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Disparities in the Utilization of Laparoscopic Surgery for Colon Cancer in Rural Nebraska: A Call for Placement and Training of Rural General Surgeons

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Abstract

Background—Advances in medical technology are changing surgical standards for colon cancer treatment. The laparoscopic colectomy is equivalent to the standard open colectomy while providing additional benefits. It is currently unknown what factors influence utilization of laparoscopic surgery in rural areas and if treatment disparities exist. The objectives of this study were to examine demographic and clinical characteristics associated with receiving laparoscopic colectomy and to examine the differences between rural and urban patients who received either procedure.

Methods—This study utilized a linked dataset of Nebraska Cancer Registry and hospital discharge data on colon cancer patients diagnosed and treated in the entire state of Nebraska from 2008–2011 (N=1,062). Multiple logistic regression analysis was performed to identify predictors of receiving the laparoscopic treatment.

Results—Rural colon cancer patients were 40% less likely to receive laparoscopic colectomy compared to urban patients. Independent predictors of receiving laparoscopic colectomy were younger age (<60), urban residence, ≥3 comorbidities, elective admission, smaller tumor size, and early stage at diagnosis. Additionally, rural patients varied demographically compared to urban patients.

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Conclusions—Laparoscopic surgery is becoming the new standard of treatment for colon cancer and important disparities exist for rural cancer patients in accessing the specialized treatment. As cancer treatment becomes more specialized, the importance of training and placement of general surgeons in rural communities must be a priority for health care planning and professional training institutions.

Keywords

access to care; colon cancer; laparoscopic colectomy; minimally invasive surgery; rural disparities

Tremendous advancements in medical technology and supporting scientific evidence are redefining the standard treatment for colon cancer. The laparoscopic colectomy for colorectal cancer (CRC) treatment was introduced in 1991 after the proven success of the minimally invasive technique for other gastrointestinal diseases.[1] While the majority of surgical resections for colon cancer are still performed using the open and more invasive technique, minimally invasive surgical (MIS) techniques such as laparoscopy are gaining in popularity due to numerous patient benefits and superior oncological outcomes.[2–6] However, the generalizability of the findings from the initial large randomized controlled trials are limited by the studies' inclusion criteria (eg, study location, elective admissions and certain tumor sites). It is also unclear if rural colon cancer patients were adequately represented in these trials. In the guidelines published by the Society of American Gastrointestinal Endoscopic Surgeons, laparoscopic surgery was recognized as a preferred method for curatively treating colon cancer when all standard oncological principles are followed. [7] Laparoscopic surgery has many benefits for colon cancer patients undergoing surgical treatment.[2–6] Studies have shown less blood loss during laparoscopic procedures, a decreased risk of wound infections and a quicker recovery of bowel function (earlier by 1 day).[6,8–11] Furthermore, patients who underwent laparoscopic colectomies had less postoperative pain, shorter hospital stays (shorter by 3 days) and an overall faster recovery compared to those who received the open procedure.[6,9–12] Despite these potential advantages, studies have shown that laparoscopic colectomy has not been widely adopted and is more likely to be performed in high-volume or teaching hospitals located in large urban areas, leaving unanswered questions about utilization and access in rural areas.[6,13]

Cancer treatment disparities exist for rural residents.[14,15] The potential factors contributing to these inequities are multifaceted and are evident for many cancer types.[1,16–19] Minimally invasive surgeries, including laparoscopic and robotic techniques are underutilized or absent in rural settings, even though resections account for a large proportion of surgical procedures performed at rural hospitals.[6,20] For example, robotic prostatectomy for prostate cancer has not been well accepted in rural hospitals.[20] Similarly, a recent study examining the relationships between hospital, provider and patient factors found that older surgeons with lower case volumes and those practicing in rural areas were significantly less likely to use laparoscopy for kidney cancer.[21] We do not know if the laparoscopic colectomy is being utilized by rural residents. As a large proportion of the US population ages, there will be an increasing demand for the scientifically proven superior MIS procedures for cancer treatment.[22] The disparities in colon cancer treatment outcomes will persist and potentially worsen if rural cancer patients cannot access these services. The laparoscopic colectomy should be advocated and accessible to all patients.

