HHS Public Access
Author manuscript
J Gastrointest Surg. Author manuscript; available in PMC 2024 July 27.

Published in final edited form as:
J Gastrointest Surg. 2023 June ; 27(6): 1228–1237. doi:10.1007/s11605-023-05656-2.

Patterns of Care and Outcomes of Rectal Cancer Patients from the Iowa Cancer Registry: Role of Hospital Volume and Tumor Location

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Abstract

Background: Centralization of rectal cancer surgery has been associated with high-quality oncologic care. However, several patient, disease and system-related factors can impact where patients receive care. We hypothesized that patients with low rectal tumors would undergo treatment at high-volume centers and would be more likely to receive guideline-based multidisciplinary treatment.

Methods: Adults who underwent proctectomy for stage II/III rectal cancer were included from the Iowa Cancer Registry and supplemented with tumor location data. Multinomial logistic regression was employed to analyze factors associated with receiving care in high-volume hospital, while logistic regression for those associated with ≥12 lymph node yield, pre-operative chemoradiation and sphincter-preserving surgery.

Results: Of 414 patients, 38%, 39%, and 22% had low, mid, and high rectal cancers, respectively. Thirty-two percent were >65 years, 38% female, and 68% had stage III tumors. Older age and rural residence, but not tumor location, were associated with surgical treatment in low-volume hospitals. Higher tumor location, high-volume, and NCI-designated hospitals had higher nodal yield (≥12). Hospital-volume was not associated with neoadjuvant chemoradiation rates or circumferential resection margin status. Sphincter-sparing surgery was independently associated with high tumor location, female sex, and stage III cancer, but not hospital volume.

Conclusions: Low tumor location was not associated with care in high-volume hospitals. High-volume and NCI-designated hospitals had higher nodal yields, but not significantly higher

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All authors have provided substantial contribution to this work, including drafting/revising the manuscript, and approved the final version. All authors agree to be accountable for all aspects of this work.

Disclosure: The authors have nothing to disclose.

neoadjuvant chemoradiation, negative circumferential margin, or sphincter preservation rates. Therefore, providing educational/quality improvement support in lower volume centers may be more pragmatic than attempting to centralize rectal cancer care among high-volume centers.

Keywords

Rectal cancer; Hospital volume; Rural surgery; Tumor location; Outcomes

Introduction

Current National Comprehensive Cancer Network (NCCN) guidelines for locally advanced rectal cancer (LARC) recommend the use of preoperative chemotherapy and radiation followed by an oncologic proctectomy.[1] In the United States, the quality of this care pathway has been evaluated by standard metrics including the appropriate use of neoadjuvant chemoradiation, ≥12 lymph-node yield, and rates of sphincter-preservation and negative margins.[2, 3] Historically, adherence to these guidelines has been variable across the country, resulting in worse outcomes when compliance was low.[2, 4] Studies investigating the reasons for non-adherence to guideline-based treatments have identified several patient, disease, and system related variables, including age, socioeconomic factors, tumor distance from the anal verge, and surgeon/institution volume.[5, 4, 6, 7]

In a Surveillance, Epidemiology, and End Results (SEER)-Medicare data analysis, LARC patients who underwent surgical resection at National Cancer Institute (NCI) designated cancer centers or hospitals with residency programs or medical school affiliations were more likely to receive guideline concordant care.[8] However, no difference in the proportion of patients undergoing sphincter-preserving surgery by facility type was observed. Similar findings were reported in another SEER patterns of care study, which analyzed a nationally representative sample of rectal cancer patients, showing that the receipt of guideline-recommended preoperative chemoradiation was significantly associated with treatment at larger hospitals (defined as >500 beds).[9]

Sphincter-preservation rates in the United States have been reported to vary between 48-77% and are impacted, besides tumor factors, by patient demographics, education, geography, and surgery center volume.[10] While these factors have been studied individually in various populations, they have not been evaluated in the same cohort, making it challenging to discern whether the difference in quality of care is due to unmeasured case mix differences or actual variation in practice across institutions. For instance, tumors in the distal rectum are less likely to undergo sphincter-preservation but are thought to be more likely treated in high-volume institutions, while proximal tumors may not always need neoadjuvant treatment but have a greater likelihood of sphincter-preservation.

