Rural hospitals are not associated with worse postoperative outcomes for colon cancer surgery

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Running Head: Rural Hospitals and Colon Cancer Surgery

Key Words: access to care, cancer, colon, rural, surgery

Abstract

Purpose: We sought to determine whether colorectal cancer surgery can be done safely at rural hospitals. The current study compared outcomes among rural patients who underwent colon resection at rural and non-rural hospitals.

Methods: Medicare beneficiaries who underwent colon resection for cancer between 2013 and 2017 were identified using the Medicare Inpatient Standard Analytic Files. Patients and hospitals were designated as rural based on rural-urban continuum codes. Risk-adjusted postoperative outcomes and hospitalization spending were compared among patients undergoing resection at rural versus non-rural hospitals.

Results: Among 3,937 patients who resided in a rural county and underwent colon resection for cancer, mean age was 76.3 (SD: 7.1) years and 1,432 (36.4%) patients underwent operative procedure at a rural hospital. On multivariable analyses, no differences in postoperative outcomes were noted among Medicare beneficiaries undergoing colon resection for cancer at non-rural versus rural hospitals. Specifically, the risk-adjusted probability of experiencing a postoperative complication at a non-rural hospital was 15.4% (95% CI: 14.1%-16.8%) versus 16.3% (95% CI: 14.2%-18.3%) at a rural hospital (OR 1.08, 95% CI: 0.85-1.38); 30-day mortality (non-rural: 2.9%, 95% CI: 2.2-3.6 vs. rural: 3.5%, 95% CI: 2.4-4.5) was also comparable. In addition, price standardized, risk-adjusted expenditures were similar at non-rural ($18,610, 95% CI: $18,037-$19,183) and rural ($19,010, 95% CI: $18,630-$19,390) hospitals.

Conclusion: Among rural Medicare beneficiaries who underwent a colon resection for cancer, there were no differences in postoperative outcomes among non-rural versus rural hospitals. These findings serve to highlight the importance of policies and practice guidelines that secure safe, local surgical care allowing rural clinicians to accommodate strong patient preferences while delivering high-quality surgical care.

Key Words: access to care, cancer, colon, rural, surgery

Nearly 60 million people, representing 20% of the United States (US) population, live in rural communities and often depend on the local hospital as their primary access to health care.[1] In 2010, people living in rural communities accounted for 3.7 million inpatient visits at US rural hospitals.[2] However, rural hospitals face a number of challenges in providing high-quality care locally, including a shortage of health care providers and specialists, low patient volumes, and a disproportionate number of uninsured patients.[3–7] These significant challenges have contributed to the growing number of rural hospitals that have closed due to the inability to maintain a profit.[8,9] Since 2010, 134 rural hospitals have closed,[10] and a report from 2016 estimated that an additional 673 rural hospitals were at risk of closing within 10 years.[9] Surgical services not only represent an important component of financial stability for an otherwise vulnerable small hospital,[11,12] but surgery also is the cornerstone of treatment for many patients with colon cancer who live in a rural setting.[13] Over the past decade there has been an 82% increase in the number of people who lived farther than an hour from any hospital, and as of 2015 up to 10% of the US population resided outside of a 30-mile radius of a hospital with the capacity to perform adult inpatient surgery.[14,15] For surgical cancer care specifically, between 2005 and 2015 the number of people living greater than 60 minutes from a hospital that provided surgical services with an approved American College of Surgeons (ACS) Commission on Cancer (CoC) program nearly doubled from 6% to 11%.[16] Even more concerning, as

the COVID-19 pandemic continues to tax hospitals throughout the country, there is a growing concern that rural hospitals may not have the reserve to remain fiscally viable.[17,18]

Despite the importance of rural surgical care—both in reducing travel burden for millions of Americans and in contributing to the financial stability for rural hospitals during a period of mass closures—there is continued debate regarding which surgeries are safe to be done locally. Multiple studies have reported that high-risk operations performed at high-volume hospitals result in lower mortality.[19–21] In turn, these data have led some surgeons and policy makers to advocate for regionalization of surgical care to hospitals with a minimum volume standard.[22,23] Such arguments for regionalization must be weighed, however, against the increase in travel burden among rural cancer patients, which can have a negative impact on quality of life and adherence to treatment / follow-up.[24] In particular, previous data have suggested that rural hospitals may indeed be capable of providing high-quality surgical care locally for select operations.[25]

Given that colon cancer is the third most common cancer diagnosis in the US and colon resection is considered an intermediate risk surgery, identifying whether it can be safely performed in rural settings is a priority for both health care providers and policy makers.[26] We sought to define outcomes and cost of colorectal cancer resection among rural Medicare beneficiaries aged 65 years or older who received care locally compared with rural patients who traveled to an urban center for surgery. In particular, we hypothesized that there would be no difference in surgical outcomes among rural patients who underwent colon resection at rural versus non-rural hospitals. These findings may be useful to direct policy aimed at optimizing access to health care and quality of care for rural residents.

