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Clinical, Sociodemographic and Service Provider Determinants of Guideline Concordant Colorectal Cancer Care for Appalachian Residents

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Abstract

Background—Colorectal cancer represents a significant cause of morbidity and mortality, particularly in Appalachia where high mortality from colorectal cancer is more prevalent. Adherence to treatment guidelines leads to improved survival. This paper examines determinants of guideline concordance for colorectal cancer.

Methods—Colorectal cancer patients diagnosed in 2006-2008 from 4 cancer registries (Kentucky, Ohio, Pennsylvania, and North Carolina) were linked to Medicare claims (2005-2009.) Final sample size after exclusions was 2932 stage I - III colon, and 184 stage III rectal cancer patients. The 3 measures of guideline concordance include adjuvant chemotherapy (stage III colon cancer, <80 years), ≥ 12 lymph nodes assessed (resected stage I – III colon cancer), and radiation therapy (stage III rectal cancer, <80 years). Bivariate and multivariate analyses with clinical, sociodemographic, and service provider covariates were estimated for each of the measures.

Results—Rates of chemotherapy, lymph node assessment, and radiation were 62.9%, 66.3%, and 56.0%, respectively. Older patients had lower rates of chemotherapy and radiation. Five comorbidities were significantly associated with lower concordance in the bivariate analyses: myocardial infarction, congestive heart failure, respiratory diseases, and dementia with chemotherapy; and diabetes with adequate lymph node assessment. Patients treated by hospitals with no Commission on Cancer (COC) designation or lower surgical volumes had lower odds of adequate lymph node assessment.

Conclusions—Clinical, sociodemographic, and service provider characteristics are significant determinants of the variation in guideline concordance rates of 3 colorectal cancer measures.

Keywords

cancer; demography; epidemiology; health disparities; Medicare

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Appalachian residents have a higher cancer burden and mortality than the rest of the country.[1] Factors include more poverty and geographic isolation,[2] and fewer health care resources, including most counties classified as health professional shortage areas.[3] The result is cancer disparities.[4]

While access to health care resources is clearly important, so is quality of care. The Commission on Cancer (COC) of the American College of Surgeons, in coordination with the National Quality Forum, has endorsed evidence-based guidelines of colorectal cancer treatment. We know little about the extent of guideline concordant colorectal cancer care in Appalachia. Population-based studies are either uncommon, or focused on different guidelines, making comparisons difficult. Surveillance Epidemiology & End Results (SEER) studies of post-operative care find variability across guidelines and geographic regions.[5-6]

This study focuses exclusively on Appalachia. Although this region is usually characterized as remote, poor, and elderly, it is actually quite heterogeneous along many dimensions—urbanicity, health care accessibility, poverty, and socioeconomic status. We do not compare Appalachia to non-Appalachian regions; however, what we learn from Appalachia can doubtless apply to other parts of the country, eg, areas of concentrated poverty or in economic decline, areas with large universities/college towns, areas with a high percent of elderly who are aging in place, areas bypassed by the federal highway system, and areas lacking health infrastructure.

In this paper, we examine the clinical, sociodemographic and provider determinants of variation in concordance with widely accepted treatment guidelines for colorectal cancer patients.[7-10] Although we expect some variation in clinical practice based on such factors as provider and patient choice, other determinants such as age,[11] comorbidities or functional status,[11] provider capacity,[12] sociodemographics,[11,13-16] and location[13,16] are expected to influence treatment. We expect the larger and COC-designated hospitals with high surgical volumes, particularly in metropolitan areas, to have higher guideline concordance as well as those with radiation or chemotherapy units. We also expect higher concordance among younger white patients, those treated by physicians with higher volumes of care, and those with fewer comorbid illnesses.

METHODS

Defining the Sample

We collected unique patient identifiers from 4 state cancer registries (Kentucky, Ohio, Pennsylvania, and North Carolina) for colorectal cancer patients diagnosed during the 3-year period 2006-2008 from Appalachian counties (see Figure 1). Individual identifiers were submitted to the Centers for Medicare and Medicaid Services (CMS) to obtain Medicare claims for the years 2005-2009. Figure 2 shows the total number of cases and exclusion criteria. The final sample consisted of 2,932 stage I – III colon cancer cases and 184 stage III rectal cancer cases, for an overall total of 3,116 cases.

Measures

We measured guideline concordance across 3 dimensions of colorectal cancer care based on guidelines promulgated by the COC[17] and the National Quality Forum:[18] (1) adjuvant chemotherapy for stage III colorectal cancer; (2) removal and assessment of ≥ 12 lymph nodes in resected colorectal cancer.[19] Additionally, the COC, with the American Society of Clinical Oncology and National Comprehensive Cancer Network, endorsed our third guideline: (3) radiation therapy for stage III rectal cancer receiving surgical resection, either pre- or post-operatively.[20] We also considered oncologic resection of stages I-III colon

cancer but since over 97.5% of patients received this guideline-concordant surgical resection, we decided against this guideline due to the uniformly high rates of resection and the small variabilities observed.