Many national-level studies have demonstrated disparities in the utilization of the laparoscopic procedure, but they have failed to thoroughly describe patient factors influencing this treatment gap, specifically within the context of urban and rural.[2,6] There is also an inadequate and inconsistent description of the demographic and clinical differences between rural and urban colon cancer patients requiring surgical treatment options.[23] Significant differences between rural and urban patients have been noted for other cancer sites and treatments; these differences may influence selection for the laparoscopic colectomy.[23,24] The Midwest experiences a disproportionately high burden of colorectal cancer incidence and mortality, suggesting a specific need to investigate the extent of rural disparities and factors predicting the use of laparoscopic surgery in this region.[25] In utilizing a unique dataset representative of colon cancer patients at the state level, this study may illuminate distinct patient factors driving the cancer treatment disparities. Nebraska has a large and geographically diverse rural population, making this the ideal setting to describe potential cancer treatment disparities based on geographic location of residence. The primary objective of the present study was to examine demographic and clinical characteristics associated with receiving the laparoscopic colectomy within the state of Nebraska. Additionally, we compared the differences in colon cancer demographics and clinical characteristics in rural and urban populations.

Methods

This study was approved by the Institutional Review Board at the University of Nebraska Medical Center.

Study Population and Data Sources

This study used a linked dataset consisting of Nebraska Cancer Registry (NCR) and inpatient hospital discharge data (HDD) from 2008–2011. The NCR and HDD include demographic and diagnostic information from all nonmilitary health care facilities across Nebraska, and therefore the data can be linked to draw inference on the civilian population across the entire state. The data linkage of the NCR and HDD databases was performed by the Nebraska Department of Health and Human Services. Nebraska residents 19 years and older, diagnosed and treated for colon cancer (ICD-9 codes C18.0–C18.9) between the years 2008–2011 were included in the analysis (n=1,062). Demographic and tumor characteristics were obtained from the NCR while the HDD provided procedure and hospital variables.

The laparoscopic colectomy ICD-9-CM codes are 17.3, 17.31–17.39, and the open and converted are 45.7, 45.71–45.79, 45.81–45.83, V64.40–V64.41. The rural and urban classification is consistent with the Office of Management and Budget (OMB) 2013 Metropolitan and Micropolitan definitions.[26] This study used the Charlson Comorbidity Index (CCI), enhanced Deyo algorithm, to account for the multiple ICD-9-CM codes related to each diagnosis category.[27] The CCI applies weights based on the number and severity of each diagnosis to produce a score for each subject.[27] Sixteen diagnoses were included in the

CCI and are published elsewhere.[27] The final CCI score was then grouped into 4 categories (none, 1, 2, 3 or more weighted comorbidities).

Statistical Analysis

Summary statistics including frequencies and percentages were reported for all categorical variables; the mean (median) and standard deviation were displayed for continuous variables between the laparoscopic and open treatment groups. Four converted cases were included in the open colectomy group. To address the first study objective, the colon cancer patients' demographic and clinical characteristics were compared between the laparoscopic and open treatment groups using parametric Chi-square or Fischer's Exact test for categorical variables and *t*-tests for continuous variables. The Wilcoxon Mann-Whitney test was used for non-normally distributed continuous data. Furthermore, the Cochran-Armitage test was used to examine linear associations for ordinal variables between the 2 treatment groups. Secondly, all factors significantly associated with treatment group in univariable analyses and variables clinically relevant were included in a multivariable logistic regression model, with stepwise selection to identify independent predictors of receiving laparoscopic treatment and to control for potential confounders. Any missing data were excluded from the final analysis. All analyses were conducted in SAS version 9.3 (SAS Institute, Inc., Cary, North Carolina). The significance level was set at $P < .05$ and 2-sided P values were reported.

Results

Of the 1,062 colon cancer patients examined, 302 (28%) had laparoscopic and 760 (72%) had open colon resection. Table 1 summarizes the patient demographic and clinical characteristics between the 2 treatment groups. Patients who received the open colon resection were more likely to be older than those receiving the laparoscopic surgery ($P < .001$). The open surgery group was more likely to have Medicaid or Medicare compared to the laparoscopic group (63.8% vs 56.0%; $P < .05$). A significantly greater proportion of patients in the open surgery group resided in rural counties compared to the laparoscopic group (59.9% vs 46.1%; $P < .001$). A number of clinical factors were also examined by treatment group. The majority of surgeries were elective; however, 19.2% of open surgeries were performed emergently compared to only 10.3% laparoscopically ($P < .001$). Patients who received the open surgery were significantly more likely to be diagnosed at late American Joint Committee on Cancer (AJCC) stage compared to the laparoscopic group ($P < .001$). Patients receiving the laparoscopic treatment had, on average, significantly smaller tumors compared to the standard surgery group ($P < .001$). Tumor characteristics were not significantly different between treatment groups. Table 2 shows that patients who underwent the laparoscopic treatment had significantly shorter hospital stays compared to the standard treatment (5.0 vs 7.0 days, $P < .01$). The average laparoscopic treatment was more expensive compared to the open procedure ($39,024 vs $36,610), but the difference in the median cost was not significant.

