Age and Rural Residence Effects on Accessing Colorectal Cancer Treatments: A Registry Study

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Objectives: To test the hypotheses that older patients with colorectal cancer (CRC) and rural patients are less likely to undergo surgery, radiation, and chemotherapy.

Study Design: Retrospective study.

Methods: A total of 6561 patients with CRC between January 1998 and December 2003 were identified by incident *International Classification of Diseases for Oncology* codes from the Nebraska Cancer Registry. In multivariate logistic regression analyses, we studied the association of age and residence county (rural vs urban and micropolitan) with each of 3 CRC treatments by anatomic site.

Results: After adjusting for patient demographics, insurance payer, ratio of providers to population, and cancer stage, patients with colon cancer living in micropolitan counties were more likely to receive chemotherapy than those living in rural counties (P <.001). Compared with patients aged 19 to 64 years, patients with colon cancer 85 years and older (P <.001) and patients with rectal cancer 75 years and older (P <.05) were less likely to undergo surgery. Patients with CRC 75 years and older were less likely to receive radiation, and patients with colon cancer 65 years and older and patients with rectal cancer 75 years and older were less likely to receive chemotherapy (P <.001 for both).

Conclusions: In Nebraska, older patients with CRC were less likely to undergo surgery, radiation, and chemotherapy. Patients with colon cancer in rural counties were less likely to undergo chemotherapy than those in micropolitan counties. Decision makers need to consider issues of age and rural residence in patient access to CRC treatments.

(Am J Manag Care. 2010;16(4):265-273)

Second to lung cancer, colorectal cancer (CRC) is one of the most frequent causes of cancer-related morbidity and mortality in the United States, with 146,970 new CRC cases and 49,920 related deaths in 2009 among both sexes.[1,2] Estimated annual national spending of $8.4 billion (in 2004 US dollars) for CRC has been reported.[3]

Standard treatment delivered without racial/ethnic and health insurance disparities, among other factors, increases CRC survival.[1,2,4-11] National Cancer Institute (NCI) guidelines[9,10] recommend standard treatment of CRC with various combinations of surgery, radiation, and chemotherapy depending on the stage and site (colon vs rectum) of disease. Current guidelines include surgery and chemotherapy for stage III (regional) colon cancer and a combination of surgery, radiation, and chemotherapy for advanced stage II (penetration through bowel wall) and stage III rectal cancer.[9,10] The use of adjuvant radiation and chemotherapy increased in the early 1990s based on National Institutes of Health[5] consensus conference recommendations but varied depending on patient age, sex, race/ethnicity, insurance payer, and geographic location of CRC care.[7,11-14] Racial/ethnic minorities and those in impoverished urban communities have higher CRC morbidity and mortality rates.[15-17]

Evidence from 5 published studies[7,11,14,18,19] about the association of geographic access with CRC treatments is mixed. A study[7] of incident cases of CRC occurring in Florida in 1994 found that urban residents were significantly less likely than nonurban residents to undergo radiation but not surgery or chemotherapy. An analysis of the NCI's Surveillance, Epidemiology, and End Results (SEER) registry data annually between 1987 and 1991 and in 1995 found overall variations in the use of standard adjuvant therapy among patients with CRC; however, the odds of receiving treatment were not significantly different among US regions.[11] Studies of California residents with CRC[18] and Louisiana residents with colon cancer[19] revealed no significant rural-urban differences in receipt of adjuvant radiation and chemotherapy, respectively. No rural-urban differences in the likelihood of undergoing surgery were found among patients with CRC in Australia.[14] However, the same study found that patients seen at rural hospitals were less likely to undergo surgery than patients seen at nonrural hospitals, suggesting that treatment in a rural setting may affect whether a patient receives certain CRC treatments.

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Take-Away Points

In Nebraska, older patients with colorectal cancer (CRC) were less likely to undergo surgery, radiation, and chemotherapy, and patients with colon cancer in rural versus micropolitan counties were less likely to undergo chemotherapy. In planning cancer control efforts for access to CRC treatments, providers and policymakers need to consider:

- Addressing age and rural residence effects.
- Using 3-category geographic measures (vs 2-category rural-urban classification) to better unmask access differences.
- Assessing factors related to decreased likelihood of CRC treatments among older patients and decreased likelihood of chemotherapy among patients with colon cancer in rural versus micropolitan counties.

