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Disparities in minimally invasive surgery for colorectal cancer in Florida

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ABSTRACT

Background: The cost of minimally invasive surgery (MIS) raises potential for racial and social disparities. The aim of this study was to identify the racial, socioeconomic and geographic disparities associated with MIS for colorectal cancer (CRC) in Florida.

Methods: Using the Florida Inpatient Discharge Dataset, we examined the clinical data of patients who underwent elective resections for CRC during 2013–2015. Multivariable analysis was performed to identify differences in gender, age, race, urbanization, region, insurance and clinical characteristics associated with the surgical approach.

Results: Of the 10,224 patients identified, 5308 (52%) had open surgery and 4916 (48%) had MIS. Females ($p = 0.012$), Medicare-insured patients ($p = 0.001$) and residents of South Florida were more likely to undergo MIS. Patients with Medicaid ($p = 0.008$), metastasis ($p < 0.001$) or 3–5 comorbidities ($p = 0.004$) had reduced likelihood of MIS. Hispanic patients in Southwest Florida had reduced likelihood of receiving MIS than whites ($p < 0.017$). Patients who underwent MIS had significantly reduced LOS ($p < 0.001$).

Conclusions: Consistent with national studies, MIS for CRC in Florida is associated with insurance status and geographic location. There are patient-level regional differences for racial disparities in MIS for CRC in Florida.

Introduction

Since its introduction three decades ago, minimally invasive surgery (MIS) has become the preferred approach for many abdominal surgical procedures.[1–3] The benefits of reduced postoperative pain, early return of bowel function, shorter hospital stay and reduced postoperative mortality support the increasing use of minimally invasive techniques for abdominal surgeries.[4–9] In addition, previous research suggests that both laparoscopic and robotic approaches are associated with decreased composite morbidity and complications compared to the open approach.[5,7] There is also some evidence that the adoption of robotics could consolidate the benefits of laparoscopic surgery, while eliminating some of its disadvantages such as surgeon's hand tremors, limited wrist movement and conversion rates to open surgery.[7,9,10] However, the cost and technical expertise associated with minimally invasive platforms[10–12] raise the potential for patient disparities in the utilization of these innovative techniques.

Although multiple studies have shown racial and social disparities in the use of MIS for colorectal cancer surgery, a significant portion of these studies utilized national datasets, which often do not account for differences that may exist at the state level.[13–16] The regionalization of healthcare delivery in the United States, both on a policy level and on the patient level, warrants state level investigations to corroborate national findings or identify additional gaps for legislative interventions at the state level. Florida is the 4th most populous state in the United States, with a population of more than 18.8 million.[17] The tremendous geographical, economic, and ethnical diversity of the state positions it as an excellent model for

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investigating potential disparities in patient care.[17] Moreover, socioeconomic and racial disparities have been documented for colorectal cancer care such as screening and deaths in Florida.[18–20]

The purpose of this study was to determine whether the receipt of MIS for colorectal cancer in Florida varies by patient race, socioeconomic status and geographic location within the state. Our hypothesis was that MIS is more likely to be associated with commercial insurance, white race and urban locations of Florida but with additional potential differences in comparison to nationally reported data.

Material & methods

Data source

This analysis utilized the 2013–2015 Florida Inpatient Discharge Dataset. De-identified patient level data from all acute care hospitals within the state of Florida, as well as information regarding cancer diagnosis, metastatic spread, treatment, patient demographics, hospital and physician identifiers are available within the dataset.[21] The Institutional Review Board categorized the research as exempt due to the publicly available nature of the dataset, as well as its lack of protected health information.

Population and variables

All patients diagnosed with colorectal cancer and who received a related colorectal surgery (See Box 1 for the associated ICD-9 codes) were included in the study. Exclusions included patients that were identified as emergent or urgent cases (n = 6936) as these populations and circumstances provide significant differences in the treatment. Also excluded were patients who underwent multiple segmental colectomy (n = 42) and pull-through resection (n = 73) based upon small samples. In addition, patients who had more than one procedure type and conversions from laparoscopy or robotic surgery to open surgery were also excluded (n = 757).

Dependent variable

The dependent variable for this analysis was whether the surgical procedures the patient received were classified as open or MIS which included laparoscopic and robotic surgeries. Diagnoses and surgical procedures were defined by ICD-9 Codes (See Box 1). The surgery was classified as MIS if a laparoscopic code or robotic surgery indicator was present. If neither indicator was present, it was classified as an open surgery.