Methods

Data source and study population

Data from 2013 through 2017 were retrieved from the Medicare Inpatient and Outpatient Standard Analytic Files (SAFs), which are maintained by the Centers for Medicare & Medicaid Services (CMS). The SAFs include patient-level data on demographic characteristics, diagnoses, procedures, and expenditures. Patients who underwent a colon resection for cancer were identified using the procedure codes of the ninth and tenth revision of the International Classification of Diseases (ICD-9-CM: ICD-10-CM:). Patients were excluded if they were not enrolled in Medicare Parts A and B; patients were also excluded if they were enrolled in a Health Maintenance Organization (HMO) in the month of the surgical episode. Patients transferred during their index hospitalization were excluded from analysis. Only patients who were residents of a rural county and underwent an elective operation without metastatic disease were included. Patients were identified as either residing in a rural or non-rural county based on the United States Department of Agriculture Rural-Urban Continuum Codes. The Rural-Urban Continuum Codes form a classification scheme that distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area.[23] Counties were designated as rural using code 7 (Urban population of 2,500 to 19,999, not adjacent to a metro area), 8 (Completely rural or less than 2,500 urban population, adjacent to a metro area), or 9 (Completely rural or less than 2,500 urban population, not adjacent to a metro area). All other codes were labeled as non-rural. Similarly, hospitals were designated as either rural or non-rural based on the reported address on their Healthcare Cost Report Information System (HCRIS) filing and the Rural-Urban Continuum Codes.[24] The number of patients from each state varied (Supplementary Table 1).

Main outcomes

The primary outcome of interest was the risk-adjusted odds of having a postoperative complication at rural versus non-rural hospitals among rural Medicare beneficiaries aged 65 years or older undergoing a colon resection for cancer. Several secondary outcomes were examined including postoperative mortality, serious complications, failure-to-rescue, length-of-stay, discharge destination, and total episode expenditure. ICD-10-CM codes were used to identify 30-day postoperative complications such as pulmonary failure, pneumonia, myocardial infarction, deep venous thrombosis, pulmonary embolism, renal failure, surgical site infection, gastrointestinal bleeding, and postoperative hemorrhage. These complications represented a subset of codes from administrative claims with the greatest sensitivity and specificity.[25-27] Serious complications were defined as the presence of a coded complication and an extended length-of-stay (LOS) (>75th percentile for each procedure).[28,29] Because most patients without complications are discharged earlier, the addition of the extended LOS criterion was intended to increase the specificity of the outcome variable.[25,30] Mortality was defined as death occurring within 30 days of the index operation. Failure-to-rescue was defined as death during the index hospitalization following a complication. Total index hospitalization expenditure included actual Medicare payments for the index hospitalization.

Medicare payments were used to explore if location of care—rural versus non–rural hospitals—was associated with any difference in expenditures. The total episode payment was defined as the sum of diagnosis-related group payments, outlier payments, and payments for readmissions within 30 days of discharge. To compare Medicare expenditures at non-rural hospitals with rural hospitals, price-standardized payments were examined. This analysis was done because payments from Medicare are determined in part by geography (to account for variation in cost of living and the wage index) and the setting in which they provide care (e.g., if hospitals provide care to a disproportionate share of low-income patients or participate in graduate medical education). By

removing these intended adjustments, the comparison of price-standardized amounts provides better insight into differences in resource use among hospitals. For price standardization, this study used methods described initially by the Medicare Payment Advisory Commission,[27,28] as has been done in multiple previous reports using Medicare data to examine payments for surgical procedures.[29–31]

Hospital designations

In an effort to determine the effects of Critical Access Hospital (CAH) status and American College of Surgeons (ACS) Commission on Cancer (CoC) accreditation, subset analyses were performed among patients who underwent colon resection at a hospital with these designations. The ACS CoC is a multidisciplinary consortium of professional organizations that strives to improve cancer care through setting standards related to prevention, research, and education, as well as through the monitoring of comprehensive cancer care.[32] CAH is a separate designation given to eligible rural hospitals by the Centers for Medicare & Medicaid Services (CMS). The CAH designation is designed to reduce the financial vulnerability of rural hospitals and improve access to health care by keeping essential services in rural communities.[33] As such, CAHs receive certain benefits, such as cost-based reimbursement for Medicare services. Eligible hospitals must meet the following conditions to obtain CAH designation: have 25 or fewer acute care inpatient beds, be located more than 35 miles from another hospital, maintain an annual average length of stay of 96 hours or less for acute care patients, and provide 24/7 emergency care services.