Earlier literature on age and geographic access to CRC treatments[7,8,11-19] is limited to western, southern, and northeastern US states, whose population demographics differ from those in Nebraska. Between 2000 and 2004, Nebraska had 5292 cases of CRC.[20] Of 93 counties in Nebraska, 64 are rural (noncore) nonmetropolitan (nonmetro) counties, 20 are micropolitan nonmetro centered on urban clusters of 10,000 to 49,999 persons, while only 9 are urban metropolitan (metro) counties.[21-23] According to 2007 estimates from US Department of Agriculture and US Census data, about 42% of Nebraskans live in rural counties.[21,22]

To help providers and public health policymakers plan strategies for ensuring access to therapy, we performed a retrospective study to examine the potential effects of age and rural residence on receipt of CRC treatments. Our a priori hypotheses were that patients living in rural counties are less likely to receive each NCI-recommended CRC treatment (surgery, radiation, or chemotherapy) than patients living in nonrural counties after controlling for patient demographics and cancer stage at diagnosis. Based on earlier studies[7,11,18] of cancer registry data, we expected that older patients with CRC are less likely than younger patients to receive CRC treatments.

METHODS

Data Sources

Using the population-based statewide Nebraska Cancer Registry (NCR), we identified patients 19 years and older who had been diagnosed as having incident CRC between January 1998 and December 2003. The estimated completeness of case ascertainment by the NCR was 98% to 100% for 1998-2002 based on audits.[24,25] For NCR data collection, registrars reabstracted hospital medical records and corroborated information on patient demographics, tumor characteristics, and treatment planned or given within 4 months of diagnosis. The NCR records all cancer-directed treatments administered within 4 months of beginning therapy, regardless of sequence or degree of completion and regardless whether therapy was performed at the reporting institution or elsewhere.

Inclusion and Exclusion Criteria

The *International Classification of Diseases for Oncology* (*ICD-O-3*) codes are "used principally in tumor or cancer registries for coding the site (topography) and the histology (morphology) of neoplasms, usually obtained from a pathology report."[26] Patients with *ICD-O-3* codes of C18.0 to C18.9 for colon cancer, C19.9 for rectosigmoid cancer, and C20.9 for rectal cancer were included. Because of differing pathology and treatment implications, patients with codes C18.1 (carcinoid of appendix), C21 (anal canal carcinoma), and C26.0 (unspecified digestive organs) were excluded.[7] Because of our interest in treatments of first CRC diagnosis, we included initial tumors of patients with multiple tumors and excluded all subsequent tumors (n = 252). The institutional review board at the University of Nebraska Medical Center approved the data sources for this study after an expedited review.

Data Variables

The study outcomes were dichotomous (ie, receipt vs nonreceipt) for each of 3 CRC-specific NCI-recommended treatments, namely, surgery, radiation, and chemotherapy. A dichotomous rural-urban definition of geographic access used in previous studies[7,18,19] may mask important variation in CRC incidence and mortality rates[27] and may misclassify some rural populations that may be affected by nonmetro diversity.[28,29] The 2003 county-based Office of Management and Budget (OMB) metropolitan and nonmetropolitan classifications[28-32] have been often used as a policy tool in determining eligibility and reimbursement for many federal programs.[30] We first sorted patients with CRC into 3 residence county groups (1 metro and 2 nonmetro) using the OMB classification. The first group included patients in the "urban metro" counties with large (≥1 million residents) or small-metro (50,000 to <1 million residents) central counties. These small-metro counties may have 1 or more urbanized areas that are cities with a population of at least 50,000 and outlying counties that are economically tied to the central (core) counties, measured by commute to work. The second group included patients in the micropolitan nonmetropolitan (nonmetro) counties (centered on urban clusters with 10,000-49,999 residents plus surrounding counties that are linked through commuting ties). The third group included patients in the noncore nonmetro counties commonly known as "rural (noncore)" nonmetro counties containing a town of 2500 to 9999 residents or containing a town of fewer than 2500 residents. Therefore, patient residence county was ordered as a hierarchical variable into 3 groups, namely, urban, micropolitan, or rural.