In this context, we sought to evaluate the association between patient demographics, tumor location, receipt of neoadjuvant chemoradiation, sphincter-sparing rates, and hospital-volume in the same state-wide patient cohort. We hypothesized that patients with low rectal tumors would be treated at high-volume hospitals, and that treatment at high-volume hospitals would be associated with increased rates of compliance to NCCN guidelines and sphincter-preserving approaches. Therefore, using Cancer Registry data from the rural state of Iowa (ICR), the current study aimed to: 1) determine demographic and clinicopathologic features, including rectal tumor location, associated with receiving care at high-volume hospitals; and 2) evaluate the association between hospital-volume and guideline recommended care including lymph node yield, pre-operative chemoradiation, and rates of sphincter-preserving surgery.

Patients & Methods

Patient Population

The ICR was queried for adults with microscopically confirmed stage II/III rectal cancer between 2013-2017 who received cancer-directed surgery. This is a population-based active surveillance registry and a member of the National Cancer Institute's SEER program. It collects patient demographics, tumor characteristics, treatment data, and follow-up information on all cancers diagnosed or treated among residents of the state of Iowa.[11] Distance from anal verge was coded as high, medium or low by a general surgery resident (GX) and ICR registrars. Because data on tumor height were collected as part of a study in which patients would be surveyed,[12] inclusion criteria specified that patients had to be presumed to be alive as of October 2018. Exclusion criteria included having been diagnosed with another malignancy prior to rectal cancer, dying before receiving the survey, not receiving treatment with curative intent, wrong mailing address, and tumor abstraction after October 2018.

Study Variables

Patient demographics included age at diagnosis, sex, race/ethnicity, marital status at diagnosis, insurance, education, income, and rurality. Education, income, and rurality were categorized using residential Zone Improvement Program (ZIP) code. Education and income were extracted from the American Community Survey.[13] Education was based on the percentage of individuals in the residential ZIP code with at least a bachelor's degree split into quartiles (Quartile 1 (Q1): 0-27.5%, Q2-Q3: 27.8-38.1%, and Q4: 38.1-100%). Income was the average family income within the residential ZIP code. Utilizing the Rural-Urban Commuting Area (RUCA) 3-tier scheme developed at the University of Washington, rurality was classified into urban, large rural, and small rural.[14] ICR data were employed to describe hospitals where patients underwent surgery. NCI designation was determined by the NCI Cancer Center online directory and included both NCI-designated Cancer hospitals and NCI-designated Comprehensive Cancer Centers.

Tumor characteristics included AJCC 7th edition stage, rectal tumor location, surgery type, receipt of radiation and chemotherapy as part of first course treatment. Patients undergoing low anterior resection (primary surgery site codes 30, 40) and abdominoperineal resection (codes 50, 70) were included. A hierarchy of available data to categorize tumor location was followed: 1) distance from anal verge (low: <6 cm, mid: 6-12 cm, high: >12-16 cm), 2) distance from dentate line, 3) distance from the anorectal ring, anal sphincter, or rectosigmoid junction, 4) location described as "low/distal", "middle", or "high/proximal", 5) provider note of tumor being palpable on digital rectal exam (yes: low).

