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ORIGINAL ARTICLE

Disparities in utilization of robotic surgery for colon cancer: an evaluation of the U.S. National Cancer Database

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Abstract

Despite the benefits of minimally invasive surgery for colorectal procedures, significant disparities in access to these techniques remain. While these gaps have been well-documented for laparoscopy, few studies have evaluated inequalities in access to robotic surgery. We analyze whether disparities exist in the use of robotic surgery in the management of colon cancer. The U.S. National Cancer Database was queried for patients with non-metastatic colon adenocarcinoma who underwent resection with the robotic platform (2010–2016). Demographic, clinicopathologic, and treatment facility-related variables were analyzed with respect to preferential utilization of robotic surgery with multivariable logistic regression. Patients with metastatic disease, missing or incomplete surgical information, and those who underwent local tumor excision were excluded. 74,984 patients were identified, 3001 (4%) of whom underwent robotic surgery. In multivariable analysis, patients who were older, Black, or were living in an urban area had decreased odds of receiving robotic surgery compared with open or laparoscopic surgery. Patients who were privately insured or living in areas with higher education had increased odds of receiving robotic surgery. Robotic surgery was also preferentially associated with lower clinical stage, more recent year of diagnosis, and hospitals with higher procedural volume. As advantages of the robotic platform are becoming better understood, use of this approach is increasing in popularity for treatment of non-metastatic colon cancer. Despite this, significant disparities exist with respect to patient demographics and socioeconomic factors, and access may only be limited to certain types of hospitals. Further studies are needed to define why these inequalities exist.

Keywords Robotic surgery · Colon cancer · Healthcare disparities

Introduction

The benefits of minimally invasive surgery (MIS) in the operative management of colorectal diseases have been demonstrated in numerous studies [1–6]. For colon cancer, minimally invasive colectomy has been associated with fewer complications and short-term morbidity with similar long-term outcomes [7–9]. Though laparoscopy has gained tremendous popularity over the past several decades due in large part to these advantages, it still has surgeon-specific disadvantages including limited range of motion, loss of dexterity, and only two-dimensional instrument articulation. The robotic platform was developed to overcome these disadvantages and combine the benefits of an open approach (three-dimensional vision, increased dexterity, and range of motion) and a laparoscopic approach (less post-operative pain, faster recovery, improved visualization). The robotic platform also provides the surgeon the benefit of improved ergonomics. Although the role of robotics with regards to colon cancer surgery has not been well-defined, utilization of the robotic platform for colorectal surgery has increased tremendously over the past 20 years [10, 11].

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The growth in popularity of the robotic platform in colorectal surgery underscores the need to assess not only intra-operative and post-operative outcomes compared to open and laparoscopic approaches, but also patient access to the robotic platform as well as inequalities in its use. Despite the well-known advantages and increasing utilization of MIS, continuing demographic and socioeconomic disparities in access to these techniques have been described in many different surgical fields, limiting the benefits of these approaches to patients of certain backgrounds [12–14]. Specifically, in the field of colorectal surgery, factors such as patient race, higher income, and private insurance have all been associated with preferential use of minimally invasive surgery [15, 16]. This inequality in access to emerging technology not only represents injustice in our healthcare system that must be addressed, but also limits the generalizability of research in robotics to certain subsets of the overall population.

The goal of our study was to evaluate the demographic, clinical, socioeconomic, and hospital factors associated with receipt of a robot-assisted surgical approach for colectomy for patients with non-metastatic colon cancer. Though previous studies have evaluated disparities in MIS in general with regards to colon cancer, none have addressed factors specifically associated with the preferential use of the robotic platform [17, 18]. We hypothesized that similar disparities in utilization would exist with the robotic platform as compared with laparoscopy.

Methods

We retrospectively reviewed data from the U.S. National Cancer Database (NCDB) from 2010 to 2016. The NCDB is jointly sponsored by the American College of Surgeons and the American Cancer Society with data representing more than 70% of newly diagnosed cancers in the United States accrued from more than 1500 Commission on Cancer-accredited facilities. Since data within the NCDB registry are de-identified, this study was deemed exempt by our Institutional Review Board (IRB) review and, therefore, approval and written consent was not required.