Patients were classified into 4 age groups (19-64, 65-74, 75-84, or ≥85 years), 2 marital status groups (married vs unmarried, including single, separated, divorced, and widowed), and 2 races/ethnicity groups (white non-Hispanic vs other, including black non-Hispanic, Hispanic, and all other non-Hispanic races/ethnicities). Insurance payer groups were Medicare, private, insurance not otherwise specified, or other (including the few patients covered by Medicaid, the uninsured, and patients with other insurance). Clinical and pathologic cancer stage was defined by SEER summary stages (in situ, local, regional, distant, or unstaged). Socioeconomic factors of income and education were unavailable from the NCR. Therefore, by linking each patient's zip code of residence at the time of CRC diagnosis, age group, and sex to US Census data, we estimated education as less than high school or high school or above. Similarly, all patients were assigned a median annual family income according to their zip code of residence. Patient residence county–specific ratio of providers (including primary care physicians) to 10,000 population, a confounder of geographic access to care, was calculated using the Area Resource File.[21] Because association of diagnosis year (1998-2000 vs 2001-2003) with each CRC treatment was not statistically significant, we excluded diagnosis year as a confounder in multivariate analyses of CRC treatment outcomes.

Statistical Analysis

For the power calculation, assuming that about 6000 patients with CRC satisfied the study eligibility criteria based on the most recent (2004) NCR data[20] and assuming that about one-third of the patients belonged to the 3 residence county categories, 30% of the variability in patient residence county could be explained by confounding patient-level covariates. After adjustment for confounders,[33] for 2-sided .05-level statistical tests, we had 80% power to detect a 3% to 5% absolute difference in the proportion of patients receiving the treatment of interest among the 3 residence county categories (calculated using Power Analysis and Sample Size [PASS 2005] software; NCSS, Kaysville, UT).

Because of differences in prognosis and treatments, a patient could receive more than 1 of 3 CRC treatments simultaneously. Therefore, we separately analyzed the association of age and residence county with each treatment in multivariate models, as in a previous study.[7] First, we summarized descriptive statistics of the study population by 3 treatments (surgery, radiation, and chemotherapy) for colon cancer and for rectal cancer. In univariate analyses, we evaluated the association of categorical covariates and continuous covariates (median annual family income and residence county–specific ratio of providers to 10,000 population) individually with each treatment using χ^2 test and t test (or Wilcoxon rank sum nonparametric test), respectively. In multivariate logistic regression models, we evaluated the association of residence county with the dichotomous treatment outcomes (receipt vs nonreceipt) using adjusted odds ratios and 95% confidence intervals. Because the use of surgery, radiation, and chemotherapy depends on CRC stage at diagnosis, we controlled for cancer stage in the multivariate analysis. The statistical significance of main effects was assessed using the likelihood ratio test and the Wald test, and the goodness of fit of the models was assessed using the Hosmer-Lemeshow test. All tests were 2-sided at the .05 level. Assuming data to be missing at random,[34] we excluded patients with missing data from the analyses. Data analyses were performed using statistical software (SAS version 9.1 for Windows; SAS Institute, Inc, Cary, NC).

RESULTS

Distribution of CRC Treatments

Table 1 gives the distribution of NCI-recommended CRC treatments by patient characteristics for colon cancer and for rectal cancer. Most patients (89.1% with colon cancer and 78.2% with rectal cancer) underwent surgery. Fewer patients received radiation (3.3% with colon cancer and 41.2% with rectal cancer) or chemotherapy (30.5% with colon cancer and 46.0% with rectal cancer). In univariate analyses, residence county was associated with likelihood of undergoing surgery and chemotherapy (P <.01) (but not radiation) for colon cancer but was not associated with likelihood of undergoing all treatments for rectal cancer. Age was associated with treatment type received (P <.001) in patients with colon cancer and in patients with rectal cancer. Marital status, insurance payer, and cancer stage at diagnosis were significantly associated with each treatment type in patients with colon cancer and in patients with rectal cancer. The following characteristics were not significantly associated with CRC treatments: residence county–specific ratio of providers to 10,000 population for all treatment types, education and race/ethnicity for radiation and chemotherapy (in colon cancer and in rectal cancer), and sex and median annual family income for radiation (in colon cancer and in rectal cancer) and for surgery (in rectal cancer). Therefore, we included all potential confounders in multiple logistic regression models to evaluate the associations of age and residence county with each of the treatment types for colon cancer and for rectal cancer.