For this study, we made some restrictions. We focused on patients age < 80 for the chemotherapy and radiation measures because the supportive randomized trials did not include patients of advanced age. Moreover, the guidelines refer to the evaluation for, not receipt of these therapies. Therefore, we assume that patients strong enough to be resected are robust enough for these therapies; ie, receipt is a proxy for evaluation. Finally, our evaluation of the lymph node assessment was restricted to resected colorectal cancer patients (stage I-III) so as to limit our analysis to cases treated with curative intent, since it is impossible to distinguish curative from palliative intent in stage IV patients.

The claims-based ACE-27 was selected as a measure of comorbidity burden[21] and is based on 26 different comorbidities, most with 4 levels of severity: none, mild, moderate, and severe. We calculated 2 volume of care variables from all 2008 national Medicare claims associated with facilities in our database. For these variables, we examined all claims with procedure codes for colorectal cancer removal/resection, and summed all non-duplicate unique claims for the facility in which each patient was treated. Similarly, we calculated the volume of each surgical provider using all 2008 national claims with surgery codes associated with the provider for all oncological colorectal resection procedures (colectomies, proctosigmoidectomies, protectomies, colostomies/ileostomies) defined in our study. We categorized these variables into volume quartiles. Patient-level sociodemographic variables (age, gender, race), and clinical variables (stage, tumor size, grade) were derived from registry data. Treatment information was based on registry and claims data combined using a study-specific algorithm (available upon request). Metro/non-metro location was a county-level variable based on patient address at time of diagnosis and the 2003 USDA rural-urban continuum codes.[22] Facility characteristics were obtained from the Provider of Services file from CMS, and COC status was derived from the COC website facility locator using 2011 information.[23] Surgical provider characteristics, including surgical graduation year, were obtained from 3 sources: Medicare Physician Identification and Eligibility Registry (MPIER)[24] and National Provider Identification File, both from CMS, and Internet sources.[25-26]

Statistical Analysis

We conducted bivariate and multivariate analyses of sociodemographic and service provider characteristics with each of the 3 dimensions of colorectal cancer care using SAS version 9.2 (SAS Institute Inc., Cary, North Carolina). We assessed statistically significant differences with each variable and guideline concordance for each dimension of CRC using Chi-square statistics (t-tests for continuous variables), but comparing to Fisher exact tests and Wald tests from a logistic regression with firth correction for borderline cases. For the multivariate models, a multiple imputation procedure incorporated cases with missing data into the analysis, followed by a generalized linear mixed model. For each concordance sample, 5 data sets with different imputations were created using the SAS procedure PROC MI and results for each dataset were then combined using the SAS procedure PROC MIANALYZE according to the formulas used in multiple imputation.[27] The Markov chain Monte Carlo (MCMC) method, which assumes multivariate normality, was used to impute all missing values, with the EM algorithm used to find the initial starting values.[28] All candidate factors were included as part of the imputation model, including the outcomes in the multivariate models.[29,30] Categorical variables were included as dummy variables and in cases where the variable was missing, the imputations were left unrounded.[31-32] Selected covariates had missing data only for the lymph node concordance samples (N = 2932). These covariates included gender (0.2% missing), grade (3.7%), specialty (4.1%), log tumor size (8.2%),

COC status (5.0 %), radiation treatment offered by facility (5.2%), facility surgical volume (5.2%), physician specialty (4.1%), graduation year (4.5%), and number of beds in facility (5.0%). A generalized linear mixed model[33] was then used to examine the associations between concordance and predictors. The model took the form of a logistic regression with random intercept, where the random intercept captured a random effect at the county level and fixed effects included significant predictors from the bivariate analysis. Finally, the SAS procedure PROC GLIMMIX was used to calculate parameter estimates with the default estimation method (Pseudo-likelihood Estimation based on linearization). This estimation method conditions on the random effects, so that the parameter estimates from the model are interpreted as the slopes controlling for potential latent county-level confounders.

Covariate adjusted rates were also calculated (but not reported in tables) where the predicted concordance and non-concordance probabilities from the logistic model are calculated for each patient in the sample using their corresponding covariates and then the expected value over the covariate mix, or equivalently, the average of the predicted probabilities over the sample, is reported.[27,28]

RESULTS

The descriptive statistics of our colon (n=2932) and rectal cancer (n=184) samples are summarized in Table 1. Our sample contained proportionately more women with colon cancer (58.4%) but less with rectal cancer (43.2%). Both colon and rectal cancer patients were predominately white (97%), with about half (53.5%) living in Pennsylvania; note 30% of these lived in the 7-county Pittsburgh Metropolitan Statistical Area. Among patients without missing tumor size or grade, most colon and rectal tumors were >2 cm in size (88.8% and 89.0%, respectively) with moderately differentiated grade (71.6% and 71.9%, respectively). All 3 stages were well represented in the colon cancer sample, with stage II disease being the modal category. Rectal cancer cases were all stage III according to protocol. Comorbidity burden among these patients was substantial; 88.1% of the colon cancer patients and 80% of the rectal cancer patients had at least some level of burden, and nearly 30% and 20%, respectively, had “severe” comorbidity burden. Of the colon cancer patients, 23.6% received chemotherapy, although not all patients would qualify or be expected to receive such treatment. Almost 60% of the rectal cancer patients received radiation.