Data on proctectomies performed in Iowa hospitals were obtained from the Iowa Hospital Association (IHA) to investigate surgery volume. All discharge data records from the IHA with ICD-9 procedure codes 48.31 or 48.4-48.69, or ICD-10 codes 0DT.P0ZZ, 0DT.P4ZZ, 0DT.P7ZZ, 0DT.P8ZZ were included. The number of procedures each hospital performed were calculated. Patients who did not have a primary diagnosis of colorectal cancer or underwent local excision, destruction, or polypectomy surgeries were excluded. Surgical volume was categorized by the average number of proctectomies/year into low- (≤ 3), medium- (4-15), and high-volume (≥16) hospitals.[12]

Statistical analyses

In univariate analysis, Chi-square tests were for categorical variables and 2-sided t-tests were used for continuous variables. Variables with a cell count below 5 were omitted and replaced with a "*" per ICR privacy policies. Multinomial logistic regression was conducted comparing low- or medium- vs high-volume surgery hospitals. Additionally, logistic regression models were used to assess the following outcomes: nodal yield ≥12, neoadjuvant chemoradiation therapy, and sphincter-preserving low anterior resection (LAR) versus abdominoperineal resection (APR). This study was approved by the University of Iowa Institutional Review Board. Analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC).

Results

Of the 1,781 rectal cancers diagnosed between 2013 and 2017, 789 were microscopically confirmed stage II/III at the time of diagnosis and of those 664 received cancer directed surgery: 564 were first primaries. Among them, 61 patients did not meet inclusion criteria, while 89 (17.7%) died before the end of October 2018. Therefore, a total of 414 patients were included: 32% were >65 years, 38% were female, and 4% non-white. Over 50% were living in rural areas. Tumor location was categorized as low in 39% of cases, mid in 38%, and high in 22%. Overall, 32% were stage II, and 68% stage III. Seventy percent of the patients underwent a LAR and 30% an APR, with 14% of the proctectomies performed at low-, 21% at medium-, and 65% at high-volume hospitals.

Cohort by Tumor location

The distribution of age, sex, race, marital status, insurance status, income, education, rurality, and stage did not differ by tumor location (Table 1). Sphincter-sparing surgery was more commonly performed for higher tumor locations, with 36% of low, 86% of mid, and 98% of high tumors undergoing a LAR as opposed to an APR (p<0.001). Similarly, there was an increased rate of nodal yield ≥12 in those patients with high tumor location (p=0.003), while neoadjuvant chemoradiation was more frequently administered to individuals with low rectal tumors (low=80%, mid=78%, high=47%, p=0.001).

Hospital Surgical Volume

In univariate analysis, patients >65 years, those residing in small rural areas, and with median household income of <$50,000 were more likely to undergo surgery at low-volume hospitals (Table 2). There were no differences in gender, race, marital and insurance status, overall stage, tumor location, sphincter-preserving surgery, and neoadjuvant chemoradiation rates among the three hospital-volume groups. A lower proportion of patients had nodal yield ≥12 at low-volume hospitals as compared to medium- and high-volume facilities (p=0.001).

In multinomial logistic regression comparing patients who received surgery at low- and medium-volume hospitals versus high-volume hospitals, older age and living in small rural areas remained associated with increased odds of having surgery at a low-volume hospitals (OR= 2.5, 95% confidence interval [CI] 1.3-4.7, and OR= 2.6, CI 1.2-5.4, respectively; Table 3). Tumor location and stage were not significantly associated with hospital-volume.

Neoadjuvant Chemoradiation therapy

In univariate analysis, older individuals (>65 years) received chemoradiation therapy less often than younger patients (29% vs 39%, p=0.043; analyses not shown). No differences were observed in rates of neoadjuvant therapy based on gender, race, marital and insurance status, rurality, income, education, or tumor stage. However, neoadjuvant chemoradiation was more often administered to patients with low tumors (low =44%, mid=42%, high=15%, p=0.001), and was associated with significantly lower rates of nodal yield ≥12 (76% vs 87%, p=0.012).