CRC Treatments by Residence County

When fitting all multivariate logistic regression models, collinearity between predictors was not a concern. For study objective focus and clarity, we summarize age and residence county effects (regardless of statistical significance) and other statistically significant covariates in Table 2, Table 3, and Table 4.

Table 1. Characteristics of Patients With Colon Cancer and With Rectal Cancer in Nebraska by Treatment Type Between 1998 and 2003

Characteristic	Overall (N = 6561) N (%)[a]	Colon Cancer (N = 5235)		
		Surgery (n = 4666) n (%)[b]	Radiation (n = 171) n (%)[b]	Chemotherapy (n = 1597) n (%)[b]
Age, y, No. (%)		<.001	<.001	<.001
19-64	1801 (27.5)	1233 (94.1)	80 (6.1)	659 (50.3)
65-74	1824 (27.8)	1348 (92.6)	50 (3.4)	545 (37.5)
75-84	1943 (29.6)	1437 (89.9)	38 (2.4)	346 (21.7)
≥85	993 (15.1)	648 (78.4)	3 (0.4)	47 (5.7)
Sex, No. (%)		<.01		<.001
Male	3348 (51.0)	2318 (91.2)	90 (3.5)	846 (33.3)
Female	3213 (49.0)	2348 (88.6)	81 (3.1)	751 (28.4)
Race/ethnicity, No. (%)[a]	(N = 6433)	<.05		
White non-Hispanic	6152 (95.6)	4387 (90.2)	164 (3.4)	1508 (31.1)
Other	281 (4.4)	202 (86.0)	6 (2.6)	79 (33.6)
Marital status, No. (%)[a]	(N = 6213)	<.001	<.05	<.001
Married	2506 (40.3)	2732 (93.7)	115 (3.9)	1086 (37.3)
Unmarried	3707 (59.7)	1820 (89.7)	55 (2.7)	480 (23.7)
Education, No. (%)[a]	(N = 6556)	<.05		
<High school	184 (2.8)	116 (83.5)	1 (0.7)	42 (30.2)
≥High school	6372 (97.2)	4548 (90.1)	170 (3.4)	1555 (30.8)
Median annual family income [a]	(N = 6556)	<.01 (n = 4664)		<.001
Mean (SD), $	38,919 (10,631)	39,188 (10,767)	39,477 (10,972)	40,235 (11,584)
Residence county–specific ratio of providers to 10,000 population				
Mean (SD)	6.0 (5.6)	6.0 (6.5)	5.5 (2.0)	6.1 (10.7)
Insurance payer, No. (%) [a]	(n = 5912)	<.001	<.001	<.001
Medicare	3992 (67.5)	2992 (91.3)	81 (2.5)	812 (24.8)
Private	834 (14.1)	599 (94.9)	37 (5.9)	317 (50.3)
Insurance NOS	739 (12.5)	524 (96.3)	35 (6.4)	273 (50.3)
Other	347 (5.9)	251 (93.3)	12 (4.5)	108 (40.2)
Residence-county, No. (%)		<.01		<.01
Rural	2012 (30.7)	1375 (88.1)	55 (3.5)	424 (27.2)
Urban	2976 (45.4)	2174 (89.7)	77 (3.2)	774 (32.0)
Micropolitan	1573 (24.0)	1117 (92.3)	39 (3.2)	399 (33.0)
SEER stage at diagnosis, No. (%)[c]		<.001	<.001	<.001
In situ	369 (5.6)	259 (93.2)	0	0
Local	1845 (28.1)	1386 (98.0)	11 (0.8)	92 (6.5)
Regional	2751 (41.9)	2253 (99.3)	112 (4.9)	1021 (45.1)
Distant	1081 (16.5)	682 (75.8)	45 (5.0)	463 (51.6)
Unstaged	515 (7.9)	86 (25.9)	3 (0.9)	21 (6.3)

NOS indicates not otherwise specified; SEER, Surveillance, Epidemiology, and End Results.
[a]Sample size N is indicated if there was missing data. Missing data include the following: 128 for race/ethnicity, 348 for marital status, 5 for education, 5 for median annual family income, and 649 for insurance payer. Missing for colon cancer are 42 for surgery, 40 for radiation, and 49 for chemotherapy. Missing for rectal cancer are 2 for surgery, 2 for radiation, and 3 for chemotherapy. *P* value is given if statistically significant for the association of patient characteristics with receipt of respective colon or rectal treatments.
[b]n (%) represents the number and percent of colon or rectal cancer patients who received respective treatments for each patient characteristic.
[c]Each stage may have received more than 1 treatment type.