Statistical methods

Unadjusted analyses were used to compare patients who had an elective versus non-elective operation using x^2 and t-test for categorical and continuous variables, respectively. Multivariable, mixed-effects logistic regression models with a random effect for county were utilized to estimate the primary outcome, which was the probability of having a postoperative complication. Subsequent models estimated the probability of 30-day readmission, failure-to-rescue (FTR), LOS, 30-day mortality, and index hospitalization expenditures. Poisson regression models were used for LOS and generalized linear regression with gamma distribution and log link for expenditures. These models controlled for age, sex, race, tumor location, operative approach (i.e., minimally invasive), Elixhauser comorbidities, hospital teaching status, CAH designation, and ACS CoC accreditation. The calendar year of the operation was included as an indicator variable to control for secular trends.

All statistical analyses were performed using Stata statistical software version 16 (StataCorp LLC, College Station, TX). All tests were two-sided, and *P* values of less than 0.05 were considered to indicate statistical significance. The study was deemed exempt from approval by the institutional review board of The Ohio State University because data were de-identified.

Results

Among 3,937 Medicare beneficiaries who resided in a rural county and underwent colon resection for cancer, mean age was 76.3 (SD: 7.1) years, roughly one-half were female (n=2,019, 51.3%), the cohort was overwhelming White (n=3,733, 94.8%), and most patients had 3 or more comorbidities (n=2,724, 69.3%). Overall, 2,144 (54.5%) patients had a tumor located in the ascending colon with fewer patients having sigmoid cancer (n=626, 15.9%). At the time of surgery, most patients had an open colectomy (n=2,435, 61.8%), while a subset (n=1,502, 38.2%) underwent surgery using a minimally invasive approach **(Table 1)**. Following surgery, 619 (16.2%) beneficiaries had a

postoperative complication during the index admission; 365 (9.4%) had a serious complication requiring an extended LOS with a 5.6% (n=220) incidence of FTR. Overall mean LOS was 6.4 days (SD: 4.5). At the time of discharge, the majority of patients were discharged home (n=2,717, 68.2%), with a subset discharged with home health care (n=515, 11.1%); a small subset was discharged to a post-acute care (PAC) facility (n=428, 10.9%). Of note, 1.1% (n=45) of patients were transferred to another acute care hospital after the index operation. Overall, 455 (11.8%) beneficiaries were readmitted within 30 days of discharge and 120 (3.3%) individuals died within 30 days of discharge. The mean expenditure associated with an episode of care related to a colectomy was $18,893 (SD: $13,951)**(Table 2).**

Among the 3,937 Medicare beneficiaries who resided in a rural county who underwent colon resection for cancer, 1,432 (36.4%) underwent the operative procedure at a rural hospital while 2,505 (63.6%) beneficiaries had the operation at a non-rural hospital. Baseline patient characteristics including age, sex, and race/ethnicity were similar among beneficiaries who underwent colectomy at a rural versus non-rural hospital (all $P > 0.005$) **(Table 1)**. In addition, other factors such as patient comorbidities and tumor location were comparable among beneficiaries who underwent colectomy at a non-rural versus rural hospital. Of note, patients who underwent surgery at a non-rural hospital were more likely to have had a MIS approach (non-rural: 41.6% vs. rural: 32.1%; $P < 0.001$). Despite differences in hospital characteristics, patients who underwent colectomy at a non-rural versus rural hospital had a comparable incidence of complications (non-rural: 16.3% vs. rural: 15.2%), readmissions (non-rural: 11.7% vs. rural: 11.2%), and 30-day mortality (non-rural: 2.9% vs. rural: 3.4%) (all $P > 0.05$). Mean expenditures for the episode of care associated with the colectomy were similar among non-rural ($19,002) versus rural ($18,854) hospitals ($P = 0.69$)**(Table 2)**. Patients who underwent colon resection at a rural hospital had a higher incidence of being transferred (1.9%) versus individuals who had surgery at a non-rural hospital (0.7%)($P < 0.001$).