Multivariable Analyses

Table 2 shows the results of the multivariable analysis. Younger age was significantly associated with receipt of laparoscopic surgery ($X^2 = 9.02$, $P < .05$). Compared to patients aged 80 and older, those between the ages of 60 and 79 had 1.6 times the odds of receiving laparoscopic surgery and those younger than 60 years of age were almost 2 times more likely to receive laparoscopic surgery. Rural residents had significantly lower odds of receiving laparoscopic surgery compared to urban residents (OR=0.62; 95% CI: 0.46–0.85). Colon cancer patients diagnosed at an early AJCC stage (0-III) had greater odds of receiving laparoscopic surgery compared to those diagnosed at a late stage (OR=1.74; 95% CI: 1.24–2.43). As the average tumor size increased, the odds of laparoscopic surgery significantly decreased ($P < .05$). The number of comorbidities was significantly associated with receiving the laparoscopic surgery. Patients who had 3 or more existing comorbidities at the time of surgery had significantly greater odds of receiving the laparoscopic surgery (OR=1.51; 95% CI: 0.75–3.01).

Demographic and clinical characteristics were compared between rural and urban populations in order to describe factors associated with geographical location. Table 3 shows that rural residents were significantly older, with 16.1% of residents less than 60 years of age compared to 30% residing in urban counties ($P < .0001$). Race/ethnicity was found to be associated with geographic location, with urban areas having a higher proportion of non-Hispanic black, Hispanic black and other races compared to rural areas ($P < .0001$), again, consistent with population patterns in Nebraska. Marital status also varied by location, with a larger percentage of patients being married in urban counties (41.0%) compared to rural (33.1%) ($P < .05$). A larger proportion of rural residents were insured with Medicare or Medicaid or a combination of both (69.0% vs 51.1%), while more urban residents had private insurance (29.5% vs 17.4%) ($P < .0001$). More rural residents received the standard colectomy compared to laparoscopic ($P < .0001$) and had more emergency operations compared to those residing in urban locations ($P < .01$). The number of positive lymph nodes and number of lymph nodes examined were both significantly associated with geographic location. Nearly 10% of rural patients had 5–10 positive lymph nodes compared to 5% of urban ($P < .01$). Urban patients had a more extensive regional lymph node examination (≥11) compared to rural ($P < .01$). Although non-significant, on average urban residents waited longer for surgery than rural patients. We also examined the time from cancer diagnosis to treatment between rural and urban populations in Nebraska. A total of 454 (87.0%) rural patients were treated within 30 days compared to 344 (81.5%) of urban patients. Moreover, urban patients had, on average, a longer duration between diagnosis and treatment (15 days) compared to rural (12 days) ($P = .05$).

Discussion

This is the first published study to investigate the use of laparoscopic surgery for treatment of colon cancer between rural and urban residents in the Midwest. After adjusting for age, stage, clinical factors, and comorbidities, rural patients were 40% less likely to receive laparoscopic surgery. Other demographic and clinical factors independently predicted the receipt of laparoscopic surgery including: younger age at diagnosis, presence of 3 or more comorbidities, early stage at diagnosis, and a smaller tumor size. There are well-established benefits of the laparoscopic surgery over the standard open procedure for colon cancer treatment.[28] The laparoscopic colectomy is less invasive while maintaining and even surpassing the standard surgical approach in both short- and long-term outcomes.[1,29,30] Despite these potential advantages, there is significant variation in the utilization of the laparoscopic treatment for colon cancer in some settings.[1,6,31]