Independent variables

Patient level characteristics including sex, age, race/ethnicity, location including region and rurality, payer type and comorbidities were included as co-variates. Race and ethnicity were categorized as White, Black or African American, and Hispanic or Latino. Payer type was categorized as Medicare, Medicare Managed Care, Medicaid (including Medicaid Managed Care Patient), commercial or other which includes self-pay or non-payment. Patient's regional locations were based upon the seven regions of the Florida Department of Transportation and indications of rurality were defined by the Florida Department of Health.[22] The Elixhauser Score identifies patient comorbidities. The score was divided into four categories indicating the presence of 0, 1–2, 3–5 or greater than 5 comorbidities; however obesity and metastatic cancer were excluded from the score and included separately due to their importance.[23,24] Additional covariates included in the mixed effects

Box 1
Details of Diagnostic Codes and Procedural Codes Retrieved from the Florida Inpatient Discharge Dataset 2013–2015 (International Classification of Diseases, 9th Revision)

Primary diagnoses

153.0 Malignant neoplasm of hepatic flexure.

153.1 Malignant neoplasm of transverse colon.

153.2 Malignant neoplasm of descending colon.

153.3 Malignant neoplasm of sigmoid colon.

153.4 Malignant neoplasm of cecum.

153.5 Malignant neoplasm of appendix vermiformis.

153.6 Malignant neoplasm of ascending colon.

153.7 Malignant neoplasm of splenic flexure.

153.8 Malignant neoplasm of other specified sites of large intestine.

153.9 Malignant neoplasm of colon unspecified site.

154.0 Malignant neoplasm of rectosigmoid junction.

154.1 Malignant neoplasm of rectum.

Minimally invasive procedures

17.32 Laparoscopic Cecectomy.

17.33 Laparoscopic right hemicolectomy.

17.34 Laparoscopic resection of transverse colon.

17.35 Laparoscopic Left Hemicolectomy.

17.36 Laparoscopic sigmoidectomy.

45.81 Laparoscopic Total Intra-Abdominal Colectomy.

48.42 Laparoscopic Pull-Through Resection of Rectum.

48.51 Laparoscopic Abdominoperineal Resection of the Rectum.

17.41 Open Robotic Assisted Procedure.

17.42 Laparoscopic Robotic Assisted Procedure.

Open procedures

45.71 Open and Other Multiple Segmental Resection of Large Intestine.

45.72 Open and Other Cecectomy.

45.73 Open and Other Right Hemicolectomy.

45.74 Open and Other Resection of Transverse Colon.

45.75 Open and Other Left Hemicolectomy.

45.76 Open and Other Sigmoidectomy.

45.82 Open Total Intra-Abdominal Colectomy.

48.43 Open Pull-Through Resection of Rectum.

48.52 Open Abdominoperineal Resection of the Rectum.

48.63 Other Anterior Resection of Rectum.

Table 1
Baseline demographic and clinical characteristics by surgical approach.

Characteristics	MIS (N = 4916)	Open (N = 5308)	Total (N = 10224)	*P* Value
Sex				0.012[a]
Female	2424 (49.3%)	2486 (46.8%)	4910 (48.0%)	
Male	2492 (50.7%)	2822 (53.2%)	5314 (52.0%)	
Age, y				0.004[b]
Mean (SD)	68.9 (12.4)	68.1 (12.8)	68.5 (12.6)	
Median (IQR)	70.0 (61.0–78.0)	69.0 (60.0–78.0)	70.0 (60.0–78.0)	
Range	(17.0–99.0)	(20.0–99.0)	(17.0–99.0)	
Race				<0.001[a]
Missing	119	134	253	
White	3513 (73.2%)	3978 (76.9%)	7491 (75.1%)	
African American	419 (8.7%)	525 (10.1%)	944 (9.5%)	
Hispanic or Latino	865 (18.0%)	671 (13.0%)	1536 (15.4%)	
Elixhauser Score				<0.001[a]
0	918 (18.7%)	947 (17.8%)	1865 (18.2%)	
1-2	2429 (49.4%)	2454 (46.2%)	4883 (47.8%)	
3-5	1393 (28.3%)	1677 (31.6%)	3070 (30.0%)	
More than 5	176 (3.6%)	230 (4.3%)	406 (4.0%)	
Length of stay (days)				<0.001[b]
Missing	1	3	4	
Mean (SD)	5.5 (4.2)	7.3 (5.4)	6.4 (4.9)	
Median (IQR)	4.0 (3.0–6.0)	6.0 (4.0–8.0)	5.0 (4.0–7.0)	
Range	(1.0–69.0)	(1.0–87.0)	(1.0–87.0)	
Year				0.217[a]
2013	1762 (35.8%)	1991 (37.5%)	3753 (36.7%)	
2014	1803 (36.7%)	1895 (35.7%)	3698 (36.2%)	
2015	1351 (27.5%)	1422 (26.8%)	2773 (27.1%)	
Payer				<0.001[a]
Medicare	1802 (36.7%)	1867 (35.2%)	3669 (35.9%)	
Medicare Managed Care	1332 (27.1%)	1330 (25.1%)	2662 (26.0%)	
Medicaid	169 (3.4%)	256 (4.8%)	425 (4.2%)	
Commercial	1466 (29.8%)	1621 (30.5%)	3087 (30.2%)	
Other	147 (3.0%)	234 (4.4%)	381 (3.7%)	
Patient location				0.062[a]
Missing	124	139	263	
Rural	223 (4.7%)	283 (5.5%)	506 (5.1%)	
Urban	4569 (95.3%)	4886 (94.5%)	9455 (94.9%)	
Obesity	615 (12.5%)	725 (13.7%)	1340 (13.1%)	0.086[a]
Metastatic Cancer	795 (16.2%)	1266 (23.9%)	2061 (20.2%)	<0.001[a]
Patient County				<0.001[a]
Missing	124	139	263	
Southwest Florida	773 (16.1%)	960 (18.6%)	1733 (17.4%)	
Northeast Florida	542 (11.3%)	473 (9.2%)	1015 (10.2%)	
Northwest Florida	243 (5.1%)	384 (7.4%)	627 (6.3%)	
Southeast Florida	847 (17.7%)	1002 (19.4%)	1849 (18.6%)	
Central Florida	760 (15.9%)	1003 (19.4%)	1763 (17.7%)	
South Florida	789 (16.5%)	492 (9.5%)	1281 (12.9%)	
West Central Florida	838 (17.5%)	855 (16.5%)	1693 (17.0%)	
Surgeon Volume				<0.001[b]
Mean (SD)	42.5 (39.8)	34.7 (32.5)	38.4 (36.4)	
Median (IQR)	33.0 (14.0–60.0)	25.0 (11.0–48.0)	29.0 (12.0–54.0)	
Range	(1.0–198.0)	(1.0–198.0)	(1.0–198.0)	
Teaching Hospital Status				0.095[a]
Missing	7	12	19	
Non-teaching	2229 (45.4%)	2492 (47.1%)	4721 (46.3%)	
Teaching	2680 (54.6%)	2804 (52.9%)	5484 (53.7%)	
Hospital Size				<0.001[a]
Small	138 (2.8%)	201 (3.8%)	339 (3.3%)	
Medium	588 (12.0%)	790 (14.9%)	1378 (13.5%)	
Large	4190 (85.2%)	4317 (81.3%)	8507 (83.2%)	