The NCDB Colon Participant User File (PUF) was queried for patients with non-metastatic adenocarcinoma (ICDO-3 code 8140/3) of the colon (C18.0–18.9) who underwent segmental/partial colectomy, hemicolectomy/subtotal colectomy, or total colectomy (Procedural Code 30, 40, and 50, respectively) with the robotic platform. Patients were excluded if they had metastatic disease, histology other than adenocarcinoma, underwent local tumor excision, non-invasive behavior, or if demographic or surgical information including operative approach (open, laparoscopic, robotic) was missing or incomplete.

Receipt of surgery with the robotic platform was the primary outcome of interest. Patients who underwent conversion from a robotic to open approach were included in the robotic surgery cohort as part of an intention-to-treat analysis. Demographic information of interest included mean age, sex, race, patient residence in metropolitan, urban, or rural counties, insurance type, percent of residents without high school degree in patient zip codes, and patient income quartiles (ranging from < \$38,000 and > \$63,000). Clinical variables included Charlson comorbidity index, clinical stage, year of diagnosis (2010–2016), and procedure. Facility characteristics included facility type (community cancer program, comprehensive community cancer program, academic/research program, and integrated cancer network) as defined by the NCDB in Table 1. Procedure facility volume was also created by stratifying hospitals into categories (low, moderate, high) based on annual colectomies performed (< 100, 100–300, and > 300).

Statistical analysis

Univariable analysis was performed using chi-squared test for categorical variables and independent samples t test for the continuous variable "Age" to evaluate the association between receipt of robotic surgery, patient demographics, clinicopathologic factors, and treatment facility-related variables. Covariates significantly associated with receipt of robotic approach at the univariable level were then entered into a multivariable logistic regression model following a purposeful selection stepwise approach to identify covariates independently associated with robotic procedures. Area under the receiver operating characteristics (ROC) curve was calculated as a measure of our multivariable model's predictive ability. All two-sided p values of < 0.05 were considered statistically significant. All statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC).

Results

After exclusions, 74,984 cases were identified, 3001 (4%) of which underwent a robotic approach between 2010 and 2016. 245 patients (8.5%) underwent conversion to open. Characteristics of all patients can be seen in Table 2. The mean age of all patients was 69.6 years old. 51.7% of patients were female and 84.6% of patients were White. Most patients lived in a metropolitan area (84.8%) and were insured with Medicare (60.1%). Clinically, 40.0% of patients were diagnosed with stage 1 disease while 37.1% of patients and 22.9% of patients were diagnosed with stage II and stage III disease, respectively. A majority of patients received their surgery at a comprehensive community cancer program (48.0%) and at high procedural volume centers (64.4%).

Table 1 Definitions of facility type by American College of Surgeons Commission on Cancer

Facility type	Definition
Community cancer program	The facility accessions more than 100 but fewer than 500 newly diagnosed cancer cases each year and provides a full range of diagnostic and treatment services, but referral for a portion of diagnosis or treatment may occur. Participation in the training of resident physicians is optional
Comprehensive community cancer program	The facility accessions 500 or more newly diagnosed cancer cases each year. The facility provides a full range of diagnostic and treatment services either on-site or by referral. Participation in the training of resident physicians is optional
Academic comprehensive cancer program	The facility participates in postgraduate medical education in at least four program areas, including internal medicine and general surgery. The facility accessions more than 500 newly diagnosed cancer cases each year, and it offers the full range of diagnostic and treatment services either on-site or by referral
Integrated network cancer network	The organization owns, operates, leases, or is part of a joint venture with multiple facilities providing integrated cancer care and offers comprehensive services. At least one facility in the category is a hospital and must be a CoC-accredited cancer program. Generally, INCP's are characterized by a unified cancer committee, standardized registry operations with a uniform data repository, and coordinated service locations and practitioners. Each entity meets performance expectations for the quality measures under the umbrella of the integrated program. The INCP participates in cancer-related clinical research either by enrolling patients in cancer-related clinical trials or by referring patients for enrollment at another facility or through a physician's office