There are barriers to implementing minimally invasive surgery (MIS), including laparoscopy, in rural communities for surgeons, patients and hospitals. All surgeons learning the laparoscopic colectomy must overcome a steep learning curve, adapt to a longer operation and know when to make the decision to convert from the laparoscopic to the open procedure.[1] The laparoscopic colectomy is a complex procedure requiring a great amount of surgical skill and a sufficient case volume to maintain those skills. Therefore, circumstances alone may not permit the skilled rural surgeon to offer the minimally invasive treatment to his or her patients simply because there is not a steady demand for the procedure. Similar observations have been reported for many complex and minimally invasive procedures, including the treatment for prostate cancer.[20,32] Markin et al[20] found a noticeable decline in the number of prostatectomies performed in rural hospitals between 1998 and 2009 due to the advancements in robotic surgery, another minimally invasive surgery technique. Regardless of surgical approach, we found rural patients who underwent a colectomy had significantly fewer lymph nodes examined. A large proportion of rural patients had fewer than 12 lymph nodes examined, the recommended number of lymph nodes per specimen.[33,34]

Barriers also exist to rural colon cancer patients wanting to undergo the laparoscopic treatment. We found that rural residents were more likely to be older, have emergency/urgent admissions, a later stage at diagnosis, and larger tumor size compared to urban colon cancer patients. When considering these characteristics combined, they can influence a rural patient’s ability to safely undergo the laparoscopic treatment. Older patients diagnosed with late stage disease or presenting with an emergency admission are generally not good candidates for laparoscopic surgery. Furthermore, large and bulky tumors can be difficult to manage with the laparoscopic device in inexperienced hands. Concerns about resecting the entire tumor or encountering other anatomical challenges may influence the surgeon’s decision to use the open technique in order to ensure optimal resection and the patient’s safety. Although, if these clinical concerns could be managed by the surgical team, the laparoscopic treatment for colon cancer offers tremendous patient benefits over the standard open procedure including: a shorter hospital stay, less blood loss during surgery, and fewer wound infections leading to less pain and a faster recovery.[6,9,10] Last, rural hospitals may have difficulty affording the expensive equipment, especially if they expect to treat a low number of patients annually. Previous studies have shown that teaching and high-volume hospitals located in urban areas are performing a greater number of laparoscopic colectomies.[6,31] Rural hospitals are normally low-volume and can lack important resources necessary to offer specialized cancer treatment.[20,35,36] In addition to geographic location of residence, other factors independently predicted the receipt of laparoscopic surgery.

There were demographic and clinical factors found to be independently associated with receiving the laparoscopic colectomy. Younger age predicted the receipt of laparoscopic surgery, a finding consistent with several other studies.[2,37] However, as utilization of the laparoscopic colectomy increases, there is more recent evidence suggesting the minimally invasive surgery is safe and results in favorable outcomes in both young and elderly patients.[10,38] The presence of 3 or more comorbidities was predictive of laparoscopic surgery receipt after controlling for other patient characteristics. In support, some studies have found preexisting diagnoses don't influence treatment as much as patient age and other factors.[37] Feroci et al[38] found that patients considered at high risk because of the presence of serious comorbidities still experienced better outcomes after the laparoscopic surgery compared to the open. Yet other studies have shown patients with 3 or more comorbidities were less likely to undergo the minimally invasive procedure.[32] There are several different methods to creating a comorbidity index which could account for some of the differences. Variations in surgeon expertise, patient selection and hospital resources may also impact the ability to manage higher-risk patients including those with multiple comorbidities undergoing minimally invasive surgery.

Additional clinical factors predicted if a patient underwent the laparoscopic surgery. We found early stage disease independently predicted receipt of the minimally invasive procedure. Other studies have demonstrated a similar finding.[6,37] Late-stage disease can complicate the procedure and lead to concerns about clearing surgical margins and examining enough lymph nodes. However, a recent study showed that laparoscopic colectomy is safe and effective for advanced-stage colon cancer.[39] A smaller tumor size was predictive of receiving the laparoscopic surgery, as bulky or large tumors may be difficult to manipulate with the laparoscopic device. Patient characteristics including age, disease stage, comorbidities, and other clinical factors can influence their suitability for the minimally invasive surgery. The laparoscopic treatment results in better patient outcomes and should be available to all colon cancer patients regardless of location of residence.