Abbreviation: IQR, interquartile range.
[a] χ^2 test.
[b] Kruskal-Wallis test.

model were hospital size and teaching status. Hospital size was defined by the number of staffed beds and is categorized as small (less than 100), medium (100–199), and large (greater than 200 staffed beds). Teaching status was defined by the presence of medical residencies; if a medical residency was present the facility was indicated as a teaching hospital. Finally, surgeon volume was included to provide indication concerning surgeon experience relating to the surgery. Surgeon volume was categorized based on every 10-case increase in the number of surgeries performed by the operating surgeon in the study period.

Outcome of interest

Length of stay was included as an outcome of interest.

Analysis

Data were described as percentages or means. Pearson $\chi 2$ and

Table 2
Univariate associations between surgical approach and patient, hospital, and surgeon characteristics.

MIS vs Open Surgery		
Variable	OR (95% CI)	*P* Value
Year (2013 is referent)		
2014	1.08 (0.98, 1.18)	0.119
2015	1.07 (0.97, 1.18)	0.157
Age (10 year increase)	1.05 (1.02, 1.08)	0.002
Payer (Commercial is referent)		
Medicaid	0.73 (0.59, 0.9)	0.003
Medicare	1.07 (0.97, 1.18)	0.183
Medicare Managed Care	1.11 (1, 1.23)	0.054
Other	0.7 (0.56, 0.86)	0.001
Female	1.1 (1.02, 1.19)	0.012
Rural	0.84 (0.7, 1.01)	0.062
Elixhauser Score (0 is referent)		
1-2	1.02 (0.92, 1.14)	0.702
3-5	0.86 (0.76, 0.96)	0.009
More than 5	0.79 (0.64, 0.98)	0.032
Obesity	0.9 (0.81, 1.01)	0.086
Metastatic Cancer	0.62 (0.56, 0.68)	<0.001
Patient Region (Northeast is referent)		
Central	0.66 (0.57, 0.77)	<0.001
Northwest Florida	0.55 (0.45, 0.68)	<0.001
South Florida	1.4 (1.18, 1.65)	<0.001
Southeast Florida	0.74 (0.63, 0.86)	<0.001
Southwest Florida	0.7 (0.6, 0.82)	<0.001
West Central Florida	0.86 (0.73, 1)	0.049
Race (White is referent)		
African American	0.9 (0.79, 1.04)	0.145
Hispanic or Latino	1.46 (1.31, 1.63)	<0.001
Hospital Size (Small is referent)		
Medium	1.08 (0.85, 1.38)	0.239
Large	1.41 (1.13, 1.76)	<0.001
Teaching (Non-teaching is referent)	1.07 (0.99, 1.16)	0.095
Surgeon Volume (10 cases increase)	1.06 (1.05, 1.07)	<0.001

Abbreviations: OR, Odds ratio; CI, Confidence interval.