Obtained from: https://www.facs.org/quality-programs/cancer/coc/accreditation/categories

Results of univariable analysis are seen in Table 2. Patients who received robotic surgery were younger (68.0 ± 12.0 vs. 69.8 ± 12.4), less likely to be Black (10.6 vs. 12.2%) and more likely to be White (85.2 vs. 84.5%), more likely to live in a metropolitan area (88.6 vs. 84.6%) and less likely to live in urban (10.2 vs. 13.6% and rural (1.2 vs. 1.8%) areas (all $p < 0.05$). In terms of socioeconomic factors, patients who received robotic surgery were more likely to have private insurance (37.5 vs. 29.7%) and less likely to have no insurance (1.5 vs 3.1%), Medicare (55.4 vs 60.3%), Medicaid (3.7 vs. 4.4%), or unknown insurance (1.2 vs. 1.7%) ($p < 0.0001$). Additionally, patients receiving robotic surgery were more likely to live in zip codes in the highest education quartile (27.0 vs. 21.8%) and have income in the highest quartile (34.4 vs. 30.6%) (all $p < 0.001$). Clinically, patients receiving robotic surgery were more likely to have a have a lower Charlson comorbidity score of 0 (69.2 vs. 66.8%) or 1 (22.0 vs. 23.1%), have a lower clinical stage of cancer (50.8 vs. 39.6%), were diagnosed in later years compared to earlier years, and undergo a segmental colectomy (88.6 vs. 84.6%) (all $p < 0.05$). In terms of hospital characteristics, patients receiving robotic surgery were more likely to be treated at an academic/research hospital (28.1 vs. 25.7%) or integrated cancer network hospital (13.6% vs. 12.1%) that had high procedural volume (66.8 vs. 64.3%) (all $p < 0.001$). There was no significant difference in approach by patient sex.

Results from multivariable analysis of factors independently associated with use of the robotic platform is seen in Table 3. Increasing patient age (per 1 year increase; aOR = 0.99), Black patients (aOR = 0.87), and patients living in an urban area (aOR = 0.80) were independently associated with decreased adjusted odds of receipt of robotic surgery when compared to White patients and patients living in metropolitan areas. With regard to socioeconomic factors, patients who were uninsured (aOR = 0.48), had Medicaid (aOR = 0.67) Medicare (aOR = 0.89) or unknown insurance status (aOR = 0.67) were significantly associated with decreased independent adjusted odds of undergoing a robotic approach compared to those with private insurance. Those in the highest education quartile (aOR = 1.27) were independently associated with increased adjusted odds of undergoing a robotic approach (all $p < 0.05$). Additionally, compared with patients with clinical stage I disease, patients who were diagnosed with stage II (aOR = 0.73), or stage III (aOR = 0.69) disease had decreased independent adjusted odds of undergoing robotic surgery (all $p < 0.001$). More recent year of surgery was also associated with increased adjusted odds of robotic approach (2016 v 2010; aOR = 8.32; $p < 0.001$). Patients undergoing a hemicolectomy/subtotal colectomy (aOR 0.87) or total colectomy (0.71) were also associated with decreased adjusted odds of robotic approach compared to segmental colectomy (all $p < 0.001$). Facility characteristics such as high procedural volume centers (aOR = 1.18) were associated with increased adjusted odds of offering a robotic approach while community cancer program hospitals (CCP) were associated with decreased adjusted odds (aOR 0.70) of offering a robotic approach compared to academic/research hospitals (all $p < 0.05$).