We report the bivariate analyses of sociodemographic and service provider characteristics (Table 2) and comorbidity burden (Table 3) for the dimensions of guideline-concordant colorectal cancer care; the multivariate analyses are summarized in Table 4. A sensitivity analysis using smaller samples and no imputed data generated similar results (available upon request).

The bivariate analyses with sociodemographic characteristics are reported in Table 2. The table also shows overall rates of chemotherapy (for stage III colon cancer), adequate lymph node assessment (for stage I-III colon cancer), and radiation therapy (for stage III rectal cancer) of 62.9%, 66.9%, and 56.0%, respectively. There were significantly lower rates of chemotherapy among the 561 stage III colon cancer patients who were older rather than younger (56.3% and 69.7%, respectively). Among the 2932 stages I-III colon cancer patients there were significantly lower rates of adequate lymph node assessment among males versus females (61.6% and 66.9%, respectively), among blacks, Hispanics, and other races versus whites, among those with stage I disease, those treated in smaller hospitals, facilities with no COC designation, and among patients treated in either a surgical facility or by a provider with a relatively low volume of cases. Adequate lymph node assessment rates were also lower among patients treated in hospitals in non-metropolitan areas (62.9%), with no

radiation therapy units (57.7%), or by other than colorectal cancer surgeons (65.7%). The radiation therapy analyses among the stage III rectal cancer cases were limited by small sample size (n=184) with age, race (only whites), and hospital COC designation being significant. Concordance rates of 66% versus 45.5% among those aged 66-73 versus 74-80 were statistically different ($P < .05$.)

Table 3 summarizes the bivariate analyses of the 3 guidelines and comorbidity burden. Of the 561 colon cancer patients, 62.9% received chemotherapy, but those with myocardial infarction, congestive heart failure, respiratory diseases, or dementia had statistically significantly lower rates (45.0%, 44.8%, 52.2%, and 12.8%, respectively). Among the 2932 stage I-III colon cancer patients, only those with diabetes had somewhat lower rates of adequate lymph node assessment (62.5%) compared to an overall rate of 66.3% among all colon cancer patients. There were no significant determinants of radiation for stage III rectal cancer.

The multivariate analyses (Table 4) summarize the statistically significant predictors of each of the 3 guidelines. Older patients had lower odds of chemotherapy (one-third lower odds for every 5 years increase in age using the parameter estimates), and those with dementia had one-tenth the odds of chemotherapy, although the prevalence of patients with dementia was extremely small. Among the 2932 stage I-III colon cancer patients, whites and females were associated with higher odds (OR = 1.6 with adjusted rates 67% whites versus 57% nonwhites, and OR = 1.2 with adjusted rates 68% females versus 64% males) of adequate lymph node assessment. Patients with stage I vs III had half the odds of adequate nodal assessment (adjusted rates of 59% versus 72%). Stage II was also significantly different from Stage III (OR=0.78 with adjusted rates of 68% vs 72%). Those who had diabetes had a 22% lower odds of adequate nodal assessment (adjusted rates of 63% vs 68%). Log tumor size was associated with higher nodal assessment (OR = 1.87), which results in adjusted rates at 20mm, 40mm, and 60mm of 59%, 68%, and 73%, respectively. Physician graduation year was also associated with higher nodal assessment (OR = 1.01), which results in adjusted rates at 1975, 1985, and 1995 of 65%, 67%,69%, respectively. Patients treated in hospitals with some COC designation had 2 to 3 times the odds of receiving adequate lymph node assessment. Patients with lower surgical resection volumes were less likely to receive adequate nodal assessment than those with higher volumes (q1 = 58%, q2 = 58%, q3 = 72%, vs q4 = 78%). Among the 184 stage III rectal cancer patients, there was a 10% lower odds of radiation therapy for every year increase in age (41% lower odds for every 5 years using parameter estimates), with adjusted rates for 65, 70, and 75 years being 73%, 63%, and 51%, respectively. We interpret the rectal cancer results with caution because of the low sample size.