On multivariable analysis, demographic characteristics and hospital-volume were not associated with receipt of neoadjuvant chemoradiation (Table 4). Patients living in small rural areas were less likely to receive neoadjuvant chemoradiation compared to individuals in urban areas (OR= 0.5, CI 0.3-0.8), but no difference was found between large rural and urban areas. High tumor location was associated with lower odds of undergoing neoadjuvant chemoradiation compared to low tumors (OR= 0.2, CI 0.1-0.4).

Surgical approach

Females were more likely to undergo LAR rather than APR (42% vs 27%, p=0.001; analyses not shown). Surgical approach did not differ by age, race, marital or insurance status, rurality, income, and education level. Additionally, there was a similar distribution of nodal status, overall stage, and lymph node yield between the two groups. Patients with lower tumors were more likely to undergo an APR (65%) than LAR (36%, p=0.001) and to receive neoadjuvant chemoradiation (p=0.005). Among patients with available data on circumferential resection margin (CRM; 74%), 6% (n=18) were positive. There was no difference based on hospital-volume (p=0.06), although CRM involvement increased with proximity to the anal verge in all low, mid, and high-volume institutions (data not shown per registry policy).

In multivariate analysis, compared to APR, males had lower odds of receiving a LAR (OR= 0.5, CI 0.3-0.8; Table 5). Conversely, patients with mid and high tumors were more likely to have a LAR than those with low tumors (mid: OR= 13.3, CI 7.3-24.5; high: OR= 111.8, CI 25.5-489.9). Hospital-volume was not associated with differences in surgical approach.

Nodal Yield

In unadjusted analyses, nodal yield ≥12 was significantly associated with older age, living in an urban area, higher income levels, higher education, and high tumor location, but not with gender, race, marital status, insurance status, overall stage, and surgical approach.

After adjustment for available confounders, older age, higher income, high tumor location, and lack of neoadjuvant chemoradiation were found to be significantly associated with a nodal yield ≥12. Additionally, patients undergoing surgery at low-volume hospitals had lower odds of a nodal yield ≥12 compared to mid- and high-volume hospitals (OR= 0.4, CI 0.2-0.8; Table 6).

Discussion

In this population-based cohort of patients from a rural state with locally advanced rectal cancer, we observed that younger individuals and those living in urban settings were more likely to undergo treatment at high-volume hospitals, while location of the tumor did not impact where patients received surgical care. Patients who underwent surgical resection at low-volume hospitals compared to mid- and high-volume hospitals were less likely to have a nodal yield of ≥12. However, treatment at high-volume institutions was not associated with higher rates of receiving neoadjuvant chemoradiation, negative CRM, or sphincter-preserving surgeries.

Following the individual diagnosis of rectal cancer in a patient, the subsequent setting where they receive care is influenced by the diagnosing endoscopist, the referring providers, and the multidisciplinary team that eventually treats the patient. These dynamics are further impacted by patient preferences and characteristics, as well as the patients' healthcare system. In our cohort, older age and living in a rural area were associated with receiving care at low-volume hospitals. These findings are consistent with the findings of Chioreso et al., who found that among older patients with stage II/III rectal adenocarcinoma (n=1,601) those living in rural communities were less likely to seek care at high-volume hospitals.[15] Among the disease specific factors that can affect where patients undergo treatment is the location of the tumor, as distal or low rectal cancers are more likely to require an APR, considered to require greater technical expertise and more likely to be performed in high-volume hospitals. However, our data suggests that rectal tumor location does not significantly impact where patients with LARC receive surgical care. These findings, along with observations from other studies, suggest that certain subsets of patients may have practical issues like transportation and/or prefer the familiarity with their local hospital.[16] As a result, these factors may be more influential in where they receive care rather than the specific features of their cancer or the knowledge of the quality of care in high-volume centers.[16] This contention is supported by findings from a consumer survey of 2,004 random adults throughout the United States that found that the most influential factors in the decision making of where to receive care were hospital reputation (62%) and primary care physician opinion (53%).[17] While hospital-volume was an important factor for 37% of the cohort, just above risk of death (35%); guidelines adherent care was relevant for only 18% of the patients.