Table 2 Demographic, clinicopathologic, and hospital factors associated by surgical approach, unadjusted

Variable	All approaches ($n=74{,}984$)	Open or laparoscopic ($n=71{,}983$)	Robotic ($n=3001$)	*p* value
Mean age	69.6 ± 12.3	69.8 ± 12.4	68.0 ± 12.0	**< 0.001**
Sex				0.193
Male	36,208 (48.3%)	34,724 (48.2%)	1484 (49.5%)	
Female	38,776 (51.7%)	37,259 (51.8%)	1517 (50.5%)	
Race				**< 0.001**
White	63,410 (84.6%)	60,853 (84.5%)	2557 (85.2%)	
Black	9121 (12.2%)	8804 (12.2%)	317 (10.6%)	
Other	2453 (3.2%)	2326 (3.2%)	127 (4.2%)	
Patient census area				
Metropolitan	63,560 (84.8%)	60,901 (84.6%)	2659 (88.6%)	**< 0.001**
Urban	10,124 (13.5%)	9818 (13.6%)	306 (10.2%)	
Rural	1300 (1.7%)	1264 (1.8%)	36 (1.2%)	
Insurance				**< 0.001**
None	2290 (3.1%)	2245 (3.1%)	45 (1.5%)	
Private	22,512 (30.0%)	21,387 (29.7%)	1125 (37.5%)	
Medicaid	3291 (4.4%)	3179 (4.4%)	112 (3.7%)	
Medicare	45,079 (60.1%)	43,417 (60.3%)	1662 (55.4%)	
Other government	582 (0.8%)	562 (0.8%)	20 (0.7%)	
Unknown	1230 (1.6%)	1193 (1.7%)	37 (1.2%)	
Percent of residents without high school degree in patient's zip code				**< 0.001**
> 29.0%				
20.0–28.9%				
14.0–19.9%				
< 14.0%	13,164 (17.6%)	12,708 (17.7%)	456 (15.1%)	
	20,566 (27.4%)	19,861 (27.6%)	705 (23.5%)	
	24,715 (33.0%)	23,684 (32.9%)	1031 (34.4%)	
	16,539 (22.0%)	15,730 (21.8%)	809 (27.0%)	
Income quartile				**< 0.001**
< $38,000	13,981 (18.6%)	13,443 (18.7%)	475 (15.8%)	
$38,000–47,999	18,147 (24.2%)	17,500 (24.3%)	647 (21.6%)	
$48,000–62,999	19,847 (26.5%)	19,030 (26.4%)	817 (27.2%)	
> $63,000	23,072 (30.1%)	22,010 (30.6%)	1062 (35.4%)	
Charlson comorbidity index				
0				**0.02**
1	50,144 (66.9%)	48,066 (66.8%)	2078 (69.2%)	
2	17,272 (23.0%)	16,612 (23.1%)	660 (22.0%)	
3	5174 (6.9%)	4998 (6.9%)	176 (5.9%)	
	2394 (3.1%)	2307 (3.2%)	87 (2.9%)	
Clinical stage				**< 0.001**
I	30,048 (40.0%)	28,524 (39.6%)	1524 (50.8%)	
II	27,831 (37.1%)	26,891 (37.4%)	940 (31.3%)	
III	17,105 (22.9%)	16,568 (23.0%)	537 (18.9%)	
Year of diagnosis				**< 0.001**
2010	13,668 (18.2%)	13,479 (18.7%)	189 (6.3%)	
2011	12,959 (17.3%)	12,677 (17.6%)	282 (9.4%)	
2012	12,313 (16.4%)	11,974 (16.6%)	339 (11.3%)	
2013	11,544 (15.4%)	11,134 (15.5%)	410 (13.7%)	
2014	10,317 (13.8%)	9778 (13.6%)	539 (18.0%)	
2015	8472 (11.3%)	7853 (10.9%)	619 (20.6%)	
2016	5711 (7.6%)	5088 (7.1%)	623 (20.8%)	

Table 2 (continued)