DISCUSSION

It is estimated that 143,460 new cases of colorectal cancer will be diagnosed in the US in 2012, and 51,690 Americans will die from colorectal cancer.[34] Colorectal cancer is the number 2 cause of cancer death in the US and the fourth most prevalent cancer. Within Appalachia, colorectal cancer represents a significant cause of morbidity and mortality, yet treatment guidelines are associated with improved survival.[7-10]

Among the colorectal cancer patients in our study, the rates of guideline-concordant chemotherapy, adequate lymph node assessment, and radiation (for rectal cancer) were 65.3%, 66.3%, and 56.0%, respectively. Our results in Appalachia were consistently lower than a recent NewYork study[35] of Medicaid and Medicare stage III colorectal cancer patients diagnosed between 2004-2006, which reported 79.4% and 71.8% chemotherapy concordance rates, respectively, for the 2 payer groups. Concordance rates for adjuvant

radiation therapy among Medicaid and Medicare stage IIB and stage III rectal cancer patients were 72.3% and 66.9%, respectively. Concordance in Appalachia was also lower than one Veterans Administration study[36] that reported 73.5% chemotherapy concordance among stage III colorectal cancer patients, lower than another study among 8 Comprehensive Cancer Network centers with chemotherapy concordance rates of 90%,[37] and lower than a recent SEER study[38] where 73.6% of patients undergoing radical (curative intent) colon resection had at least 12 lymph nodes harvested. On the other hand, our results were similar to a CDC Patterns of Care study[39] among 7 states where 67% of stage III colorectal cancer patients received chemotherapy.

Our study identified specific sociodemographic, clinical, comorbidity, and service provider characteristics that were related to the rates of guideline concordance among 4 measures. Older Medicare beneficiaries had lower rates of both chemotherapy and radiation, and whites had nearly double the odds of adequate lymph node assessment compared with other races. Clinical characteristics (stage, grade, and tumor size) determined the odds of adequate lymph node assessment. The evidence of a dose-response relationship in the bivariate analysis, lower rates of concordance for chemotherapy associated with higher levels of comorbidity burden, did not hold up in the multivariate analysis, with comorbidity burden probably confounded by age. Patients treated in hospitals with no COC designation or lower surgical volumes had lower odds of lymph node assessment. Hsu and colleagues[40] reported that depth of tumor invasion, poor versus well differentiated grade, and tumor length and localization influenced whether patients had at least 12 lymph nodes assessed. Baxter et al[41] used SEER data to show that rates of adequate lymph node assessment were higher among whites, those with more advanced disease (Stage II or III versus I) and those with moderate or well grade differentiation.

Some of the results from the study are intuitive. It is both logical and clinically sound that older patients would have lower rates of both chemotherapy and radiation therapy because of the higher risk of complications from these treatments. In fact, the guidelines for adjuvant chemotherapy in colorectal cancer specify that consideration of chemotherapy is only required in those less than 80 years of age. Most papers in the literature have shown lower rates of these 2 therapies with age.[42,43] Additionally, patients with dementia are less likely to receive a meaningful clinical benefit from aggressive adjuvant therapy.

Some of our findings are less easy to explain, and may reflect provider biases or choices. Several studies have shown that rates of ≥12 lymph nodes harvested have increased dramatically since the late-1990s.[44] Nevertheless, there are several possible explanations for fewer than 12 lymph nodes being sampled in an oncologic resection. Because node-positive patients are stage III, and the more nodes that are sampled, the less likely it is for every lymph node to be negative, some of the patients are probably falsely staged as stage I due to undersampling. Similarly, diabetic patients may have smaller surgical resections because of concerns about the patient's ability to recover from the surgery. Physicians who graduated more recently may be more likely to excise at least 12 nodes because they were trained in an era when the guidelines were being promulgated. Finally, the quality of the pathologic examination is closely tied with the institution. Large hospital size and hospital COC designation are proxies for provider education and awareness of appropriate guidelines, and one would expect higher concordance with increased awareness among providers. The effects may also relate to increased scrutiny of cancer outcomes and process measures at these larger and COC-designated facilities. The fact that whites had nearly double the odds of adequate lymph nodes assessed, even while controlling for hospital size and hospital COC designation, implies that there may be unmeasured socioeconomic, cultural, or behavioral disparities among races that affect guideline concordance for this measure. This

racial disparity deserves further scrutiny, particularly in areas such as southern Appalachia where the number of minority cases is much higher.

Our study has both weaknesses and strengths. Sample size is limited in some analyses, particularly among rectal cancer patients, and claims data limitations are well-known and reported[45-54] We focused on elderly (66+) colorectal cancer patients from 4 Appalachian states by design, and we needed to have at least 1 year of Medicare claims prior to cancer diagnosis. Although one could certainly argue that generalizability is limited to this age group and region, we suggested earlier that some characteristics of Appalachia, eg, economic decline and lack of health infrastructure, are shared by other regions of the United.States. Thus, the importance of COC designation certainly reaches beyond Appalachia. The breadth of our study is notable, and a significant strength, because we draw colorectal cancer cases from the Appalachian population of 4 different states. The linkage of registry to Medicare claims is ideal for this kind of research because it combines the strengths of both central cancer registries and Medicare claims. Cancer registries are among the best source of cancer case identification for population research,[55,56] and Medicare claims provides more reliable and complete information on treatment.