Kruskal Wallis tests were used to compare categorical and continuous variables respectively. Univariate logistic regression was performed to determine the associations between independent variables and the use of MIS. Odds ratios, 95% confidence intervals and p-values are reported. In order to assess disparities in the use of MIS vs open approaches, a multivariable logistic regression model which consisted of a patient level model and a mixed effects model was conducted predicting MIS (laparoscopic and robotic surgeries) versus open surgery. The patient level model controlled for race/ethnicity, Florida geographic region, patient demographics, payer type, locations, comorbidities and year. In addition to controlling for the aforementioned patient level covariates, the mixed effects model also controlled for hospital size, teaching status and surgeon volume. Additionally, a multivariable linear regression model (consisting of a patient level model and a mixed effects model) was performed comparing length of stay and the surgical route while controlling for the aforementioned covariates. Length of stay was log-adjusted in order to improve the variables distribution for modeling purposes. All tests of significance were 2-sided, and both parameter estimates (regression coefficients) as well as p-values are 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 10,224 patients were analyzed. Of these, 5308 (52%) had open surgery and 4916 (48%) had MIS. The mean ages were 68.5 years overall, 68.9 years for MIS and 68.1 years for open surgery. The patient sample consisted of 52% males, 75.1% whites, 47.8% with 1 or 2 comorbidities, 35.9% with Medicare insurance, 13.1% obese patients, 20.2% with metastatic disease and 94.9% residing in urban areas (Table 1). Among the patients who underwent MIS, 50.7% were males, 73.2% were whites, 49.4% had 1 or 2 comorbidities, 36.7% were Medicare insured, 12.5% obese, 16.2% had metastatic disease and 95.3% resided in urban areas. The median length of stay was 2 days shorter for MIS than open surgery (4 days versus 6 days, $p < 0.001$). The median surgeon volume was statistically different between MIS versus open surgeries (33.0 cases versus 25.0 cases, $p < 0.001$).

On univariate analysis, as demonstrated in Table 2, the odds of undergoing MIS increased with every 10-year increase in age (Odds Ratio [OR], 1.05, 95% Confidence Interval [CI], 1.02–1.08). Medicaid insured patients had lower odds of MIS use (OR 0.73, CI 0.59–0.9) than commercial insurance, while female patients had higher odds of MIS use than males (OR 1.1, CI 1.02–1.19). Patients with 3–5 comorbidities (OR 0.86, CI 0.76–0.96), greater than 5 comorbidities (OR 0.79, CI 0.64–0.98) or metastatic disease (OR 0.62, CI 0.56–0.68) had lower odds of MIS use. Residence in South Florida was associated with higher odds of MIS use (OR 1.4, CI 1.18–1.65) than Northeast Florida. Hispanic or Latino patients had higher odds of MIS use (OR 1.46, CI 1.36–1.63) than whites. Large hospitals had higher odds of MIS use than small hospitals (OR 1.41, CI 1.13–1.76). The odds of undergoing MIS increased with every 10-case increase in surgeon volume (OR 1.06, CI 1.05–1.07). There was no association between MIS utilization and year of diagnosis, rural versus urban location, or obesity.

The multivariable analysis (Table 3) showed that patients with Medicare insurance were more likely to receive MIS compared to commercial insured patients ($p = 0.001$). However, patients with Medicaid as their payer were less likely to undergo MIS than patients with commercial insurance ($p = 0.008$). Female patients

Table 3
Multivariate associations between surgical approach and patient, hospital, and surgeon characteristics showing interaction with patient region and race.