Variable	All approaches ($n = 74{,}984$)	Open or laparoscopic ($n = 71{,}983$)	Robotic ($n = 3001$)	p value
Procedure				**< 0.001**
Segmental colectomy	63,560 (84.8%)	60,901 (84.6%)	2659 (88.6%)	
Hemicolectomy/subtotal colectomy	10,124 (13.5%)	9818 (13.6%)	306 (10.2%)	
Total colectomy				
	1300 (1.7%)	1264 (1.8%)	36 (1.2%)	
Facility type				**< 0.001**
Community cancer program (CCP)	10,515 (14.0%)	10,233 (14.2%)	282 (9.4%)	
Comprehensive CCP				
Academic/research	15,991 (48.0%)	34,524 (48.0%)	1467 (48.9%)	
Integrated network	19,335 (25.8%)	18,491 (25.7%)	844 (28.1%)	
	9143 (12.2%)	8735 (12.1%)	408 (13.6%)	
Volume				**< 0.001**
Low	8891 (11.9%)	8595 (11.9%)	296 (9.9%)	
Moderate	17,796 (23.7%)	17,095 (23.8%)	701 (23.4%)	
High	48,297 (64.4%)	46,293 (64.3%)	2004 (66.8%)	

Statistically significant values ($p < 0.05$) are given in bold

Discussion

Our study demonstrates an association between preferential use of robotic surgery and certain patient demographic, socioeconomic, and clinical factors. In multivariate analysis, older patients, Black patients, and patients living in urban areas were all less likely to receive a robotic approach compared with patients who were younger, White, and living in metropolitan areas. Additionally, patients with private insurance, higher income, and those living in areas with the highest percentage of those completing high school were much more likely to undergo robotic surgery. Clinically, patients diagnosed in later years, those with lower-stage disease, and those who required more limited resection of the colon also preferentially underwent a robotic approach. Finally, patients treated at an academic center with higher procedural volume were more likely to receive robotic surgery.

Colorectal cancer is the third most common cancer in both men and women in the United States, with over 150,000 cases diagnosed annually [19]. Despite improvement in incidence and mortality in the United States for the past few decades, significant disparities persist. For example, colorectal cancer has approximately 20% greater incidence in the Black population as compared with the White population and Black patients are diagnosed at a more advanced stage and younger age compared with White patients [20]. Although they present with higher incidence and more advanced disease at diagnosis, Black patients are less likely to receive neoadjuvant chemotherapy and radiation as well as surgical treatment for colon cancer [21, 22]. Studies analyzing clinical delay in colon cancer, defined as the time between medical presentation and treatment initiation, suggest that while racial disparities are prominent, age-related differences are insignificant [23, 24]. One study found that although patients treated at academic centers have improved overall survival vs. those receiving care at comprehensive community programs, race-based disparities, but not Medicaid-based disparities, persisted across treatment facilities [25]. These findings speak to the interplay of several socio-contextual health determinants across racial groups, such as access to insurance, health literacy, healthcare utilization, social support, and logistical barriers; moreover, they serve as a call to mitigate such racial discrepancies in clinical outcomes.

Other factors such as lower socioeconomic status and weaker insurance coverage have also independently been linked with more limited access to care and poorer outcomes for patients with colon cancer [22, 26–28]. Interestingly, studies of equal access-healthcare systems such as the Military Health System have not shown the same disparities seen in the general population, suggesting that when access is distributed equally to all, treatment inequalities are eliminated [29]. These findings suggest that inequalities in access or strength of insurance could play a major role in outcome disparities for patients of different socioeconomic background. Although our data revealed no significant differences in surgical approach by patient sex, studies have indicated that females over 65 years of age exhibit higher colon cancer mortality and lower 5-year survival rates compared to their age-matched male counterparts [30–32]; this disparity is hypothesized to be linked to gender differences in anatomic location of

Table 3 Multivariable logistic regression of factors independently associated with use of robotic platform