Future research could be aimed at confirming our results by expanding the scope of our analysis to non-Appalachian urban and rural populations. Also, since COC status and surgical volume are significant in this study, we could investigate whether smaller centers that are affiliates of larger ones excel compared to similarly sized non-affiliated centers. If there is a difference in guideline concordance, we could design an intervention that provides more avenues of linking smaller centers to experts.

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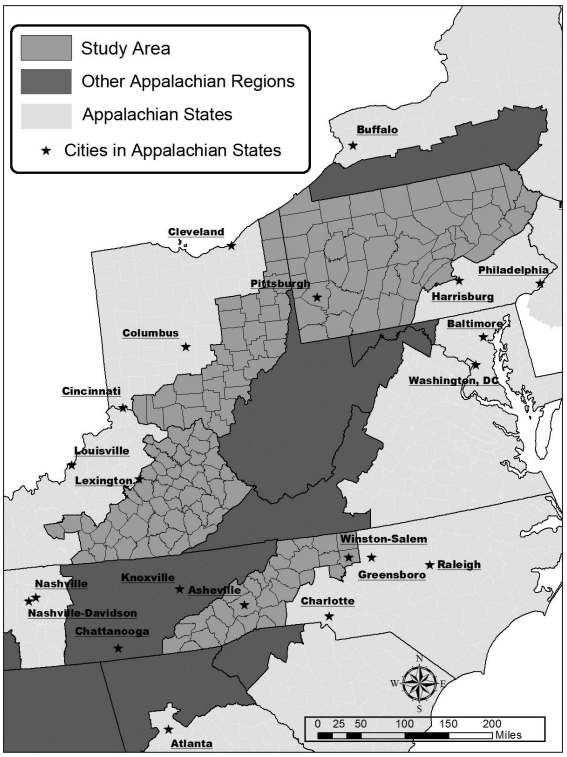

Figure 1.
Appalachian Counties in Pennsylvania, Kentucky,Ohioand North Carolina

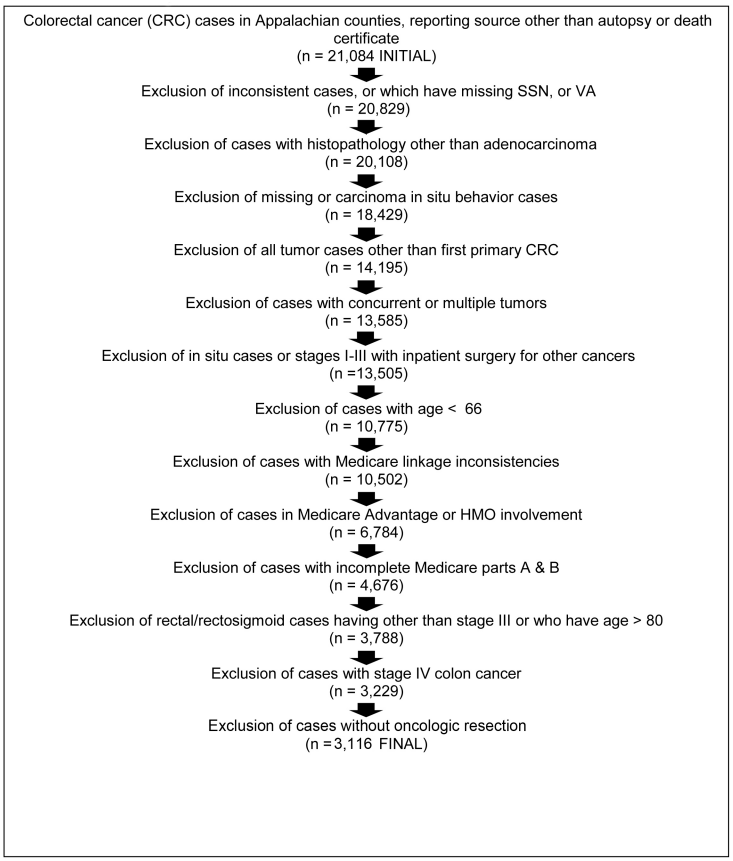

Figure 2.
Study participarts and exclusion criteria, colorectal concer patients living in Appalachian counties in four states, 2006-2008

Table 1

Characteristics of Stage I – III Colorectal Cancer Patients Living in Appalachian Counties in 4 States, 2006-2008