MIS vs Open Surgery					
Covariates	Interaction	Patient Level Model		Mixed Effects Model[a]	
		OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Year (2013 is referent)					
2014		1.08 (0.98,1.19)	0.119	1.05 (0.94, 1.17)	0.362
2015		1.06 (0.95,1.17)	0.291	1.02 (0.9, 1.14)	0.809
Urban		1.14 (0.94,1.39)	0.192	1.13 (0.86, 1.48)	0.385
Payer (Commercial is referent)					
Medicaid		0.74 (0.6,0.92)	0.008	0.72 (0.56, 0.92)	0.008
Medicare		1.19 (1.07,1.33)	0.001	1.31 (1.15, 1.48)	<0.001
Medicare Managed Care		1.09 (0.97,1.22)	0.133	1.13 (0.99, 1.3)	0.064
Other		0.69 (0.55,0.87)	0.002	0.66 (0.51, 0.86)	0.002
Female		1.11 (1.02,1.2)	0.012	1.12 (1.03, 1.23)	0.013
Elixhauser Score (0 is referent)					
1 to 2		1.01 (0.9,1.14)	0.823	0.99 (0.87, 1.13)	0.901
3 to 5		0.83 (0.73,0.94)	0.004	0.84 (0.72, 0.97)	0.018
More than 5		0.78 (0.62,0.98)	0.034	0.74 (0.57, 0.96)	0.024
Obesity		0.91 (0.81,1.03)	0.141	0.84 (0.73, 0.97)	0.015
Metastatic Cancer		0.64 (0.57,0.7)	<0.001	0.63 (0.56, 0.71)	<0.001
Race (White is referent)					
African American		0.85 (0.59,1.22)	0.374	0.99 (0.83, 1.18)	0.986
Hispanic or Latino		2.15 (0.97,4.75)	0.059	1.04 (0.75, 1.43)	0.056
Patient Region (Northeast is referent)					
Central Florida		0.6 (0.5,0.71)	<0.001	0.77 (0.47, 1.28)	0.465
Northwest Florida		0.61 (0.49,0.77)	<0.001	0.43 (0.19, 1)	0.641
South Florida		1.37 (1.04,1.81)	0.027	1.24 (0.71, 2.17)	0.098
Southeast Florida		0.68 (0.57,0.81)	<0.001	0.82 (0.49, 1.38)	0.783
Southwest Florida		0.68 (0.57,0.8)	<0.001	0.75 (0.5, 1.17)	0.212
West Central Florida		0.81 (0.68,0.97)	0.022	0.69 (0.4, 1.19)	0.393
Hospital Size (Small is referent)					
Large		N/A	N/A	1.14 (0.64, 2.03)	0.647
Medium		N/A	N/A	1.02 (0.56, 1.88)	0.941
Surgeon Volume (10 cases increase)		N/A	N/A	1.04 (1.01, 1.08)	0.020
Teaching (Non-teaching is referent)		N/A	N/A	1.04 (0.74, 1.46)	0.835
Interaction between Race and Region					
Central Florida	African American	1.67 (1.01,2.75)	0.044	1.6 (0.9, 2.86)	0.110
Central Florida	Hispanic or Latino	0.53 (0.22,1.27)	0.155	0.5 (0.24, 1.01)	0.052
Northwest Florida	African American	0.61 (0.34,1.12)	0.109	1.12 (0.57, 2.22)	0.738
Northwest Florida	Hispanic or Latino	0.2 (0.03,1.17)	0.073	1.12 (0.66, 1.92)	0.672
South Florida	African American	0.8 (0.45,1.44)	0.461	0.76 (0.39, 1.47)	0.418
South Florida	Hispanic or Latino	0.47 (0.2,1.1)	0.082	1.23 (0.65, 2.34)	0.528
Southeast Florida	African American	1.16 (0.73,1.84)	0.54	0.44 (0.17, 1.15)	0.092
Southeast Florida	Hispanic or Latino	0.61 (0.26,1.41)	0.244	0.23 (0.03, 1.83)	0.166
Southwest Florida	African American	1.06 (0.6,1.89)	0.836	0.46 (0.18, 1.16)	0.099
Southwest Florida	Hispanic or Latino	0.33 (0.13,0.82)	0.017	0.59 (0.23, 1.47)	0.254
West Central Florida	African American	1.3 (0.75,2.27)	0.356	0.27 (0.1, 0.74)	0.011
West Central Florida	Hispanic or Latino	0.54 (0.23,1.3)	0.169	0.47 (0.18, 1.23)	0.123

Abbreviations: OR, Odds ratio; CI, Confidence interval; N/A, Non applicable.
[a] Mixed effects model combined patient level, hospital level and surgeon level factors.

were more likely to receive MIS than males ($p = 0.012$). Patients with metastatic cancer ($p < 0.001$), 3–5 comorbidities ($p = 0.004$) or greater than 5 comorbidities ($p = 0.034$) had reduced likelihood of undergoing MIS.

The region in Florida where the patient lived also affected their likelihood of having MIS or open surgery. Patients living in Central Florida ($p < 0.001$), Northwest Florida ($p < 0.001$), Southeast Florida ($p < 0.001$), Southwest Florida ($p < 0.001$), and West Central Florida ($p = 0.022$) were all less likely to receive MIS than patients living in Northeast Florida. In contrast, patients in South Florida were more likely to receive MIS than in Northeast Florida ($p = 0.027$). Similar to the univariate analysis, MIS use was not related to the year of diagnosis, urban location, or obesity. However, the previously observed greater use of MIS among Hispanic or Latino patients was no longer apparent. The mixed effects model (Table 3) showed no association between hospital size or teaching status and the odds of undergoing MIS. However, an increase in surgeon volume remained associated with higher odds of MIS use (OR 1.04, CI 1.01–1.08).