On multivariable analyses, no differences in postoperative outcomes were noted among Medicare beneficiaries undergoing colon resection for cancer at non-rural versus rural hospitals **(Figure 1)**. Specifically, the risk-adjusted probability of experiencing a postoperative complication at a non-rural hospital was 15.4% versus 16.3% at a rural hospital (OR 1.08, 95% CI: 0.85-1.38). Median LOS (non-rural: 6.4 days vs. rural: 6.4 days), as well as 30-day readmissions (non-rural: 11.5% vs. rural: 11.7%) and 30-day mortality (non-rural: 2.9% vs. rural: 3.5%) were also comparable (all $P > 0.05$). Of note, risk-adjusted probability of minimally invasive surgery was 35.3 (95% CI: 32.3-38.3) at rural hospitals versus 39.5 (95% CI: 37.3-41.6) at non-rural hospitals (OR: 0.81, 95% CI: 0.68-0.98); length of stay was significantly less for minimally invasive surgery (5.2 days, 95% CI: 5.5-5.8) versus open surgery (6.8 days, 95% CI: 6.7-7.0) (Coef -0.20, 95% CI: -0.23 to -0.17). At the time of discharge, patients who underwent colectomy at a non-rural hospital had the same probability of being discharged home (69.2%) as did patients who had their surgery at a rural hospital (67.1%) ($P > 0.05$). Similarly, there was no difference in home health utilization (non-rural: 12.5% vs. rural: 13.1) or discharge to PAC facility (non-rural: 10.3% vs. rural: 10.7%) ($P > 0.05$). In addition, price standardized, risk-adjusted colectomy expenditures were similar at non-rural ($18,610) and rural ($19,010) hospitals ($P = 0.253$)**(Table 3)**. Of note, patients from rural hospitals had a similar risk-adjusted probability of being transferred to another acute care hospital after their operation compared with non-rural hospitals (non-rural: 1.2% vs. rural: 1.1%) ($P = 0.699$).

In a subset analysis of only Medicare beneficiaries who had colectomy performed in a rural hospital (n=1,432, 36.4%), there were no differences in postoperative outcomes relative to ACS CoC accreditation, including discharge destination or episode of care expenditures (**Table 4**). In addition, among rural Medicare beneficiaries who underwent colectomy in a rural hospital, Critical Access Hospital (CAH) designation did not impact risk of complications (non-CAH: 15.5% vs. CAH: 11.9%, $P = 0.129$) or 30-day mortality (non-CAH: 3.5% vs. CAH: 2.9%, $P = 0.638$)**(Table 4)**. Patients treated at a

rural CAH were, however, less likely to be discharged with home health care services (non-CAH: 13.5% vs. CAH: 6.9%) or to a PAC facility (non-CAH: 12.1% vs. CAH: 6.4%)(both $P < 0.05$). In addition, price standardized, risk-adjusted episode of care expenditures were less at non-CAH ($18,550) versus CAH ($20,645) ($P = 0.002$)**(Table 4)** hospitals.

Discussion

Ensuring equal access to high-quality cancer care is important to mitigate disparities, yet it requires focused efforts to coordinate health care delivery systems by health care providers and policy makers. In particular, increasing regionalization of cancer care to high-volume urban centers can have a disproportionate effect on rural populations, leading to a growing disparity in access to care.[34–36] Patients in need of surgical care may be especially impacted given the recent emphasis on regionalization of operative procedures to urban settings.[37] In turn, an increasing number of patients need to travel longer distances to obtain surgical services.[35,38] Given that colon cancer is the third most common cancer in the US, and surgical resection is a key element in curative-intent treatment, the current study was important as we defined outcomes following colectomy at non-rural versus rural hospitals. Of note, there were no differences in postoperative outcomes following colectomy, including similar LOS, 30-day readmission, and mortality among Medicare beneficiaries who underwent colectomy at a rural versus non-rural hospital. Of note, patients who underwent colectomy at a non-rural hospital also had the same probability of being discharged home (OR 0.88, 95% CI: 0.72-1.07), as well as comparable overall expenditures related to the episode of care (non-rural: $19,002 vs. rural: $18,854). In addition, ACS Commission on Cancer accreditation and CAH status were not associated with differences in postoperative outcomes among patients who underwent colectomy at a rural hospital. Collectively, these data should serve to inform evidence-

based policy guidelines and inform payors that patients can undergo colon resection for cancer safely at local rural hospitals.