Characteristics	Stages I-III Colon Cancer (n=2932)		Rectal Cancer (n=184)	
	Frequency	Percent	Frequency	Percent
Age				
66-73	883	30.2	97	52.7
74-80	962	32.8	87	47.3
81+	1087	37.1	0	0
Gender1				
Male	1220	41.6	104	56.5
Female	1712	58.4	80	43.5
Race/Ethnicity				
White	2842	96.9	178	96.7
Black	60	2.0	5	2.7
Hispanic	14	0.5	1	0.5
Other	11	0.4	0	0
Unknown	5	0.2	0	0
Registry				
Kentucky	347	11.8	25	13.6
North Carolina	439	15.0	28	15.2
Ohio	577	19.7	39	21.2
Pennsylvania	1569	53.5	92	50.0
Tumor Size (241 missing)				
<0.5 cm	29	1.1	1	0.6
0.5–< 2 cm	266	9.9	17	10.5
2–<4 cm	900	33.4	63	38.9
4+	1496	55.6	81	50.0
Stage				
I	864	29.5	0	0
II	1186	40.5	0	0
III	882	30.1	184	100.0
Grade (109 missing)				
Well differentiated	277	9.8	12	6.8
Moderately differentiated	2020	71.6	127	71.8
Poorly differentiated/undifferentiated	526	18.6	38	21.5
Histologic Subtype				
Adenocarcinoma, arising from a polyp	438	14.9	23	12.5

Characteristics	Stages I-III Colon Cancer (n=2932)		Rectal Cancer (n=184)	
	Frequency	Percent	Frequency	Percent
Adenocarcinoma, mucinous	345	11.8	144	78.3
Adenocarcinoma, not otherwise specified	2123	72.4	16	8.7
Signet Ring Carcinoma	26	0.9	1	0.5
Comorbidity				
None	350	11.9	37	20.0
Mild	1208	41.2	92	49.7
Moderate	507	17.3	19	10.3
Severe	867	29.6	36	19.5
Treatment				
Oncologic resection	2932	100.0	184	100.0
Chemotherapy	693	23.6	153	83.2
Radiation	62	2.1	108	58.7

Table 2

Bivariate Association of Sociodemographic or Service Provider Characteristics With Guideline Concordance for Stage I – III Colorectal Cancer Patients Living in Appalachian Counties in 4 States, 2006-2008[d]

Sociodemographic and spatial characteristics	Chemotherapy for stage III colon cancer (n=561)		›12 lymph nodes stages I – III colon cancer (n=2932)		Radiation therapy for Stage III rectal cancer (n=184)	
	N	%yes	N	%yes	N	%yes
Total	**561**	**62.9**	**2932**	**66.3**	**184**	**56.0**
Age						
Ã66-73	277	69.7[a]	883	68.3	97	66.0[a]
74-80	284	56.3	962	65.3	87	44.8
81+	0	--	1087	65.5	0	--
Race/Ethnicity[e]						
White	539	63.6	2842	66.7[a]	178	57.8[c]
Black	19	47.4	60	56.7	5	0.0
Hispanic	2	50.0	14	50.0	1	0.0
Other	1	0.0	11	54.5	0	--
Gender						
Male	263	63.9	1261	61.6[a]	104	59.6
Female	298	62.1	1746	66.9	80	51.3
Derived Stage						
Stage I	0	--	846	53.6[a]	0	--
Stage II	0	--	1186	70.6	0	--
Stage III	561	62.9	882	73.1	184	56.0
Grade						
Well differentiated	12	59.0	277	63.9[a]	12	75.0
Moderately differentiated	359	59.0	2020	63.0[a]	12	750
Poorly diff/undifferentiated	146	63.0	526	74.9	38	50.0
Hospital size						
<50 beds	24	58.3	94	63.8[a]	4	50.0
50 – 100 beds	34	61.8	204	56.4	10	50.0
100-200 beds	10 7	57.0	583	55.6	34	52.9
200 - 500 beds	241	69.3	1233	66.3	69	60.9
500+ beds	131	58.0	670	78.7	53	56.6
Hospital COC designation						
Hospital Cancer Pgm	97	66.0	457	67.6[a]	30	63.3[b]
Comprehensive Cancer Pgm	170	63.5	925	73.2	49	65.3
Teaching Hospital Cancer Pgm	52	71.2	314	76.8	30	43.3