When considering the interaction between race/ethnicity and region, Black or African American patients living in Central Florida were more likely to receive MIS than white patients ($p = 0.044$). Hispanic/Latino patients living in Southwest Florida had lower likelihood of receiving an MIS than whites ($p = 0.017$). After controlling for hospital size, teaching status and surgeon volume in the mixed effects model, these racial differences were no longer significant.

Regarding the outcome of interest, patients who underwent MIS had significantly reduced length of stay ($p < 0.001$), while Medicaid insurance ($p < 0.001$), having 3 or more comorbidities ($p < 0.001$), and African Americans in Central Florida ($p = 0.033$) were associated with significantly increased length of stay (Table 4). The mixed effects model for length of stay demonstrated no interaction between patient race and region. However, large hospitals ($p = 0.015$), medium sized hospitals ($p = 0.014$), and increased surgeon volume ($p < 0.001$) were associated with a significantly reduced length of stay.

Table 4
Multivariate associations between length of stay and surgical approach, patient, hospital, and surgeon characteristics showing interaction with patient region and race.

Length of Stay					
Covariates	Interaction	Patient Level Model		Mixed Effects Model[b]	
		Estimate[a]	*P* Value	Estimate[a]	*P* Value
Minimally Invasive Surgery		−1.5663	<0.001	−0.2211	<0.001
Year (2013 is referent)					
2014		−0.3598	0.001	−0.0338	0.002
2015		−0.3596	0.003	−0.0404	0.001
Urban		−0.5673	0.013	0.0332	0.220
Payer (Commercial is referent)					
Medicaid		1.3809	<0.001	0.1137	<0.001
Medicare		0.3142	0.01	0.0725	<0.001
Medicare Managed Care		0.1537	0.237	0.0637	<0.001
Other		0.7818	0.003	0.0705	0.009
Female		−0.6087	<0.001	−0.0509	<0.001
Elixhauser Score (0 is referent)					
1 to 2		0.7956	<0.001	0.1114	<0.001
3 to 5		2.7566	<0.001	0.3273	<0.001
More than 5		5.9463	<0.001	0.6325	<0.001
Obesity		0.0453	0.747	0.0176	0.218
Metastatic Cancer		0.8313	<0.001	0.0978	<0.001
Race (White is referent)					
African American		0.1724	0.686	0.0098	0.823
Hispanic or Latino		0.0414	0.961	0.0025	0.977
Patient Region (Northeast is referent)					
Central Florida		0.074	0.718	0.0627	0.072
Northwest Florida		−0.642	0.015	−0.029	0.519
South Florida		−0.6974	0.028	−0.1021	0.029
Southeast Florida		−0.0305	0.884	0.0239	0.529
Southwest Florida		−0.1136	0.571	0.0758	0.045
West Central Florida		0.4642	0.024	0.1071	0.004
Hospital Size (Small is referent)					
Large		N/A	N/A	−0.117	0.015
Medium		N/A	N/A	−0.126	0.014
Surgeon Volume (10 cases increase)		N/A	N/A	−0.0153	<0.001
Teaching (Non-teaching is referent)		N/A	N/A	0.091	0.001
Interaction between Race and Region					
Central Florida	African American	1.2386	0.033	0.0894	0.132
Central Florida	Hispanic or Latino	0.1397	0.881	0.0355	0.597
Northwest Florida	African American	−0.2941	0.653	0.0507	0.475
Northwest Florida	Hispanic or Latino	0.9477	0.591	0.0305	0.585
South Florida	African American	0.794	0.241	0.036	0.595
South Florida	Hispanic or Latino	0.0494	0.956	−0.003	0.964
Southeast Florida	African American	−0.0331	0.951	−0.0168	0.861
Southeast Florida	Hispanic or Latino	0.1971	0.827	0.241	0.178
Southwest Florida	African American	0.2025	0.76	0.0504	0.585
Southwest Florida	Hispanic or Latino	0.2831	0.772	0.0165	0.858
West Central Florida	African American	0.0936	0.885	0.0111	0.912
West Central Florida	Hispanic or Latino	−0.1575	0.867	−0.0481	0.618

[a] Linear regression coefficients.
[b] Mixed effects model combined patient level, hospital level and surgeon level factors.

Discussion

This study sought to evaluate the racial, socioeconomic and geographic disparities associated with the access to minimally invasive platforms for colorectal cancer surgery in Florida. Utilizing a state-wide database, through which we identified all elective colorectal cancer resections performed in Florida over a three-year period, we sought to identify differences in the surgical approach based on patient gender, age, race, urban vs rural location, region, insurance coverage and clinical characteristics such as metastasis, obesity and comorbidities. We also evaluated differences in the surgical approach based on hospital size, teaching status and surgeon volume. Consistent with national studies, patients who had Medicaid insurance, metastatic disease or a greater number of comorbidities were less likely to undergo MIS. In contrast, Medicare insured patients and residents of South Florida were more likely to undergo MIS. Unique to this study, though no racial differences were observed when looking at the composite data of colorectal cancer patients in Florida, important racial differences were noted on a closer examination of individual regions of the state. We believe that these findings do not only corroborate studies at the national level, but also provide additional support for the way differences across a highly diversified state or area can affect patient care.[17]