Rectal Cancer (n = 1326)		
Surgery (n = 1037) n (%)[b]	Radiation (n = 546) n (%)[b]	Chemotherapy (n = 610) n (%)[b]
<.001	<.001	<.001
401 (83.0)	235 (48.7)	279 (57.8)
299 (82.6)	170 (47.0)	188 (51.9)
248 (74.7)	114 (34.3)	122 (36.8)
89 (60.5)	27 (18.4)	21 (14.4)
		<.01
616 (78.6)	341 (43.5)	388 (49.5)
421 (78.0)	205 (38.0)	222 (41.2)
<.05		
987 (79.0)	528 (42.3)	587 (47.0)
26 (61.9)	13 (31.0)	18 (43.9)
<.001	<.05	<.001
653 (83.0)	352 (44.7)	409 (52.0)
344 (72.1)	185 (38.8)	193 (40.6)
<.05		
29 (65.9)	17 (38.6)	19 (43.2)
1008 (78.8)	529 (41.4)	591 (46.2)
		<.05
38,578 (10,220)	39,047 (10,694)	39,100 (10,581)
5.9 (2.2)	5.9 (2.3)	6.0 (2.2)
<.05	<.01	<.001
548 (77.2)	272 (38.3)	288 (40.6)
174 (85.7)	109 (53.7)	124 (61.1)
162 (83.1)	92 (47.2)	108 (55.4)
55 (71.4)	35 (45.5)	47 (61.0)
353 (79.7)	167 (37.7)	187 (42.3)
411 (78.0)	229 (43.5)	259 (49.2)
273 (77.1)	150 (42.4)	164 (46.3)
<.001	<.001	<.001
84 (92.3)	1 (1.1)	0
394 (91.8)	102 (23.8)	89 (20.8)
441 (91.3)	357 (73.9)	374 (77.4)
78 (43.1)	52 (28.7)	111 (61.3)
40 (28.6)	34 (24.3)	36 (25.9)

After controlling for demographic characteristics and cancer stage at diagnosis, residence county was not significantly associated with likelihood of undergoing surgery (Table 2). However, compared with patients aged 19 to 64 years, patients with colon cancer 85 years and older and patients with rectal cancer aged 75 years and older were significantly less likely to undergo surgery.

There were no significant differences in the use of radiation by residence county after controlling for demographic characteristics and cancer stage at diagnosis by patients with colon cancer or by patients with rectal cancer (Table 3). However, compared with patients aged 19 to 64 years, patients with colon cancer and patients with rectal cancer who were 75 years and older were less likely to receive radiation.

After controlling for demographic characteristics and cancer stage at diagnosis, residence county in patients with colon cancer and age in patients with colon cancer and in patients with rectal cancer (P <.001 for both) were significantly associated with receiving chemotherapy (Table 4). Among patients with colon cancer, those residing in micropolitan counties were significantly more likely to receive chemotherapy than those residing in rural counties (adjusted odds ratio, 1.47; 95% confidence interval, 1.18-1.82; P <.001). Among patients with colon cancer and among patients with rectal cancer, rural residents did not significantly differ from urban residents in receipt of chemotherapy. Compared with patients aged 19 to 64 years, patients with colon cancer 65 years and older and patients with rectal cancer 75 years and older were significantly less likely to receive chemotherapy.

DISCUSSION

This is one of the first studies about the association of age and residence county with receipt of CRC treatments in Nebraska. A previous study[35] of the NCR found that early CRC diagnosis was less likely in Nebraska among rural residents than among micropolitan county residents. This supports the use of rural residence rather than urban residence as the reference category, unlike other studies[36,37] that used the latter. In contrast to earlier studies that used the dichotomous rural-urban measure,[7,18,19,27] a 4-level measure based on the rural-urban commuting area code,[36] or a 5-level measure,[37] we used a 3-category measure of geographic access based on the 2003 OMB classification. Using the 3-category measure, we found significant geographic variation in receipt of chemotherapy among patients with colon cancer. Similar to earlier studies,[7,11,18] we found evidence of disparities in receipt of CRC treatments with increasing age among patients with colon cancer and among patients with rectal cancer.