Sociodemographic and spatial characteristics	Chemotherapy for stage III colon cancer (n=561)		›12 lymph nodes stages I – III colon cancer (n=2932)		Radiation therapy for Stage III rectal cancer (n=184)	
	N	%yes	N	%yes	N	%yes
Total	**561**	**62.9**	**2932**	**66.3**	**184**	**56.0**
NCI designated Cancer Pgm	18	50.0	105	82.9	15	80.0
Network Cancer Pgm	5	100.0	31	74.2	1	0.0
No designation	195	59.5	952	53.3	45	46.7
Hospital Ownership						
Not-for profit	473	63.2	2507	66.2	153	57.5
For profit	24	66.7	97	65.0	3	33.3
Government	40	60.0	177	67.8	14	57.1
Metropolitan location	289	61.9	1608	69.2*	96	58.3
Nonmetropolitan location	272	64.0	1324	62.9	88	53.4
Surg facility Volume						
Quartile 1 (lowest volume)	135	65.9	687	56.7[a]	29	48.3
Quartile 2	142	62.0	690	55.5	32	53.1
Quartile 3	132	66.7	707	72.4	47	61.7
Quartile 4 (highest volume)	126	57.9	696	80.0	61	59.0
Surg Provider Volume						
Quartile 1 (lowest volume)	131	58.8	658	61.9[a]	33	48.5
Quartile 2	123	67.5	749	65.4	37	46.0
Quartile 3	135	67.4	663	64.4	34	64.7
Quartile 4 (highest volume)	150	59.3	742	74.4	58	56.9
Facility Radiation Treatment						
Yes	415	62.3	2151	68.7[a]	135	59.3
No	122	55.7	629	57.7	35	48.6
Facility Chemotherapy Treatment						
Yes	155	60.7	919	67.9	38	63.2
No	382	64.1	1861	65.4	132	55.3
Provider Specialty						
Colorectal Surgery	71	56.3	310	75.2[a]	25	60.0
Other	468	64.1	2501	65.7	137	53.3
Year of diagnosis						
2006	205	61.0	1038	58.8[a]	64	57.8[a]
2007	193	66.3	995	69.5	62	66.1
2008	163	61.4	899	71.6	58	43.1
Continuous Variables	No	Yes	No	Yes	No	Yes

Sociodemographic and spatial characteristics	Chemotherapy for stage III colon cancer (n=561)		›12 lymph nodes stages I – III colon cancer (n=2932)		Radiation therapy for Stage III rectal cancer (n=184)	
	N	%yes	N	%yes	N	%yes
Total	**561**	**62.9**	**2932**	**66.3**	**184**	**56.0**
Age	74.5(4.3)[a]	73.0(4.2)	78.0(6.8)	77.8(7.0)	73.9(4.3)	72.0(4.0)[a]
Provider Graduation year	1984(10)	1983(11)	1982(11)	1984(10)[a]	1984(11)	1984(9)
Log Tumor size	3.8(0.6)	3.8(0.5)	3.4(0.7)	3.7(0.6)[a]	3.6(0.5)	3.6(0.5)

[a] Chi-square or t-test, $P < .05$

[b] For COC status vs radiation, there is only 1 facility with “Network Cancer Program” designation (Fisher exact = .0473. When this facility is grouped into another category, “Community Hospital Comprehensive Program,” (Fisher exact $P = .0609$.). Due to very small sample size, results are not as robust and classified as statistically insignificant.

[c] Fishers exact test $P< .05$.

[d] Missing cases not included in bivariate comparisons; total sample size may change by each comparison.

[e] Race statistical comparisons compared White vs Other only.

Table 3

Bivariate Association of Comorbidity Burden With Guideline Concordance for Stage I - III Colorectal Cancer Patients Living in Appalachian Counties in 4 States, 2006- 2008

Comorbidity Burden	Chemotherapy for stage III colon cancer (n=561)		›12 lymph nodes harvested stages I – III colon cancer (n=2932)		Radiation therapy for Stage III rectal cancer (n=184)	
	N	%yes	N	%yes	N	%yes
Total	**561**	**62.9**	**2932**	**66.3**	**184**	**56.0**
Comorbidity Severity						
none	72	65.3a	350	69.7	37	64.9
mild	247	70.0	1208	66.0	92	52.2
moderate	79	60.8	507	67.9	19	52.6
Severe	163	52.1	867	64.6	36	58.3
Comorbidities						
AMI	40	45.0a	193	62.2	8	25.0
CAD	34	58.8	163	63.8	6	66.7
CHF	67	44.8[a]	442	63.1	15	46.7
Arrhythmia	68	57.4	514	66.1	18	50.0
Hypertension	396	63.6	2114	66.0	120	52.5
Venous Disease	14	64.3	66	63.6	2	50.0
PAD	16	62.5	81	60.5	1	100.0
Respiratory diseases	132	52.2a	823	64.6	45	44.4
Hepatic	8	37.5	37	70.3	2	100.0
Stomach or Intestine	41	58.5	281	68.0	15	60.0
Pancreas	1	100.0	8	62.5	0	--
Renal System	27	55.5	180	60.0	7	28.6
Diabetes	189	61.9	883	62.5a	51	58.8
Stroke or CVA	4	25.0	65	58.5	3	33.3
Dementia	8	12.5a	63	60.3	2	0.0
Paralysis	1	0.0	24	70.8	0	--
Neuromuscular	12	50.0	103	62.1	2	50.0
Psychiatric	1	0.0	7	71.4	0	--
Rheumatologic	3	66.6	10	50.0	0	--
AIDS	0	--	0	--	0	--
Solid Tumor	145	66.9	565	66.7	24	41.7
Leukemia	10	60.0	33	66.7	0	--
Lymphoma	0	--	1	0.0	0	--
Alcohol Abuse	4	25.0	11	54.5	1	100.0
Illicit Drugs	0	--	0	--	0	--
Obesity	12	58.3	32	81.3	2	50.0
Multimorbidity Count						