For example, racial disparity is well documented in the surgical approach for colorectal cancer using national data, though the findings have been sometimes inconsistent.[13,14,25–27] Because of these studies, we expected racial minorities including African Americans and Hispanics to be less likely to undergo MIS; however, our results indicate that the possible influence of race on MIS utilization varies by geographic regions within the state (Fig. 1). Unexpectedly, African Americans in Central Florida were more likely to undergo MIS than whites, although there are significantly more whites than African Americans in Central Florida (Supplemental Table 1). Unsurprisingly, Hispanic patients in Southwest Florida were less likely to receive MIS than whites. Although these findings

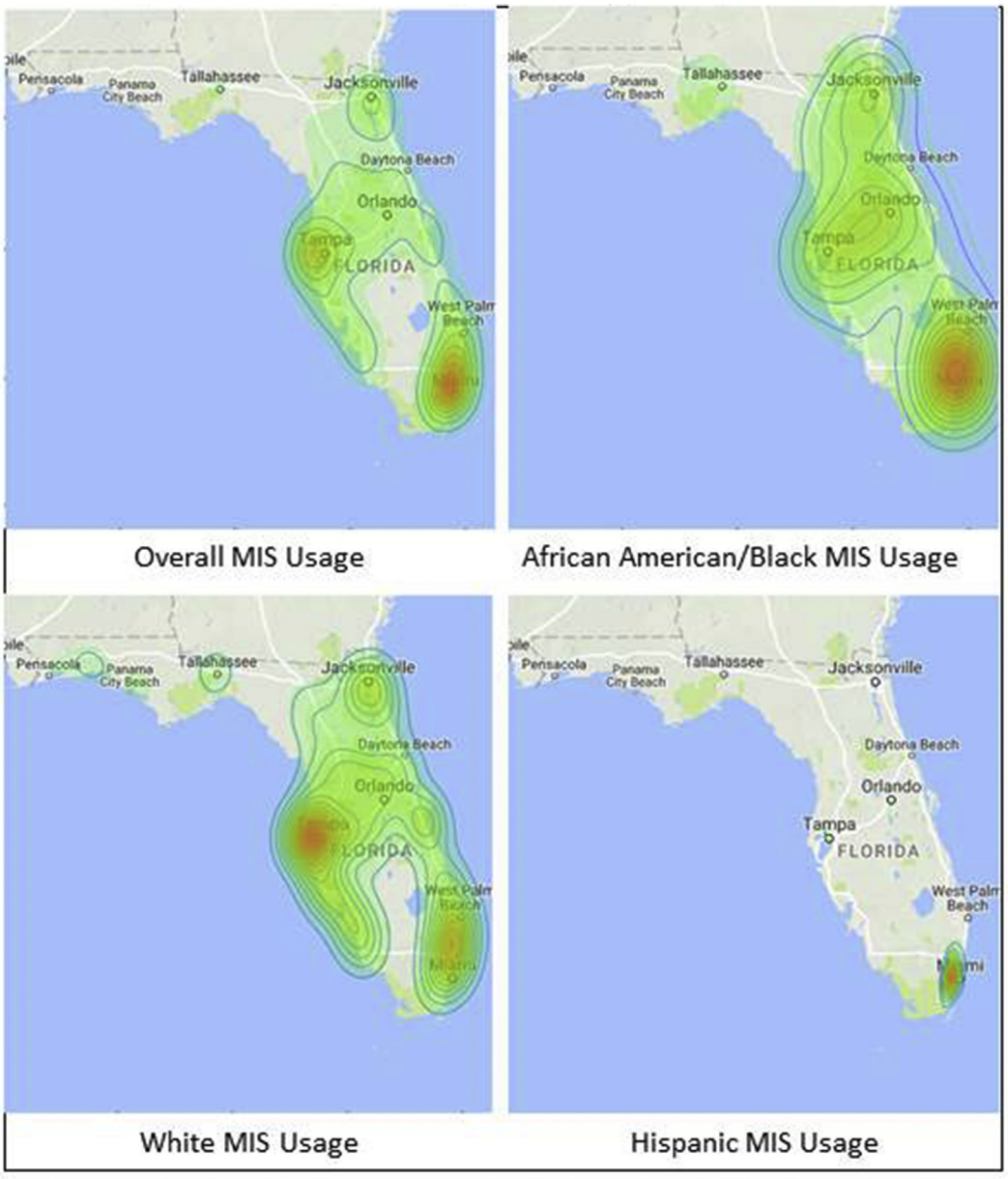

Fig. 1. Heat map identifying racial and geographic variations in MIS use for colorectal cancer throughout Florida.

were no longer significant after controlling for hospital size, teaching status and surgeon volume in the mixed effects model, they are of relevant significance at the patient level. These findings are possibly explained by regional differences such as regional payer mix and regional dissemination of MIS technologies and surgeon experience, among other factors which may not be apparent in nationally reported data. In light of this finding, researchers examining disparities of care should recognize the regionalization of patient care, and probably need to look at geographical areas smaller than the state level.