Table 2. Multivariate Predictors of Undergoing Surgery for Colon Cancer and for Rectal Cancer in Nebraska Between 1998 and 2003

Characteristic	Adjusted Odds Ratio (95% Confidence Interval)[a]			
	Colon Cancer (n = 4614))	*P*	Rectal Cancer (n = 1160)	*P*
Age, y		<.001[b]		<.05[b]
19-64	1.00 [Reference]		1.00 [Reference]	
65-74	1.03 (0.54-1.95)		0.82 (0.41-1.62)	
75-84	0.63 (0.33-1.20)		0.47 (0.24-0.95)	
≥85	0.27 (0.14-0.53)		0.33 (0.15-0.73)	
Residence county		.46		.08
Rural	1.00 [Reference]		1.00 [Reference]	
Urban	0.87 (0.60-1.26)		0.73 (0.44-1.21)	
Micropolitan	1.12 (0.74-1.68)		0.58 (0.35-0.93)	
Residence county–specific ratio of providers to 10,000 population	0.99 (0.98-1.01)	.41	0.91 (0.84-0.98)	.02
SEER stage at diagnosis		<.001[b]		<.001[b]
Local	1.00 [Reference]		1.00 [Reference]	
In situ	0.23 (0.12-0.46)		1.87 (0.63-5.51)	
Regional	2.97 (1.49-5.90)		1.00 (0.61-1.63)	
Distant	0.06 (0.04-0.09)		0.07 (0.04-0.11)	
Unstaged	0.006 (0.003-0.010)		0.03 (0.02-0.06)	

SEER indicates Surveillance, Epidemiology, and End Results.
[a]Adjusted for sex, race/ethnicity, marital status, education, median annual family income, and insurance payer, none of which were statistically significant for undergoing surgery.
[b]Statistically significant.

Rural Residence and CRC Treatments

Patients living in rural counties were less likely than patients living in micropolitan counties to receive chemotherapy for colon cancer. This was not reported in earlier studies[7,11,18,19,36,37] and suggests that the use of rural residence as a reference category may unmask differences by residence county in rural states like Nebraska. However, there were no statistically significant rural-urban differences in the likelihood of undergoing surgery, radiation, or chemotherapy among patients with colon cancer or among patients with rectal cancer. Our findings are similar to earlier reports of no significant rural-urban differences in adjuvant chemotherapy initiation among older patients with colon cancer in Michigan[37] or in chemotherapy completion by Medicare beneficiaries with stage III colon cancer based on SEER registry data,[36] which cover the metropolitan areas of several US states.[38,39] Further research is needed about barriers other than residence county such as provider recommendation and patient choice in accessing CRC treatments in urban, micropolitan, and rural areas.

Age and CRC Treatments

Earlier studies using cancer registry data from Florida,[7] SEER,[11] and California[18] reported significant differences in receipt of CRC treatments by age. Similarly in our study, compared with younger patients having colon cancer, those 85, 75, and 65 years and older were less likely to undergo surgery, radiation, and chemotherapy, respectively. Compared with younger patients having rectal cancer, those 75 years and older were less likely to undergo surgery, radiation, or chemotherapy. At least some of the age disparity in receipt of treatments may reflect patient choice to forgo therapy, especially among individuals with advanced-stage CRC or with increasing comorbidities due to older age or among individuals with demands of taking care of their farms or ranches or with increasing long-distance travel to treatment facilities from remote rural counties. Age disparities in receipt of CRC treatments may also reflect clinical judgment to withhold therapy because of lower survival benefit from chemotherapy in older age[40] and because of expected poor tolerance.