While complex surgical procedures are best performed at high-volume centers, some investigators have suggested that more common low-risk operations can be performed in rural communities with comparable outcomes as high-volume urban centers.[25,39] In particular, there has been a strong consistent volume-outcome relationship demonstrated for higher risk operations.[40–42] In turn, high-risk cancer operations have been increasingly centralized to urban areas.[37,43,44] Ibrahim et al. reported, however, that Medicare beneficiaries undergoing lower risk surgical procedures had no difference in morbidity and mortality when treated at CAH versus non-CAH hospitals. The data suggested, therefore, that some medium- to low-risk surgical procedures could be feasibly and safely performed closer to home at local centers. The current study built off this previous work by specifically examining postoperative outcomes associated with an intermediate risk surgical procedure (i.e., colectomy) performed at rural hospitals. In particular, colon resection for cancer is generally considered an intermediate risk surgical procedure with a reported 30-day mortality of 2.5%.[45] To that point, the overall incidence of complications was 16.2% with almost 1 in 10 patients having a serious complication that required an extended LOS. In addition, 30-day mortality was 3.3%. While the risk of morbidity and mortality following colectomy was not negligible, we noted that the risk of complications or postoperative death following colectomy was comparable at non-rural versus rural hospitals. These data are interesting in light of a report from Chow et al., which demonstrated that rural residents often present with cancer at later stages.[46] In the present study, after excluding patients with metastatic disease, on multivariable analysis patients with colon cancer treated at rural centers had the same odds of complications, readmission, and death within 30 days of surgery as those treated at non-rural centers (**Table 2**). Therefore, the data strongly suggest that

appropriately selected patients with colon cancer can generally undergo surgery safety at local rural centers with anticipated comparable outcomes as non-rural centers.

While previous studies have raised concern about the quality of care provided at CAHs for patients admitted with acute myocardial infarction, heart failure, or pneumonia,[47] other data have noted that in-hospital mortality for common low-risk procedures was indistinguishable between CAHs and non-CAHs.[39] To examine whether CAH designation drove differences in outcomes among rural hospitals, we performed a subset analysis of outcomes stratified by CAH status. Of note, among patients who underwent colectomy at a rural hospital, CAH designation was not associated with differences in postoperative outcomes such as complications or death. Interestingly, while outcomes were comparable for patients undergoing colectomy—a medium-risk procedure—in a separate study, we previously noted that Medicare beneficiaries who underwent hepatic or pancreatic resection—a high-risk procedure—at CAHs were at much higher risk of complications and postoperative mortality.[48] In addition to CAH status, we also examined ACS Commission on Cancer (CoC) accreditation status. The CoC criteria can be burdensome for less well-resourced hospitals; as a consequence CoC-approved hospitals tend to be larger, urban locations.[49] Interestingly, while CoC-accredited centers have been reported to perform better relative to process measures including VTE prophylaxis and postoperative β-blocker use, these centers have not demonstrated better outcome measures such as rates of postoperative urinary tract infections and glycemic control.[50] In the current study, we similarly noted no differences in outcomes among rural Medicare beneficiaries undergoing colon resection for cancer at a CoC versus a non-CoC-accredited rural hospital.

In addition to quality of care, cost of care is critical to assess the value proposition of delivering surgical services in the rural setting. Of note, mean expenditures for the episode of care associated with the colectomy was similar among non-rural hospitals versus rural hospitals ($19,002

vs. $18854, respectively, *P* = 0.69)**(Table 2)**. Interestingly, using a normalized ranking of average inpatient and outpatient Medicare charges, a study from iVantage Health Analytics noted that roughly two-thirds of all urban hospitals charge more than the average rural hospital.[51] In contrast, the costs associated with care at rural hospitals in our study was higher. The difference in charges versus costs are important as rural hospitals with CAH designation have a different reimbursement model for an episode of care.[52] Specifically, CAHs are paid for inpatient and outpatient services at 101% of reasonable costs, thereby helping to maintain the financial sustainability of these hospitals.[53] To this point, while outcomes at rural hospitals with and without CAH designation were comparable, price standardized, risk-adjusted episode of care expenditures were less at non-CAHs versus CAHs ($18,550 vs. $20,645), respectively (*P* = 0.002)**(Table 4)**. In turn, the data highlight previous criticisms of CAHs relative to cost shifting and call into question cost-based reimbursement models for rural hospitals.[54]

Limitations

Several limitations should be considered when interpreting the results of the current study. As with studies utilizing administrative data, the findings were subject to residual confounding due to unmeasured factors such as non-coded comorbidities and complications.[55,56] To minimize any potential coding bias, we selected codes from the Complication Screening Project to increase the specificity of detecting complications in claims data.[57,58] Furthermore, cancer stage was not available in the Medicare dataset; as such, the findings were subject to potential residual confounding related to extent of disease. In an effort to mitigate potential residual bias, the study cohort was limited to patients without a diagnosis of metastatic disease; in addition, the analytic models controlled for location of the primary tumor (e.g., left, transvers, right, sigmoid, colon). The study cohort also only included patients who had fee-for-service Medicare insurance; therefore, patients who either had

supplemental insurance or lacked insurance were not included in the analyses. As such, only patients aged 65 years or older were included. The majority of patients residing in rural areas are, however, older and likely to be insured by Medicare.[7] Data from the current study may not be generalizable to a younger, privately insured population.