Several reports have demonstrated that patients being treated at high-volume hospitals are more likely to receive guideline concordant care and have better outcomes.[18, 19] Del Paggio et al. in an Ontario population-based cohort study showed that hospital-volume was associated with a significantly higher nodal yield amongst colorectal cancer patients.[20] Our analyses also found that high-volume hospitals were more likely to remove/examine ≥12 lymph nodes and corresponds to findings from previous studies supporting the relationship between high-volume and achievement of such performance metrics for rectal cancer.[2, 21] It is also necessary to consider the fact that in our study this difference in lymph node yield was only between low-volume hospitals (<3 cases/year) compared to mid- (4-15) and high (>16) volume hospitals, while it was similar between the mid and high-volume hospitals. In fact, the perceived adverse impact of receiving care in low-volume hospitals compared to high-volume hospital has not been consistently demonstrated in the literature.[22, 23] A significant consideration in the studies evaluating this relationship has been the volume cut-offs that were used and if they are clinically relevant. It is likely that some of the variations in the associations between oncologic outcomes and surgical volumes are in part due to difference in case definitions and study methodology rather than variations in actual care delivery. Furthermore, the yield of lymph nodes can be independently impacted by neoadjuvant treatment, as shown with our analyses, and is also a function of the pathologists who examine the specimen and not just the quality of the surgery.[24]

In contrast to our hypothesis, hospital-volume did not correlate with other quality metrics, such as rates of sphincter-preservation, CRM involvement, or receipt of neoadjuvant chemoradiation. The association between hospital-volume and sphincter-preservation rates in previous reports has been inconsistent and confounded by the fact that tumor location was not always accounted for in the analysis. While low tumors are more likely to require an APR due to oncologic considerations, high APR rates can be due to the lack of expertise in sphincter-preservation. We did not observe an association between hospital-volume and rates of sphincter-preservation after adjustment for patient and disease characteristics including tumor location. Similarly, in a retrospective study of 1,469 patients with rectal adenocarcinoma, Leonard et al. found that high-volume hospitals were not significantly associated with higher rates of sphincter-preservation.[25] Conversely, in a 2004 nested cohort study of 1,330 patients with LARC, Meyerhardt et al. reported a significantly increased rate of APR at low-volume hospitals compared to larger institutions (46% vs 32%, $p<0.001$), regardless of tumor distance from the anal verge.[26] This study differed methodologically from ours in that it was conducted on patients enrolled in a neoadjuvant treatment trial. Therefore, these patients were under strict treatment protocols and may not have experienced therapeutic variations between high- and low-volume hospitals as would normally be seen.

Finally, our study found that while neoadjuvant chemoradiation rates varied by tumor location, consistent with current practice guidelines, it was not associated with hospital-volume.[27, 1] These findings stand in contrast to those by Gan et al., who in a cohort of 1,896 patients with LARC, found that treatment at large academic centers was associated with higher likelihood of receiving neoadjuvant therapy, although tumor location was not available to the investigators.[28]

Centralization of cancer care has been advocated as a means of improving quality of care and oncologic outcomes in rectal cancer.[2, 29, 30] The rationale stems from data demonstrating improved adherence to performance and quality measures at high-volume hospitals.[5, 31] Our data demonstrate that low- and medium-volume hospitals in rural Iowa are able to achieve important performance measures, including neoadjuvant chemoradiation, CRM clearance, and sphincter-preservation, at rates comparable to high-volume hospitals. The relevance of these observations are contextualized by the fact that low- and mid-volume hospitals often serve a greater proportion of patients who are older, Black and Hispanic, Medicare and/or Medicaid, and who do not want to travel far for care.[32, 33] As such, centralization or regionalization of health care to high-volume hospitals has the potential to worsen healthcare inequalities, decrease access to care in rural areas, and exacerbate workload at potentially overburdened high-volume hospitals.[34–37]