We demonstrated a rural/urban disparity in receiving the minimally invasive surgery for colon cancer even after controlling for admission type (urgent vs elective), stage at diagnosis and other patient factors. We investigated the time between diagnosis and treatment between rural and urban patients but did not find differences that would explain a worsening of disease stage in rural patients making them less suitable than urban patients to receive the laparoscopic colectomy. However, a surgeon's preference for an open colectomy could be influenced by tumor characteristics (ie, invasion or adhesion to adjacent tissues) not included in our database. Based on the current study and previous findings the laparoscopic treatment results in better patient outcomes, and patient factors influencing selection for the minimally invasive procedure can be safely overcome.

Rural residents already experience difficulties accessing cancer screening and treatment services for many cancer types, and the minimally invasive procedure for colon cancer is no exception.[14,16,18,32,40,41] One contributing factor to the disparity is the present shortage and decline in residents seeking general surgery because the emphasis is now on specialized medicine.[36,42] It is simply not feasible to be a surgical specialist in a rural community because these hospitals rely on their surgeons to perform a wide range of procedures, often outside the scope of their initial training.[43] Therefore, the rural surgical workforce is aging and not being replenished, which directly influences treatment options for cancer patients relying on their expertise. An important but separate issue relates to the cost and reimbursements for surgeries performed on Medicare patients. Starting in 2011, the Affordable Care Act implemented a 10% bonus payment incentive program to general surgeons practicing in a health professional shortage area (HPSA) which would include many rural communities. [44] This policy is a step in the right direction for improving health care in rural areas.

As previously mentioned, practicing rural surgeons have several barriers to keeping up with advancing technology. In a recent needs assessment administered to a sample of rural surgeons, colon resection was reported as a commonly performed procedure and respondents indicated a strong desire to learn how to perform laparoscopic colon resections.[22] The challenges to rural surgical providers and to rural patients are not new; however, technological advancements in minimally invasive surgical techniques are driving the need for strategic solutions.[45] We recommend an increase in the number of general surgeons who have training in minimally invasive surgery techniques and who work in rural communities. This can be achieved through medical schools and rural health stakeholders working together to provide opportunities for training with a rural health surgical emphasis so graduates are confident and competent when starting to work in a rural hospital.

Currently, only 12 programs in the nation offer a subspecialty or rural training track as part of general surgery, and the majority are located in urban areas.[46] Only 8 general surgery programs in 6 Midwestern states (Kansas, Iowa, Illinois, Ohio, Michigan, and Wisconsin) successfully place surgeons in large or small rural areas.[46] In addition to training and education, these residents should be incentivized for their commitment to a rural practice through loan forgiveness or reimbursement. After accruing hundreds of thousands of dollars in debt, this incentive paired with educational opportunities would persuade some surgeons to practice in rural areas. Although the demands of a rural surgeon are vast and widely variable, future rural surgeons should be trained in minimally invasive procedures as they are replacing the standard due to improved postoperative patient outcomes and quality of life.

There are several strengths of the current study including utilization of a large, population-based linked dataset to draw inference on the entire state, allowing for a strong rural/urban comparison. We also demonstrated an existing disparity after controlling for numerous patient demographic and clinical characteristics associated with treatment received. However, we recognize there are limitations inherent in large administrative databases including limited clinical variables. We were unable to control for surgeon and hospital factors which could influence the treatment received. Furthermore, distance traveled between rural residence and treatment facility to better describe this disparity was not available in the study databases. We chose to include the 4 converted cases in the open colectomy treatment group to define predictors of the outcome to be cases who successfully underwent laparoscopic surgery. This grouping does not capture the "intent to treat" laparoscopically component or account for clinical factors influencing the surgeon's decision to convert. Nevertheless, the current results were not affected due to so few cases identified as converted. Lastly, our recommendations speak to increasing access to the laparoscopic colectomy in rural areas through increased training opportunities and support of the rural surgical workforce. We do not, however, address the challenges rural surgeons face when serving smaller populations in lower-volume hospitals, thus performing fewer colectomies each year compared to more specialized colorectal cancer surgeons in urban areas. As utilization and adoption of the minimally invasive surgery increases, it will be important for further research to be conducted on the short- and long-term outcomes of laparoscopic surgeries performed in rural hospitals.