Conclusion

In conclusion, among Medicare beneficiaries who resided in rural counties who underwent colon resection for cancer, there were no differences in postoperative complications, readmissions, mortality, or Medicare expenditures among patients treated at rural versus non-rural hospitals. These findings may have important implications for administrators, insurers, and policy makers who are making decisions about hospital closures that may decrease access to surgical care for rural patients. Many patients who live in rural settings may prefer to have surgery performed locally if operative mortality is equivalent at rural and non-rural hospitals.[59] In turn, data from the current study strongly suggest that safe and affordable care can be delivered at rural hospitals for patients in need of colectomy for colon cancer.

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Table 1: Patients and hospital characteristics at rural and non-rural hospitals.

	Total N=3,937	Non-Rural N=2,505	Rural N=1,432	p-value
Mean Age, (SD)	76.3 (7.1)	76.1 (7.0)	76.5 (7.2)	0.16
Female	2,019 (51.3%)	1,258 (50.2%)	761 (53.1%)	0.078
Male	1,918 (48.7%)	1,247 (49.8%)	671 (46.9%)	
Race/Ethnicity				
White	3,733 (94.8%)	2,371 (94.7%)	1,362 (95.1%)	0.530
Black/Hispanic/Asian/Other	204 (5.2%)	134 (5.4%)	70 (4.9%)	

Mean Comorbidities	3.61 (1.89)	3.68 (1.94)	3.48 (1.78)	0.002
Comorbidities				
none	**	**	**	0.72
1 or 2	1,186 (30.1%)	749 (29.9%)	**	
3 or more	2,724 (69.2%)	1,737 (69.3%)	987 (68.9%)	
Tumor Location				
Ascending Colon	2,144 (54.5%)	1,346 (53.7%)	798 (55.7%)	0.72
Transverse Colon	452 (11.5%)	299 (11.9%)	153 (10.7%)	
Descending Colon	243 (6.2%)	156 (6.2%)	87 (6.1%)	
Sigmoid Colon	626 (15.9%)	403 (16.1%)	222 (15.6%)	
Unspecified/Other	472 (12.0%)	301 (12.0%)	171 (11.9%)	
Minimally Invasive Surgery	1,502 (38.2%)	1,042 (41.6%)	460 (32.1%)	<0.001
Critical Access Hospital	387 (9.8%)	65 (2.6%)	324 (22.8%)	<0.001
Teaching Hospital	1,620 (41.1%)	1,417 (56.6%)	203 (14.2%)	<0.001
ACS Cancer Hospitals	2,080 (52.8%)	1,756 (70.1%)	324 (22.6%)	<0.001

** Withheld due to small sample size

Table 2: Postoperative outcomes, discharge destination, and Medicare expenditure and rural and non-rural hospitals.

	Total N=3,937	Non-Rural Hospitals N=2,505	Rural Hospitals N=1,432	p-value
Complication, Index Hospitalization	619 (16.2%)	409 (16.3%)	222 (15.2%)	0.17
Serious Complication	365 (9.4%)	240 (9.6%)	130 (8.9%)	0.38
Readmission, 30 Days	455 (11.8%)	294 (11.7%)	161 (11.2%)	0.64
Mortality, 30 Days	120 (3.3%)	72 (2.9%)	48 (3.4%)	0.40
Discharge Destination				<0.001

Home	2,717 (68.2%)	1,742 (69.5%)	975 (68.1%)	
Postacute Care Facility	428 (10.9%)	273 (10.8%)	155 (10.8%)	
Home w/ Home health	515 (11.1%)	343 (13.6%)	172 (12.0%)	
Other	277 (7.0%)	165 (6.5%)	130 (9.1%)	
Transfer	45 (1.1%)	18 (0.7%)	27 (1.9%)	0.001
Length of Stay	6.4 (4.5)	6.4 (4.8)	6.3 (3.9)	0.74
Failure to Rescue	220 (5.6%)	140 (5.6%)	80 (5.6%)	1.00
Ostomy	136 (3.5%)	97 (9.6%)	39 (2.7%)	0.058
Spending, Index Hospitalization (SD)	$18,893 (13,951)	$19,002 (14,492)	$18,854 (13,375)	0.69

Table 3: Risk-adjusted postoperative outcomes and spending at rural and non-rural hospitals.