Variable	Adjusted odds ratio (95% confidence interval)	*p* value
Age, per 1 year increase	0.99 (0.98 – 0.99)	**< 0.001**
Race		
White	Reference	–
Black	0.87 (0.76–0.98)	**0.023**
Other	1.16 (0.96–1.40)	0.124
Living area		
Metropolitan	Reference	–
Urban	0.80 (0.71–0.91)	**< 0.001**
Rural	0.72 (0.52–1.02)	0.061
Insurance		
Private	Reference	–
Uninsured	0.48 (0.36–0.65)	**< 0.001**
Medicaid	0.67 (0.55–0.82)	**< 0.001**
Medicare	0.89 (0.80–0.98)	**0.019**
Other government	0.71 (0.45–1.13)	0.146
Unknown	0.67 (0.48–0.94)	**0.021**
Percent of residents without high school degree in patient's zip code		
> 29.0%		
20.0–28.9%		
14.0–19.9%	Reference	–
< 14.0%	0.97 (0.86–1.09)	0.574
	1.14 (1.02–1.28)	**0.026**
	1.27 (1.12–1.43)	**< 0.001**
Clinical stage		
I	Reference	–
II	0.73 (0.68–0.80)	**< 0.001**
III	0.69 (0.62–0.76)	**< 0.001**
Year of diagnosis		
2010	Reference	–
2011	1.58 (1.31–1.90)	**< 0.001**
2012	1.98 (1.65–2.37)	**< 0.001**
2013	2.57 (2.16–3.06)	**< 0.001**
2014	3.80 (3.22–4.50)	**< 0.001**
2015	5.46 (4.63–6.45)	**< 0.001**
2016	8.32 (7.04–9.83)	**< 0.001**
Procedure		
Segmental colectomy	Reference	–
Hemicolectomy/subtotal colectomy	0.87 (0.81–0.94)	**< 0.001**
Total colectomy	0.71 (0.62–0.82)	**< 0.001**
Facility type		
Academic	Reference	–
CCP	0.70 (0.61–0.81)	**< 0.001**
Comprehensive CCP	0.97 (0.89–1.07)	0.563
Integrated network	1.04 (0.92–1.18)	0.55
Volume		
Low	Reference	–
Moderate	1.21 (1.05–1.40)	**0.008**
High	1.18 (1.04–1.34)	**0.014**

Receiver operating characteristic (ROC) area under the curve = 0.705. Statistically significant values ($p < 0.05$) are given in bold

the neoplasia and socio-cultural barriers affecting screening practices [33].

Regardless, similar disparities have been noted with regards to access to MIS as other treatment modalities for colon cancer. Consistent with the results of our study of the robotic platform, factors such as private insurance were positively associated with receipt of a laparoscopic approach while Black race, lack of insurance, lower education and income, and treatment at a low-volume or community center have been associated with decreased utilization of laparoscopic surgery [17, 34]. With regards to robotic colorectal surgery, the results of our study are also consistent with those of a study by Ofshteyn et al. in that robotic proctectomy was more likely to occur in patients who were White, privately insured, living in a metropolitan area with a higher high school graduation rate in a treating hospital that was high volume and academic [35]. Our results, therefore, seem consistent with disparities shown in use of laparoscopy for colon cancer as well as the robotic platform for rectal cancer.

Despite the lack of randomized controlled trials favoring robotic surgery over laparoscopy for colonic resections, there has been a significant increase in the use of the robotic platform for colectomy. A study by Sheetz et al. of Medicare beneficiaries showed that robotic colectomy rose from 0.7% in 2006 to 10.9% in 2010 in all hospitals [10]. In hospitals with the highest adoption rate of robotic colectomy, it rose from 0.8 to 32.8% and robotic colectomy was shown to displace laparoscopic colectomy (43.8–25.2%) more than open colectomy (55.4–41.9%). Additionally, another study of the Michigan Surgical Quality Collaborative by Sheetz et al. found that the use of robotic colectomy increased from 2.5 to 16.3% from 2012 to 2018 [11]. It is anticipated that robotic colectomy will continue to gain popularity as the robotic platform becomes more widely available and surgeon familiarity with use of the platform increases, highlighting the need to understand which patient populations may not have equal access to it.