Rural residents experience difficulties accessing cancer services including the laparoscopic colectomy. Certain rural patient characteristics may deter some surgeons from using the laparoscopic approach despite scientific evidence stating the procedure is safe and effective even in higher-risk and elderly patients. The tremendous benefits afforded by the laparoscopic colectomy will eventually regard it as the new gold standard. As the utilization, applicability and demand of the minimally invasive surgery increases, we provide evidence of this disparity in order to prompt academic institutions and rural health care organizations to address this treatment gap through training, education and monetary incentives for the next generation of rural surgeons.

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Table 1

Demographic and Clinical Characteristics of Study Population (N=1062)

	Laparoscopic (N=302) N (%)	Open (N=760) N (%)	*P* value
Gender			.90
Male	140 (46.4)	354 (46.6)	
Female	162 (53.6)	406 (53.4)	
Age group, year			< .001
<60	85 (28.2)	151 (19.9)	
60–69	71 (23.5)	183 (24.1)	
70–79	88 (29.1)	205 (27.0)	
≥80	58 (19.2)	221 (29.1)	
Race/Ethnicity			.84
Non-Hispanic white	286 (95.0)	717 (94.7)	
Other	15 (5.0)	40 (5.3)	
Marital status			.21
Married	197 (65.5)	464 (61.1)	
Unmarried	105 (34.8)	296 (39.0)	
Residence at diagnosis			< .001
Urban	151 (53.9)	276 (40.1)	
Rural	129 (46.1)	412 (59.9)	
Insurance payer			< .05
Private	81 (26.8)	158 (20.8)	
Medicaid/Medicare	169 (56.0)	485 (63.8)	
Admission type			< .001
Elective	271 (89.7)	614 (80.8)	
Emergency/Urgent	31 (10.3)	146 (19.2)	
Tumor location			.15
Cecum	90 (29.8)	175 (23.0)	
Ascending colon	59 (19.5)	153 (20.1)	
Hepatic flexure	16 (5.3)	44 (5.8)	
Transverse colon	23 (7.6)	90 (11.8)	
Splenic flexure	12 (4.0)	33 (4.3)	
Descending colon	18 (6.0)	34 (4.5)	
Sigmoid colon	71 (23.5)	180 (23.7)	
AJCC stage			< .001
0,I,II,IIIa	218 (72.2)	423 (55.8)	
IIIb, IV, NA, Occult	76 (25.2)	315 (41.6)	
Unknown	8 (2.7)	20 (2.6)	
Grade/Differentiation			.41

	Laparoscopic (N=302) N (%)	Open (N=760) N (%)	*P* value
Well	22 (7.3)	48 (6.3)	
Moderate	197 (65.2)	492 (64.9)	
Poor	39 (12.9)	135 (17.8)	
Undifferentiated	20 (6.6)	36 (4.8)	
Unknown	24 (8.0)	47 (6.2)	
Behavior			.09
Benign/Borderline	0 (0.0)	1 (0.1)	
In Situ	7 (2.3)	5 (0.7)	
Invasive	295 (97.7)	754 (99.2)	
Tumor size (cm), mean (SD)	3.8 (2.1)	4.4 (2.6)	< .001
Number of positive lymph nodes			
1–4	60 (19.9)	195 (25.7)	< .05
5–10	20 (6.6)	59 (7.8)	
>10	9 (3.0)	34 (4.5)	
No nodes examined	9 (3.0)	29 (3.8)	
Nodes examined were negative	204 (67.6)	437 (57.5)	
Number of regional lymph nodes examined			.70
1–10	29 (9.6)	86 (11.3)	
11–20	169 (56.0)	393 (51.7)	
21–30	63 (20.9)	170 (22.4)	
>30	32 (10.6)	72 (9.5)	
No nodes examined	9 (3.0)	29 (3.8)	
Charlson Comorbidity Index			.21
0	192 (63.6)	442 (58.2)	
1	67 (22.2)	209 (27.5)	
2	24 (8.0)	82 (10.8)	
3	19 (6.3)	27 (3.6)	

Table 2

Multivariable analysis (N=866)