Comorbidity Burden	Chemotherapy for stage III colon cancer (n=561)		›12 lymph nodes harvested stages I – III colon cancer (n=2932)		Radiation therapy for Stage III rectal cancer (n=184)	
	N	%yes	N	%yes	N	%yes
Total	**561**	**62.9**	**2932**	**66.3**	**184**	**56.0**
0 morbidities	72	65.3	350	69.7	37	64.9
1 comorbidity	155	69.7	742	66.8	56	55.4
2-3 comorbidities	223	61.0	1221	66.4	70	55.7
4-5 comorbidities	86	57.0	464	65.7	17	52.9
6+ comorbidities	25	52.0	155	57.4	4	0.0

[a]Chi-square, $P < .05$ for colon cancer resection.

Table 4

Multivariate Logistic Regression of the Impact of Sociodemographic, Hospital, Distance, and Contextual Characteristics on the Receipt of Guideline Concordant Treatment for Stage I - III Colorectal Cancer Patients Living in Appalachian Counties in 4 States, 2006- 2008

	Chemotherapy (n=561)		Nodal Assessment (n=2932)		Radiation (n=184)[b]	
	OR	**95%CI**	**OR**	**95%CI**	**OR**	**95%CI**
Age in years	0.918*	0.879 – 0.959			0.90*	0.841 – 0.974
Gender: Female vs. Male			1.207[a]	1.016 – 1.435		
Race: White vs. Other			1.637[a]	1.004 – 2.668		
Grade Diff: Well vs. Poor			0.990	0.687 – 1.425		
Grade: Diff. Moderate. vs. Poor			0.824	0.647 – 1.050		
Stage: I vs. III			0.505[a]	0.398 – 0.641		
Stage: II vs. III			0.784[a]	0.633 – 0.971		
Comorbidity Index (vs. None)						
Mild	1.442	0.812 – 2.559				
Moderate	1.091	0.539 – 2.209				
Severe	0.902	0.469 – 1.737				
ACE-27 Comorbidities						
AMI	0.658	0.323 – 1.339				
Congestive heart failure	0.699	0.384 – 1.270				
Dementia	0.107*	0.013 – 0.898				
Respiratory Diseases	0.713	0.453 – 1.121				
Diabetes			0.780[a]	0.649 – 0.938		
Log Tumorsize			1.872[a]	1.608 – 2.179		
Hospital Bedsize Category (vs. 500+)						
<50			1.700	0.863 – 3.347		
50 - 100			1.427	0.829 – 2.459		
100 - 200			1.036	0.664 – 1.618		
200 - 500			0.814	0.575 – 1.152		
Hospital COC designation (vs. None)						
Hospital Cancer Program			2.405[a]	1.763 – 3.281		
Comprehensive Cancer Program			2.136[a]	1.593 – 2.864		
NCI designated Cancer Program			2.292[a]	1.198 – 4.383		
Network Cancer Program			1.794	0.691 – 4.661		
Teaching Hospital			2.069[a]	1.332 – 3.212		
Facility Radiation (yes vs. no)			1.026	0.789 – 1.335		

	Chemotherapy (n=561)		Nodal Assessment (n=2932)		Radiation (n=184)[b]	
	OR	**95%CI**	**OR**	**95%CI**	**OR**	**95%CI**
Facility Surgical Volume (versus Q4)						
Quartile 1			0.344[a]	0.223 – 0.530		
Quartile 2			0.345[a]	0.232 – 0.512		
Quartile 3			0.667[a]	0.474 – 0.939		
Other MD Specialty (vs. Colorectal Surgery)			0.917	0.652 – 1.292		
Surgery Provider Volume (vs. Q4)						
Quartile 1 (lowest)			0.963	0.716 – 1.295		
Quartile 2			0.985	0.744 – 1.304		
Quartile 3			0.867	0.648 – 1.160		
Provider Graduation Year			1.010[a]	1.001 – 1.019		
Metropolitan vs. non-metropolitan			0.980	0.756 – 1.270		
Year of diagnosis						
2007			1.668[a]	1.361 - 2.045	1.281	0.609 – 2.694
2008			1.902[a]	1.532 - 2.361	0.561	0.269 – 1.169

[a] F-statistic, $P < .05$

[b] Race and COC designation removed from analysis because of excessively unbalanced distributions and otherreasons.