The positive association between higher income and the presence of private insurance and utilization of robotic surgery has been previously described in other studies [15, 16, 35]. Given the expense of the robotic platform, only certain types of facilities are able to afford the initial capital investment as well as maintenance costs. Therefore, patients with higher incomes and private insurance may be preferentially offered robotic surgery as a means for hospitals to gain the most return on their investment. Different insurers, therefore, can significantly influence clinical decisions as to whether or not robotic technology is offered to patients whom they cover, regardless of whether a patient is an appropriate candidate for a robotic approach. As robotic technology becomes less expensive, it will ideally become more widely adopted and available to patients with other insurance types and lower incomes.

Despite this, efforts on behalf of surgeons and healthcare facilities should be made to better recruit these patients to more actively reduce disparities in access to robotic technology.

Our study also found that patients who received robotic surgery tended to be younger compared to those who underwent an open or laparoscopic approach. Given the association with increased operative times of the robotic platform compared to pure laparoscopy, this may reflect a desire to minimize the anesthetic risk of prolonged operative time for older patients who typically have more comorbidities than the young. This would be expected to change in time with the increased use of robotics and robotic teams to decrease the increased operative times that come with docking and unfamiliarity with the platform such that increased accessibility to robotics will improve care across all levels. Despite this, recent studies of elderly patients comparing laparoscopy and robotic surgery have shown equivalent results despite longer operative times with robotic surgery [36, 37]. Further studies are needed to compare outcomes between approaches in elderly patients before the optimal approach is understood.

There are several limitations to our study. As with all retrospective reviews, our study is susceptible to selection bias as surgeons could select patients with more advantageous characteristics such as lower BMI, less extensive history of abdominal surgery, or more favorable tumor characteristics, all of which ultimately affect both referral patterns and the decision of initial surgical approach. Additionally, while the Charlson score is similar to the American Society of Anesthesiologists (ASA) score, it offers no data with regard to BMI, nutritional markers, or other specific comorbidities of interest. The NCDB also does not account for previous abdominal surgical history or specific comorbidities that are important considerations when choosing a surgical approach. Detailed information regarding patient preference for approach is also unfortunately not captured by the NCDB. Finally, the NCDB does not offer surgeon-specific information of interest such as years of experience as an attending physician, years of experience with use of the robotic platform, or designation of fellowship training in Colon and Rectal Surgery, all of which would affect the decision of approach. It should also be noted that while there was statistical significance between receipt of robotic versus a laparoscopic or open approach in variables such as age and race, there may be questionable clinical significance. The goal of our study, however, was to show an association between certain patient variables and receipt of robotic surgery rather than attempt to find causation for these disparities. It is our hope that this study brings attention to the differences in which surgical technology may be offered to patients of different backgrounds and act as a launching point for future studies to address this important issue.

Conclusion

Our study is the only study we know of that evaluates preferential use of the robotic platform in the surgical management of colon cancer for certain patient populations. We demonstrate an association between specific populations showing that patients who are younger, White, privately insured, live in metropolitan areas with higher income and higher education status are more likely to receive robotic surgery compared with an open or laparoscopic approach. Additionally, patients with lower clinical disease who required more limited colonic resection and those with the ability to receive care at a higher volume and academic medical center preferentially underwent robotic surgery. As the popularity of the robotic platform increases with respect to treatment of colon cancer, awareness of these disparities is an important first step to correcting inequalities in our healthcare system.

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Declarations

Conflict of interest Dr. Michael L. Horsey, Dr. Debra Lai, Mr. Andrew D. Sparks, Mr. Aalap Herur-Raman, Dr. Marie Borum, Dr. Sanjana Rao, and Dr. Matthew Ng declares that they have no conflict of interest. Dr. Vincent J. Obias has received speaker honoraria from Medrobotics, Medtronic, and Intuitive.

Informed consent This study was analyzed by the George Washington University Institutional Review Board and deemed to be exempt from review.

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