	OR (95% CI)	Wald (X^2)	*P* value
Age group, year		9.02	< .05
<60	1.97 (1.24, 3.15)		
60–69	1.61 (1.03, 2.53)		
70–79	1.64 (1.07, 2.51)		
≥80	Reference		
Residence at diagnosis		8.90	< .01
Rural	0.62 (0.46, 0.85)		
Urban	Reference		
AJCC stage		10.32	< .005
Early (0-IIIa)	1.74 (1.24, 2.43)		
Late (111b- VI, unknown, occult, NA)	Reference		
Tumor size (cm)	0.933 (0.87,1.0)	4.10	< .05
Charlson Comorbidity Index		9.08	< .05
0	Reference		
1	0.79 (0.54, 1.15)		
2	0.49 (0.28, 0.87)		
≥3	1.51 (0.75, 3.01)		
Length of stay days, median	5.0	7.0	< .01
Total hospital charges ($), median	39,024	36,610	.91

Table 3

Demographic and Clinical Characteristics by County of Residence (N=968)

	Rural (N=541) N (%)	Urban (N=427) N (%)	*P* value
Gender			.30
Male	239 (44.2)	202 (47.3)	
Female	302 (55.8)	225 (52.7)	
Age group, year			< .0001
<60	87 (16.1)	128 (30.0)	
60–69	142 (26.3)	85 (19.9)	
70–79	149 (27.5)	119 (27.9)	
≥80	163 (30.1)	95 (22.3)	
Race/Ethnicity			< .0001
Non-Hispanic White	531 (98.3)	382 (89.9)	
Other	9 (1.7)	43 (10.1)	
Marital status			< .05
Married	179 (33.1)	175 (41.0)	
Unmarried	362 (66.9)	252 (59.0)	
Insurance payer			< .0001
Private	94 (17.4)	126 (29.5)	
Medicaid/Medicare	373 (69.0)	218 (51.1)	
Other	74 (13.7)	83 (19.4)	
Treatment group			
Laparoscopic	129 (23.8)	151 (35.4)	< .0001
Open	412 (76.2)	276 (64.6)	
Admission type			< .01
Elective	441 (81.5)	379 (88.8)	
Emergency/Urgent	100 (18.5)	48 (11.2)	
Tumor location			.89
Cecum	135 (25.0)	108 (25.3)	
Ascending colon	109 (20.2)	88 (20.6)	
Hepatic Flexure	35 (6.5)	21 (4.9)	
Transverse colon	61 (11.3)	43 (10.1)	
Splenic Flexure	27 (5.0)	16 (3.8)	
Descending colon	27 (5.0)	24 (5.6)	
Sigmoid colon	121 (22.4)	104 (24.4)	
AJCC stage			< .005
0,I,II,IIIa	305 (56.5)	287 (67.4)	
IIIb, IV, NA, Occult	217 (40.2)	134(31.5)	
Unknown	18 (3.3)	5 (1.2)	

	Rural (N=541) N (%)	Urban (N=427) N (%)	*P* value
Grade/Differentiation			.26
Well	28 (5.2)	29 (6.8)	
Moderate	367 (68.1)	271 (63.5)	
Poor	95 (17.6)	62 (14.5)	
Undifferentiated	18 (3.3)	36 (8.4)	
Unknown	31 (5.8)	29 (6.8)	
Behavior			.09
In Situ	4 (<1)	9 (2.11)	
Invasive	537 (99.3)	418 (97.9)	
Tumor size (cm), mean (SD)	4.4 (2.4)	4.1 (2.5)	.16
Number of positive lymph nodes			< .01
1–4	130 (24.0)	100 (23.4)	
5–10	52 (9.6)	20 (4.7)	
>10	25 (4.6)	15 (3.5)	
No nodes examined	18 (2.6)	11 (2.6)	
Nodes examined were negative	313 (57.9)	279 (65.3)	
Number of regional lymph nodes examined			< .01
1–10	76 (14.1)	28 (6.6)	
11–20	274 (50.7)	232 (54.3)	
21–30	118 (21.8)	104 (24.4)	
>30	50 (9.2)	48 (11.2)	
No nodes examined	18 (3.3)	11 (2.6)	
Charlson Comorbidity Index			.13
0	330 (61.0)	251 (58.8)	
1	143 (26.4)	100 (23.4)	
2	46 (8.5)	55 (12.9)	
3	22 (4.1)	21 (4.9)	
Days between diagnosis and treatment			.05
Median	12.0	15.0	
Mean (SD)	18.3 (31.2)	20.4 (34.2)	
<30	454 (87.0)	344 (81.5)	.06
30–59	50 (9.6)	65 (15.4)	
60–89	5 (<1)	4 (<1)	
≥90	13 (2.5)	9 (2.1)	