.4%)	
Other	205 (85.4%)	35 (14.6%)	240 (4.1%)	
Patient County				0.167[1]
Missing	104	19	123	
Rural	208 (83.2%)	42 (16.8%)	250 (4.4%)	
Urban	4732 (86.3%)	752 (13.7%)	5484 (95.6%)	
Obesity				0.007[1]
No	4349 (86.6%)	672 (13.4%)	5021 (85.7%)	
Yes	695 (83.1%)	141 (16.9%)	836 (14.3%)	
Patient Region				<0.001[1]
Missing	104	19	123	
Southwest Florida	761 (85.8%)	126 (14.2%)	887 (15.5%)	
Northeast Florida	508 (84.9%)	90 (15.1%)	598 (10.4%)	
Northwest Florida	362 (88.3%)	48 (11.7%)	410 (7.2%)	
Southeast Florida	898 (83.0%)	184 (17.0%)	1082 (18.9%)	
Central Florida	763 (87.4%)	110 (12.6%)	873 (15.2%)	
South Florida	914 (91.6%)	84 (8.4%)	998 (17.4%)	
West Central Florida	734 (82.8%)	152 (17.2%)	886 (15.5%)	
Hospital Size				0.142[1]
Small	301 (87.2%)	44 (12.8%)	345 (5.9%)	
Medium	651 (83.9%)	125 (16.1%)	776 (13.2%)	
Large	4092 (86.4%)	644 (13.6%)	4736 (80.9%)	
Teaching Hospital				0.906[1]
Missing	129	15	144	
No	2444 (86.1%)	395 (13.9%)	2839 (49.7%)	
Yes	2471 (86.0%)	403 (14.0%)	2874 (50.3%)	
Surgeon Volume				<0.001[2]

Table 2 (*continued*)

	No (N = 5044)	Yes (N = 813)	Total (N = 5857)	p value
N	5044	813	5857	
Mean (SD)	42.0 (52.9)	29.2 (33.0)	40.2 (50.8)	
Median	26.0	21.0	25.0	
Q1, Q3	15.0, 43.0	12.0, 37.0	14.0, 42.0	
Range	(1.0–251.0)	(1.0–251.0)	(1.0–251.0)	
Surgeon Subspecialty				0.052[1]
Missing	671	123	794	
General	3015 (85.8%)	501 (14.2%)	3516 (69.4%)	
Colorectal	1358 (87.8%)	189 (12.2%)	1547 (30.6%)	
Facility Region				<0.001[1]
Southwest Florida	747 (86.3%)	119 (13.7%)	866 (14.8%)	
Northeast Florida	565 (85.9%)	93 (14.1%)	658 (11.2%)	
Northwest Florida	376 (87.6%)	53 (12.4%)	429 (7.3%)	
Southeast Florida	956 (82.8%)	198 (17.2%)	1154 (19.7%)	
Central Florida	754 (87.3%)	110 (12.7%)	864 (14.8%)	
South Florida	900 (91.8%)	80 (8.2%)	980 (16.7%)	
West Central Florida	746 (82.3%)	160 (17.7%)	906 (15.5%)	
MIS vs Open				<0.001[1]
Open	1751 (80.0%)	438 (20.0%)	2189 (37.4%)	
MIS	3293 (89.8%)	375 (10.2%)	3668 (62.6%)	

Comparison Tests: [1]Chi-Square, [2]Kruskal Wallis.

Access to MIS and the rates of complications are not equal among the studied population and these two variables are inversely related. This study also underscores the need to increase access to MIS-trained surgeons. Additionally, living in a rural area, not having access to colorectal surgeons, and being uninsured or covered by Medicaid put patients at higher risk of receiving suboptimal treatment for their diverticulitis.

More research aiming to address healthcare disparities at multiple population levels would allow a better understanding of these aspects and lead to more tailored responses such as improved patient referral systems or insurance policy change.

Disclosure

The authors declare that there is no conflict of interest.

Funding

This work was supported by the Robert D. and Patricia E. Kern Center for Science of Health Care Delivery. The funder had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. The authors have no other financial relationships.

Table 3
Multivariate MIS nested mixed effects model.

Variable	OR	LCL	UCL	Pr > |t|
2014	0.966	0.807	1.156	0.707
2015	1.114	0.916	1.355	0.278
Rural	0.631	0.413	0.963	0.033
Medicaid	0.620	0.413	0.930	0.021
Medicare	1.078	0.826	1.405	0.581
Medicare Managed Care	0.849	0.636	1.134	0.268
Other	0.821	0.558	1.209	0.318
Female	1.188	1.013	1.393	0.034
Elixhauser score 1-2	0.887	0.737	1.067	0.203
Elixhauser score 3-5	0.535	0.421	0.681	<.001
Elixhauser score >5	0.266	0.147	0.481	<.001
Obese	0.839	0.670	1.050	0.124
Black or African American	0.826	0.559	1.221	0.338
Hispanic or Latino	1.111	0.837	1.476	0.466
Central Florida	0.857	0.435	1.689	0.657
Northwest Florida	0.750	0.342	1.643	0.472
South Florida	3.033	1.331	6.910	0.008
Southeast Florida	1.297	0.673	2.499	0.437
Southwest Florida	0.692	0.342	1.398	0.305
West Central Florida	1.105	0.563	2.168	0.771
Teaching Hospital	1.090	0.713	1.666	0.692
Age (10 year increase)	0.815	0.736	0.901	<.001
Large Hospital Size	0.666	0.304	1.457	0.309
Medium Hospital Size	0.611	0.267	1.397	0.243
Surgeon Volume	1.067	1.011	1.127	0.018
Colorectal Surgeon	1.476	1.022	2.132	0.038

Table 4
Multivariate complications nested mixed effects model.

Variable	OR	LCL	UCL	Pr > |t|
2014	0.787	0.642	0.965	0.021
2015	0.696	0.556	0.871	0.002
Rural	1.495	0.969	2.307	0.069
Medicaid	0.978	0.602	1.588	0.927
Medicare	0.827	0.609	1.123	0.224
Medicare Managed Care	0.805	0.576	1.125	0.204
Other	0.845	0.526	1.358	0.487
Female	0.880	0.732	1.059	0.177
Elixhauser score 1-2	1.486	1.173	1.881	0.001
Elixhauser score 3-5	2.775	2.105	3.659	<.001
Elixhauser score >5	5.298	3.118	9.003	<.001
Obese	1.163	0.908	1.488	0.232
Black or African American	1.254	0.819	1.921	0.297
Hispanic or Latino	1.048	0.765	1.434	0.771
Central Florida	0.982	0.650	1.481	0.929
Northwest Florida	0.732	0.447	1.199	0.215
South Florida	0.971	0.580	1.625	0.910
Southeast Florida	1.276	0.871	1.870	0.211
Southwest Florida	0.862	0.568	1.308	0.486
West Central Florida	1.168	0.782	1.745	0.448
Teaching Hospital	0.845	0.661	1.081	0.180
Age (10 year increase)	1.168	1.036	1.316	0.011
Large Hospital Size	1.120	0.644	1.949	0.687
Medium Hospital Size	1.143	0.632	2.064	0.659
Surgeon Volume	0.930	0.895	0.966	<.001
Colorectal Surgeon	1.107	0.853	1.437	0.445
MIS	0.616	0.509	0.746	<.001

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.03.001.

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