The limitations of this retrospective cohort study include the inability to directly evaluate causality between measured outcomes and study variables. This cohort is derived from a secondary analysis of a 2018 survey study of rectal cancer patients; therefore, only those who survived and were able to complete the questionnaire were included. Because of the unknown number of patients who died before the survey was administered, there is a significant potential for selection bias which could impact current findings. Therefore, these data should be interpreted in the context of this limitation. Due to lack of granularity, certain confounders may not be adjusted for, such as chemoradiation regimens, grade of mesorectal specimen, rate of complete pathologic response, or individual surgeon volume and specialty. Presenting patient symptoms such as obstruction or perforation which may determine whether a patient receives upfront surgical intervention instead of neoadjuvant chemoradiation are not recorded in the database. Moreover, survival and recurrence data were also not available; however, the focus of this study was short-term oncologic outcomes and care patterns. This study also focused on a rural, Midwestern state with a largely homogenous population, which limits its generalizability to the United States population.

In conclusion, in this state-wide cohort of LARCs, while older patients and those living in rural areas were less likely to receive care at a high-volume hospital, tumor location did not impact patterns of care, suggesting that the decision of where to receive multidisciplinary rectal cancer care might be mainly driven by geographic convenience. Although medium and high-volume hospitals were more often associated with nodal yield ≥12, they did not have higher neoadjuvant chemoradiation, negative CRM, or sphincter-preservation rates. Our results suggest that centralization of care should be based on pragmatic and practical considerations, and that providing educational and quality improvement support focused on nodal yield would be beneficial for health care providers practicing in low-volume centers.

Acknowledgments

This research was supported by NIH/NCI contract number HHSN261201800012I/HHSN26100001 (MEC, ARK); NIH/NCI K07 Cancer Prevention, Control, Behavioral Sciences and Population Sciences Career Development Award: 1K07CA197067 (MEC, NJD); NIH grant T32 CA 148062 (XG), and NIH/NCI P30 CA086862 (MEC, ARK).

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Table 1.

Association between clinicopathologic characteristics and tumor location in patients with stage II/III rectal cancers who underwent resection.

Characteristics	Tumor Location			p-value
Total	***Low*** **N=162 (%)**	***Mid*** **N=160 (%)**	***High*** **N=92 (%)**	
Age >65 years old	55 (34.0)	44 (27.5)	33 (35.9)	0.300
Female Sex	54 (33.3)	71 (44.4)	31 (33.7)	0.083
Non-white Race	5 (3.1)	5 (3.1)	5 (5.4)	0.574
Married	104 (64.2)	104 (65.0)	68 (73.9)	0.244
Public Insurance	90 (55.6)	76 (47.5)	45 (48.9)	0.318
Rurality				0.421
Small rural	60 (37.0)	68 (42.5)	29 (31.5)	
Large rural	24 (14.8)	18 (11.3)	16 (17.4)	
Urban	78 (48.2)	74 (46.3)	47 (51.1)	
Income				0.366
$35000 to 50000	46 (28.6)	49 (30.8)	22 (24.2)	
$50001 to 75000	101 (62.7)	92 (57.9)	54 (59.3)	
>$75000	14 (8.7)	18 (11.3)	15 (16.5)	
Bachelor’s Degree				0.436
<1st quartile	42 (25.9)	39 (24.4)	19 (20.9)	
1st-3rd quartile	75 (46.3)	88 (55.0)	47 (51.7)	
>3rd quartile	45 (27.8)	33 (20.6)	25 (27.5)	
Nodal stage				0.125
N0	43 (2.6.5)	50 (31.3)	38 (41.3)	
N1	90 (55.6)	87 (54.4)	45 (48.9)	
N2	29 (17.9)	23 (14.4)	9 (9.8)	
Overall Stage				0.052
II	43 (26.5)	50 (31.3)	38 (41.3)	
III	119 (73.5)	110 (68.8)	54 (58.7)	
Nodal Yield ≥12	127 (78.4)	117 (73.1)	84 (91.3)	**0.003**
Surgical Volume				0.491
Low	16 (10.5)	22 (14.3)	16 (17.8)	
Medium	35 (22.9)	32 (20.8)	15 (16.7)	
High	102 (66.7)	100 (64.9)	59 (65.6)	
Surgery				**<.001**
Abdominoperineal Resection	100 (64.5)	22 (13.8)	*	
Low Anterior Resection	62 (35.5)	138 (86.2)	90 (97.8)	
National Cancer Institute designated	44 (28.6)	40 (26.0)	16 (17.6)	0.150
Preoperative chemoradiation	129 (79.6)	124 (77.5)	43 (46.7)	**0.001**