Due to the higher hospital charges associated with MIS technologies, especially robotics,[10] socioeconomically disadvantaged patient groups have a higher risk of being denied the MIS approach.[15,16] The limited access to MIS experienced by disadvantaged patients may be further compounded by patient location, highlighted by differences in hospital resource availability or surgeon expertise between urban and rural locations. Some studies have noted a greater use of MIS platforms among patients undergoing surgical treatment in urban centers.[28,29] At the state level, we observed no significant difference in MIS use between urban and rural locations among patients undergoing elective surgical resections for colorectal cancer in Florida. However, an examination of the regions revealed greater use of MIS in South Florida. We believe this finding is explained by the presence of large urban cities, academic medical centers and MIS fellowship programs in South Florida, all of which are associated with an increased use of MIS platforms for abdominal surgeries.[30–32]

Though we expected commercial insurance to be more likely associated with MIS than all forms of government insurance, interestingly, Medicare insurance was associated with a greater use of MIS in our study. A possible explanation for this is the significant proportion of older citizens who reside in Florida. Approximately 18% of Florida residents are over the age of 65.[17] This appears to be further supported by the positive association between age and MIS utilization among our study population, as every 10 year increase in age was associated with higher odds of undergoing MIS. In contrast,

an older age has been linked with a significantly decreased utilization of MIS techniques in some national level studies,[15,33] demonstrating that the association between Medicare and MIS use is complex, and potentially influenced by multiple confounders, age being one example. Consistent with national studies,[15,26] however, Medicaid insured patients were less likely to undergo MIS among our patient population.

Unsurprisingly, we found that the minimally invasive approach was associated with a shorter hospital stay, presumably due to less invasiveness and fewer complications associated with this approach. Rather surprising was the tendency for African Americans in Central Florida to stay longer in the hospital than white patients despite what appears to be a higher likelihood for MIS. It appears that in this specific region, African Americans may yet experience worse outcomes resulting in protracted hospital stay despite a tendency to undergo the preferred approach. It could also be that this subgroup of patients was sicker or poorer than their white counterparts. However, this is not clear. Though a greater number of comorbidities and Medicaid insurance were independently associated with a prolonged stay, we would have expected these to also result in decreased likelihood for MIS. Based on the mixed effects model, this discrepancy may be due to factors external to the patient such as hospital size, teaching status, and surgeon experience.

There are important limitations to this study. The use of state level data may in some instances limit generalizability to other populations, but we believe that our findings are applicable to other areas or states with geographic, ethnic and socioeconomic diversity. Florida has a geographically, ethnically and socioeconomically diverse population which fosters comparisons with other highly diversified areas or states. Additionally, the administrative nature of the data and the retrospective perspective limit the ability to assess more granular detail about the patient, procedure and disease which constrains the ability to accurately account for all possible factors associated with MIS use. For example, patient identifiers were not available within the dataset to track past surgical history, readmissions or 30-day patient mortality. The Florida Inpatient Discharge Dataset also lacks information about patient income and educational status which would have provided an additional socioeconomic context regarding disparity associated with MIS use. Though the database contains county level data regarding education and income, we concluded that these may not accurately reflect individual patient experience, hence the decision to exclude these traditional socioeconomic markers of patient disparities from this analysis. The switch in coding system from ICD 9 to ICD 10 within the Florida Inpatient Discharge Dataset restrained the potential to extend the study period beyond 2015 due to differences in granularity between the two coding systems.

Conclusions

As more experience and widespread application of minimally invasive platforms grow nationwide, new data will become available regarding the experience of individual states or areas with the use of MIS for the treatment of colorectal cancer. State level data can corroborate national trends or identify additional gaps for legislative interventions at the state level. It is therefore of relevant importance to recognize social and racial disparities in surgical approach for colorectal cancer at the state level. We analyzed a statewide database in a major US state with tremendous geographical, economic, and ethnical diversity to investigate the racial, socioeconomic and geographic disparities associated with MIS for colorectal cancer surgery at the state level. Consistent with national studies, we found that MIS utilization for colorectal cancer in Florida is associated with insurance status and geographic location. Unique to this study, we found at the patient level that racial disparity for MIS in Florida differs by state regions and warrants further study at the state or even county level.

Author contributions

All authors were responsible for drafting of the manuscript, analysis and interpretation of data, and critical revision of the manuscript for important intellectual content. The study has been approved by all authors in the present format.

Disclosure

The authors declare that there is no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2018.11.019.

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