	Non-Rural Hospital (95% CI)	Rural Hospital (95% CI)	Absolute Difference	OR/Coef (95% CI)	p-value
Postop Complication	15.4 (14.1 to 16.8)	16.3 (14.2 to 18.3)	0.84 (-1.8 to 34)	1.08 (0.85 to 1.38)	0.524
Serious Complication	8.9 (7.8 to 10.0)	10.0 (8.3 to 11.6)	1.05 (-1.0 to 3.2)	1.16 (0.86 to 1.57)	0.316
Ostomy	4.0 (3.2 to 4.9)	2.5 (1.7 to 3.4)	-1.5 (-2.8 to -0.16)	0.61 (0.38 to 0.97)	0.038
Length of Stay	6.4 (6.2 to 6.5)	6.4 (6.2 to 6.7)	0.01 (-0.23 to 0.25)	-0.004 (-0.04 to 0.03)	0.843
Failure to Rescue	5.2 (4.4 to 6.0)	6.4 (5.0 to 7.8)	1.2 (-0.55 to 2.9)	1.32 (0.89 to 1.97)	0.173
Readmission, 30 days	11.5 (10.2 to 12.8)	11.7 (9.8 to 13.6)	0.22 (-2.3 to 2.7)	1.02 (0.79 to 1.32)	0.860
Mortality, 30 days	2.9 (2.2 to 3.6)	3.5 (2.4 to 4.5)	0.56 (-0.80 to 1.91)	1.24 (0.75 to 2.06)	0.409
Discharge Destination					
Home	69.2 (67.4 to 71.0)	67.1 (64.6 to 69.6)	-2.1(-5.4 to 1.2)	0.88 (0.72 to 1.07)	0.195
PAC Facility	10.3 (9.1 to 11.5)	10.7 (9.0 to 12.3)	0.36 (-1.8 to 2.6)	1.07 (0.82 to 1.40)	0.622
Home Health	12.5 (11.1 to 13.9)	13.1 (11.0 to 15.3)	0.63 (-2.0 to 3.3)	1.07 (0.83 to 1.39)	0.593
Transfer	1.1 (0.55 to 1.6)	1.2 (0.75 to 1.8)	0.16 (-0.65 to 0.97)	1.17 (0.53 to 2.55)	0.699
Spending, Index Hospitalization	$19,010 (18,630 to 19,390)	$18,610 (18,037 to 19,183)	-$400 (-1,084 to 283)	-0.02 (-0.06 to 0.02)	0.253

Note: Adjusted for age, sex, race, Elixhauser comorbidities, year, tumor location, operative approach (i.e., minimally invasive) hospital teaching status, critical access designation, and ACS cancer hospital accreditation.

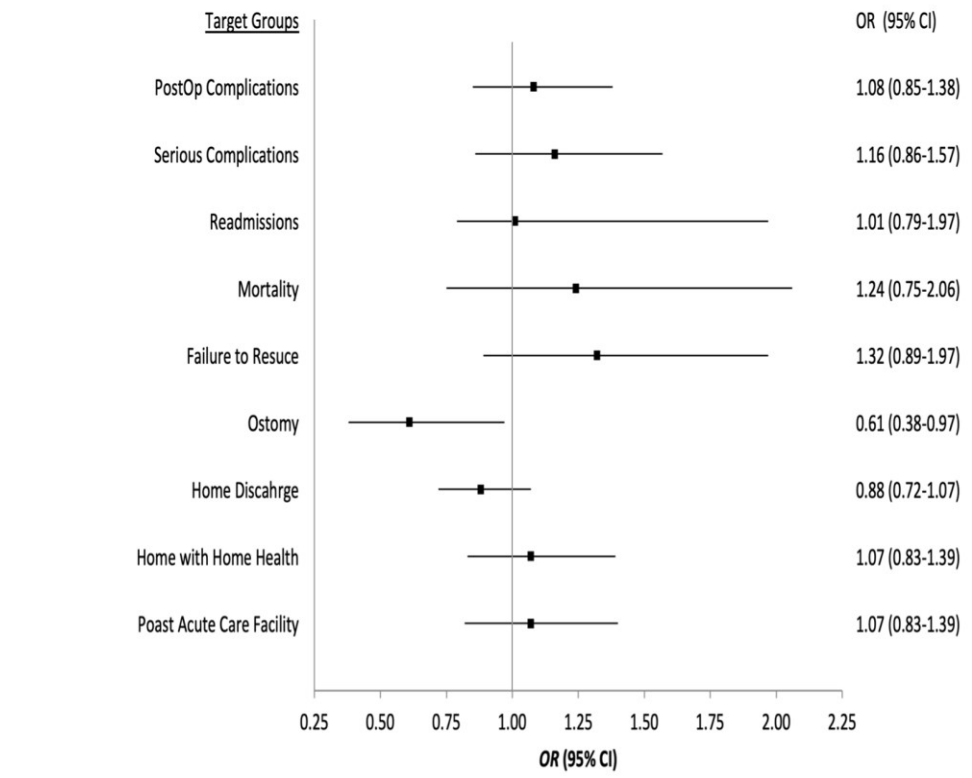
Table 4: Risk-adjusted postoperative outcomes and spending at Commission on Cancer (CoC) and Critical Access Hospitals (CAH).