CRC Treatments by Other Demographic Factors and by Cancer Stage at Diagnosis

Like others,[7,18] we found that married patients with colon cancer were more likely than unmarried patients to receive chemotherapy. As in the NCI's Pattern of Care study,[8] insurance payer was not significantly associated with receipt

Table 3. Multivariate Predictors of Undergoing Radiation for Colon Cancer and for Rectal Cancer in Nebraska Between 1998 and 2003

Characteristic	Adjusted Odds Ratio (95% Confidence Interval)[a]			
	Colon Cancer (n = 4374)	*P*	Rectal Cancer (n = 1083)	*P*
Age, y		<.001[b]		<.001[b]
19-64	1.00 [Reference]		1.00 [Reference]	
65-74	0.58 (0.31-1.08)		1.05 (0.62-1.79)	
75-84	0.39 (0.20-0.77)		0.49 (0.28-0.85)	
≥85	0.06 (0.02-0.23)		0.20 (0.10-0.41)	
Race/ethnicity		.29		.04[b]
White non-Hispanic	1.00 [Reference]		1.00 [Reference]	
Other	0.63 (0.26-1.50)		0.43 (0.19-0.96)	
Residence county		.72		.32
Rural	1.00 [Reference]		1.00 [Reference]	
Urban	0.83 (0.53-1.30)		1.27 (0.85-1.91)	
Micropolitan	0.90 (0.58-1.40)		1.31 (0.90-1.91)	
SEER stage at diagnosis[c]		<.001[b]		<.001[b]
Local	1.00 [Reference]		1.00 [Reference]	
Regional	6.84 (3.56-13.16)		10.31 (7.38-14.42)	
Distant	7.16 (3.58-14.36)		1.23 (0.80-1.89)	
Unstaged	2.63 (0.56-12.27)		1.61 (0.96-2.71)	

SEER indicates Surveillance, Epidemiology, and End Results.
[a]Adjusted for sex, marital status, education, median annual family income, insurance payer, and residence county–specific ratio of providers to 10,000 population, none of which were statistically significant for undergoing radiation.
[b]Statistically significant.
[c]To avoid infinite parameter estimates, excludes 318 patients with in situ cancer, with 1 patient undergoing radiation.

of surgery, radiation, or chemotherapy. Unlike the Florida Cancer Registry study,[7] we found no significant association in multivariate analyses of patient sex with undergoing surgery, median annual family income or insurance payer with treatment by radiation, or education with receipt of chemotherapy. As in another study,[7] there were no racial/ethnic differences in receipt of any treatment type among patients with colon cancer or in receipt of surgery or chemotherapy among patients with rectal cancer. This may be because Nebraska's population is mostly white and is less racially/ethnically diverse than other states like California or Florida, where earlier studies[7,8,18,38,39,41] were conducted. However, as with previous findings from a national study,[8] California registry,[18,41] and SEER data,[38,39] there were racial/ethnic differences in receipt of radiation among patients with rectal cancer in Nebraska. This may be because radiation carries risks and adverse effects on quality of life, with little increase in survival.[5]

More patients with rectal cancer than patients with colon cancer received radiation or chemotherapy. This may reflect the 1990 National Institutes of Health[5] consensus conference recommendation of radiation as the standard of care for regional stages of rectal cancer but not colon cancer. Compared with patients having local-stage colon cancer, the greater likelihoods of undergoing surgery among patients with regional-stage cancer and of undergoing chemotherapy among patients with regional-stage and distant-stage cancer were consistent with NCI guidelines that include surgery and chemotherapy in patients with colon cancer.[9] Compared with patients having local-stage rectal cancer, the greater likelihoods of undergoing radiation among patients with regional-stage cancer and of undergoing chemotherapy among patients with regional-stage and distant-stage cancer were consistent with NCI guidelines that include surgery, radiation, and chemotherapy in patients with rectal cancer having regional-stage disease.[10]

Limitations and Further Research

Although the NCR is an important source for population-based data, it has some limitations that challenge the identity and magnitude of true effect in the complex process of cancer treatment decision making. Because of unavailable data in the NCR, we were unable to adjust for many additional factors that could affect provider recommendations (ie, comorbidities; physician, patient, or family reasons for person-

Table 4. Multivariate Predictors of Undergoing Chemotherapy for Colon Cancer and for Rectal Cancer in Nebraska Between 1998 and 2003