Bolded p-values meet statistical significance ($p < .05$). Variables with cell counts below 5 were omitted and replaced with a "*" per Iowa Cancer Registry privacy policies.

Table 2.

Association between clinicopathologic characteristics and hospital surgical volume for patients with stage II/III rectal cancers who underwent resection.

Characteristics	**Surgical Volume**			**p-value**
Total	***Low N=55 (%)***	***Medium N=84 (%)***	***High N=261 (%)***	
Age >65 years old	27 (49.1)	26 (31.0)	73 (28.0)	**0.009**
Female Sex	24 (43.6)	28 (33.3)	97 (37.2)	0.47
Non-white Race	*	*	11 (4.2)	0.346
Married	39 (70.9)	52 (61.9)	176 (67.4)	0.504
Public Insurance	33 (60.0)	47 (56.0)	122 (46.7)	0.108
Rurality				**0.017**
Small rural	29 (52.7)	29 (34.5)	92 (35.3)	
Large rural	11 (20.0)	9 (10.7)	37 (14.2)	
Urban	15 (27.3)	46 (54.8)	132 (50.6)	
Income				**0.001**
$35000-50000	26 (48.2)	19 (22.6)	68 (26.2)	
$50001-75000	27 (50.0)	58 (69.1)	152 (58.5)	
>$75000	*	7 (8.3)	40 (15.4)	
Bachelor’s Degree				**0.004**
<1st quartile	15 (27.3)	18 (21.4)	62 (23.9)	
1st-3rd quartile	37 (62.3)	46 (54.8)	120 (46.2)	
>3rd quartile	3 (5.5)	20 (23.8)	78 (30.0)	
Nodal Stage				0.113
N0	22 (40.0)	19 (22.6)	86 (33.0)	
N1	27 (49.1)	47 (56.0)	141 (54.0)	
N2	6 (10.9)	18 (21.4)	34 (13.0)	
Overall Stage				0.077
II	22 (40.0)	19 (22.6)	86 (33.0)	
III	33 (60.0)	65 (77.4)	175 (67.1)	
Surgery Group				0.175
Abdominoperineal resection	11 (20.0)	29 (34.5)	80 (30.7)	
Low anterior resection	44 (80.0)	55 (65.5)	181 (69.3)	
Nodal Yield ≥12	34 (61.8)	70 (83.3)	216 (82.8)	**0.001**
Tumor Location				0.491
Low	16 (29.6)	35 (42.7)	102 (39.1)	
Mid	22 (40.7)	32 (39.0)	100 (38.3)	
High	16 (29.6)	15 (18.3)	59 (22.6)	
Preoperative chemoradiation	36 (65.5)	57 (67.9)	192 (73.6)	0.358

Bold p-values meet statistical significance ($p < .05$). Variables with cell counts below 5 were omitted and replaced with a “*” per Iowa Cancer Registry privacy policies.

Table 3.

Multinomial logistic regression analysis comparing clinicopathologic characteristics and hospital surgical volume for patients with stage II/III rectal cancers who underwent resection.