	No CoC	CoC	OR/Coef (95% CI)	p-value	No CAH	CAH	OR/Coef (95% CI)	p-value
Postop Complication	14.0 (12.0 to 16.0)	17.1 (13.1 to 21.1)	1.35 (0.88 to 2.10)	0.172	15.5 (13.5 to 17.5)	11.9 (8.1 to 15.6)	0.66 (0.41 to 1.12)	0.129
Serious Complication	8.8 (7.1 to 10.4)	9.2 (6.4 to 12.0)	1.06 (0.60 to 1.88)	0.824	9.4 (7.8 to 11.0)	6.4 (3.5 to 9.4)	0.57 (0.28 to 1.17)	0.124
Ostomy	3.4 (2.2 to 4.6)	2.9 (0.81 to 5.1)	0.86 (0.33 to 2.24)	0.751	3.1 (2.0 to 4.2)	4.0 (1.4 to 6.6)	1.35 (0.55 to 3.33)	0.510
Length of Stay	6.3 (6.1 to 6.6)	6.7 (6.2 to 7.2)	0.05 (-0.04 to 0.14)	0.248	6.4 (6.1 to 6.6)	6.5 (6.1 to 7.0)	0.02 (-0.05 to 0.10)	0.524
Failure to Rescue	6.4 (4.9 to 7.9)	4.4 (2.4 to 6.4)	0.57 (0.26 to 1.25)	0.161	6.4 (5.0 to 7.7)	3.5 (1.3 to 5.7)	0.42 (0.16 to 1.10)	0.076
Readmission, 30 days	10.9 (9.0 to 12.8)	12.4 (8.5 to 16.3)	1.17 (0.75 to 1.85)	0.490	11.4 (9.5 to 13.3)	10.8 (7.1 to 14.5)	0.94 (0.59 to 1.51)	0.766
Mortality, 30 days	3.6 (2.4 to 4.7)	2.9 (1.2 to 4.7)	0.79 (0.33 to 1.90)	0.601	3.5 (2.5 to 4.5)	2.9 (0.8 to 5.0)	0.79 (0.30 to 2.11)	0.638
Discharge Destination								
Home	68.8 (66.3 to 71.3)	65.8 (60.8 to 70.9)	0.83 (0.58 to 1.18)	0.305	68.3 (65.8 to 70.8)	67.7 (62.9 to 72.4)	0.96 (0.68 to 1.36)	0.831
PAC Facility	10.6 (8.8 to 12.4)	11.6 (8.2 to 15.0)	1.13 (0.70 to 1.81)	0.620	12.1 (10.3 to 14.0)	6.4 (3.7 to 9.2)	0.45 (0.25 to 0.79)	0.005
Home Health	11.4 (9.4 to 13.5)	14.0 (9.9 to 18.0)	1.3 (0.82 to 2.04)	0.273	13.5 (11.3 to 15.6)	6.9 (3.8 to 9.9)	0.45 (0.26 to 0.78)	0.004
Transfer	2.4 (1.5 to 2.4)	2.3 (0.19 to 2.9)	0.48 (0.10 to 2.18)	0.339	1.8 (0.92 to 2.6)	2.4 (1.4 to 5.4)	2.32 (0.80 to 6.70)	0.120
Spending, Index Hospitalization	$18,874 (18,187 to 19,560)	$20,132 (18,629 to 21,635)	0.06 (-0.02 to 0.15)	0.126	$18,550 (17,815 to 19,284)	$20,645 (19,481 to 21,809)	0.11 (0.04 to 0.17)	0.002

Note: Adjusted for age, sex, race, Elixhauser comorbidities, year, tumor location, operative approach (i.e., minimally invasive), hospital teaching status, critical access designation, and ACS cancer hospital accreditation.

Figure legend

Figure 1: Forest plot of postoperative outcomes at rural vs. non-rural hospitals



Note: Adjusted for age, sex, race, Elixhauser comorbidities, year, tumor location, operative approach (i.e., minimally invasive), hospital teaching status, critical access designation, and ACS cancer hospital accreditation.