Characteristic	Adjusted Odds Ratio (95% Confidence Interval)[a]			
	Colon Cancer (n = 4366)	*P*	Rectal Cancer (n = 1082)	*P*
Age, y		<.001[b]		<.001[b]
19-64	1.00 [Reference]		1.00 [Reference]	
65-74	0.60 (0.45-0.81)		0.97 (0.55-1.70)	
75-84	0.26 (0.19-0.35)		0.38 (0.21-0.68)	
≥85	0.05 (0.03-0.08)		0.09 (0.05-0.20)	
Marital status		<.001[b]		.09
Unmarried	1.00 [Reference]		1.00 [Reference]	
Married	1.48 (1.25-1.75)		1.34 (0.96-1.89)	
Residence county		<.001[b]		.37
Rural	1.00 [Reference]		1.00 [Reference]	
Urban	1.02(0.82-1.26)		1.09 (0.71-1.67)	
Micropolitan	1.47 (1.18-1.82)		1.32 (0.89-1.97)	
SEER stage at diagnosis[c]		<.001[b]		<.001[b]
Local	1.00 [Reference]		1.00 [Reference]	
Regional	15.23 (11.93-19.46)		17.97 (12.39-26.06)	
Distant	19.30 (14.67-25.39)		7.19 (4.64-11.13)	
Unstaged	1.94 (0.96-3.91)		2.43 (1.43-4.15)	

SEER indicates Surveillance, Epidemiology, and End Results.
[a]Adjusted for sex, race/ethnicity, education, median annual family income, insurance payer, and residence county–specific ratio of providers to 10,000 population, none of which were statistically significant for undergoing chemotherapy.
[b]Statistically significant.
[c]To avoid infinite parameter estimates, excludes 318 patients with in situ cancer.

alized therapy; or patient performance status, preferences for treatment or quality of life, or refusal of treatments). Our findings are generalizable to the population of a single midwestern state. Extrapolation to other states should be done with caution. Despite these limitations, our finding of no rural-urban difference is consistent with earlier studies[36,37] that adjusted for potential effects of comorbidities.

Furthermore, we examined nonmetro diversity in residence county as a measure of geographic access to CRC treatments. Because the NCR does not collect this information, we were unable to examine the effects of other measures that may also explain variations in CRC treatment receipt such as travel distance between patient residence and treatment facility, location of the treatment facility, or time from diagnosis to treatment. Future linking of the NCR to hospital discharge and insurance claims data for comorbidities, dose and duration of specific adjuvant therapies, American Joint Committee on Cancer TNM stage, and provider reasons for recommendations would make the NCR a more complete and valuable population-based cancer registry. Policymakers and providers could use this data resource to monitor the effectiveness and quality of cancer care in the state compared with national standards of care.

In conclusion, important implications for providers and public health policymakers are to consider the use of 3-category geographic measures (vs 2-category rural-urban classification) and to use rural residence (vs urban residence) as the reference category to better unmask access differences to CRC treatments. Further investigation is needed to understand the decreased likelihood of chemotherapy among patients with colon cancer living in rural (vs micropolitan) counties and the decreased likelihood of all cancer treatment types among older patients with colon cancer and with rectal cancer. This information will aid in planning cancer control programs' educational efforts and medical interventions for patient access to CRC treatments.

Acknowledgments

We acknowledge Judy Paradies, CTR, certified tumor registrar and data coordinator at the Nebraska Cancer Registry, Nebraska Department of Health and Human Services, and Timothy Parker, MA, sociologist in the Resources and Rural Economics Division at the US Department of Agriculture, for their prompt help and support at the time of the study. We thank Michael Shambaugh-Miller, PhD, Assistant Professor at the Department of Health Services Research and Administration, College of Public Health, University of Nebraska Medical Center. We also thank the peer reviewers and editors for their suggestions, which have strengthened the article.

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Funding Source: This study was supported by funding from the Nebraska Health and Human Services System to investigators from the University of Nebraska Medical Center. The views expressed herein are those of the authors and not of personnel from the Nebraska Cancer Registry or the funding agency.

Author Disclosure: The authors (JS, SW-G, Dr Sun, FQ, ECB, AGT) report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (JS, SW-G, Dr Sun); acquisition of data (SW-G, ECB); analysis and interpretation of data (JS, Dr Sun, FQ, ECB, AGT); drafting of the manuscript (JS, SW-G, FQ, ECB, AGT); critical revision of the manuscript for important intellectual content (JS, SW-G, Dr Sun, FQ, AGT); statistical analysis (Dr Sun, FQ); obtaining funding (JS, SW-G); administrative, technical, or logistic support (ECB); and supervision (JS).

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