Variable		Hospital Surgical Volume	Odds Ratio	95% Confidence Interval		P-value
				Lower bound	Upper bound	
Age	> 65 years vs ≤ 65 years	low	2.45	1.29	4.65	**0.006**
	> 65 years vs ≤ 65 years	medium	1.26	0.73	2.19	0.411
Rurality	Large rural vs Urban	low	2.61	1.04	6.58	**0.041**
	Large rural vs Urban	medium	0.73	0.33	1.64	0.445
	Small rural vs Urban	low	2.59	1.24	5.39	**0.011**
	Small rural vs urban	medium	0.90	0.51	1.55	0.684
Tumor location	Medium vs Low	low	1.79	0.83	3.87	0.140
	Medium vs Low	medium	0.95	0.54	1.66	0.852
	High vs Low	low	2.07	0.89	4.82	0.093
	High vs Low	medium	0.78	0.39	1.56	0.482
Tumor stage	III vs II	low	0.78	0.41	1.50	0.460
	III vs II	medium	1.73	0.96	3.12	0.069

Bold p-values meet statical significance (p <.05).

High-volume hospital was the reference group.

Table 4.

Multivariable analysis comparing clinicopathologic characteristics and receipt of chemoradiation for patients with stage II/III rectal cancers who underwent resection.

Variables		Odds Ratio	95% confidence interval		P-Value
			Lower Bound	Upper Bound	
Rectal volume	Low vs High	0.74	0.35	1.56	0.429
	Medium vs High	0.65	0.37	1.16	0.142
Tumor location	Mid vs Low	0.79	0.44	1.39	0.409
	High vs Low	0.19	0.10	0.35	**<.001**
Age	> 65 years vs ≤ 65 years	0.67	0.40	1.11	0.116
Nodal Yield	≥12 vs <12	2.00	1.02	3.93	**0.043**
Marital status	Married vs Unmarried	1.45	0.87	2.41	0.158
Rurality	Large rural vs Urban	0.84	.40	1.77	0.652
	Small rural vs Urban	0.49	0.29	0.84	**0.010**

Bold p-values meet statistical significance (p <.05).

Table 5.

Multivariable analysis comparing clinicopathologic characteristics and odds of undergoing low anterior resection for patients with stage II/III rectal cancers who underwent resection.

Effect		Odds Ratio	95% confidence interval		P-Value
			Lower Bound	Upper Bound	
Rectal volume	Low vs High	0.99	0.39	2.54	0.989
	Medium vs High	0.85	0.43	1.69	0.645
Tumor location	Mid vs Low	13.34	7.26	24.54	**<.001**
	High vs Low	111.78	25.51	489.88	**<.001**
Sex	Male vs Female	0.46	0.26	0.84	**0.010**
Stage	III vs II	1.98	1.06	3.67	**0.031**
Income	$35000-50000 vs >$75000	2.29	0.84	6.2	0.104
	$50000-75000 vs >$75000	2.33	0.93	5.85	0.071

Bold p-values meet statistical significance (p< .05).

Table 6.

Multivariable analysis comparing clinicopathologic characteristics and nodal yield ≥12 for patients with stage II/III rectal cancers who underwent resection.

Effect		Odds Ratio	95% confidence Interval		P-value
			Lower Bound	Upper Bound	
Tumor location	Mid vs Low	0.71	0.40	1.26	0.24
	High vs Low	2.75	1.09	6.97	**0.033**
Age	> 65 years vs ≤ 65 years	0.51	0.29	0.89	**0.017**
Preoperative chemoradiation	Received vs Not received	0.51	0.26	0.99	**0.048**
Rectal volume	Low vs High	0.40	0.20	0.84	**0.015**
	Medium vs High	1.11	0.56	2.21	0.766
Income	$35000-50000 vs >$7500	0.14	0.03	0.62	**0.01**
	$50000-75000 vs >$75000	0.25	0.06	1.08	0.063

Bold p-values meet statistical significance (p< .05).