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Explaining Black – White Differences in Receipt of Recommended Colon Cancer Treatment

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Abstract

Background—Black – white disparities exist in receipt of recommended medical care, including colorectal cancer treatment. This retrospective cohort study examines the degree to which health systems (e.g., physician, hospital) factors explain black – white disparities in colon cancer care.

Methods—Data from the Surveillance, Epidemiology, and End Results program; Medicare claims; the American Medical Association Masterfile; and hospital surveys were linked to examine chemotherapy receipt after stage III colon cancer resection among 5294 elderly (≥ 66 years of age) black and white Medicare-insured patients. Logistic regression analysis was used to identify factors associated with black – white differences in chemotherapy use. All statistical tests were two-sided.

Results—Black and white patients were equally likely to consult with a medical oncologist, but among patients who had such a consultation, black patients were less likely than white patients (59.3% versus 70.4%, difference = 10.9%, 95% confidence interval [CI] = 5.1% to 16.4%, $P < .001$) to receive chemotherapy. This black – white disparity was highest among patients aged 66 – 70 years (black patients 65.7%, white patients 86.3%, difference = 20.6%, 95% CI = 10.7% to 30.4%, $P < .001$) and decreased with age. The disparity among patients aged 66 – 70 years also remained statistically significant in the regression analysis. Overall, patient, physician, hospital, and environmental factors accounted for approximately 50% of the disparity in chemotherapy receipt among patients aged 66 – 70 years; surgical length of stay and neighborhood socioeconomic status accounted for approximately 27% of the disparity in this age group, and health systems factors accounted for 12%.

Conclusions—Black and white Medicare-insured colon cancer patients have an equal opportunity to learn about adjuvant chemotherapy from a medical oncologist but do not receive chemotherapy equally. Little disparity was explained by health systems; more was explained by

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This work was begun when Dr. Billingsley was in the University of Washington's Department of Surgery, Dr. Taplin was in the University of Washington's Department of Family Medicine and at Group Health Cooperative, and Dr. Barlow was at Group Health Cooperative.

illness severity, social support, and environment. Further qualitative research is needed to understand the factors that influence the lower receipt of chemotherapy by black patients.

Many studies have demonstrated racial differences between black and white patients in the process and outcomes of medical care. Black patients are less likely than white patients to receive screening tests (1 – 5) , diagnostic tests (2 , 6 , 7) , and a variety of treatments (7 – 12) . Although these racial disparities are not uniform (13 – 16) and some gaps have been narrowing (17) , the disparities have been demonstrated in the care of several cancer types (16 , 18 – 24) . For example, Schrag et al. (25) found that after adjusting for sociodemographic, clinical, and environmental characteristics, black patients were statistically significantly less likely than white patients to receive recommended chemotherapy for stage III colon cancer.

We sought to determine whether health care systems factors, specifically those related to the treating physicians or hospitals, can help explain black – white disparities in colon cancer care. For example, we examined whether differential rates of medical oncology consultation between black and white colon cancer patients existed that might have influenced adjuvant chemotherapy use in these populations. We chose to examine colon cancer treatment because of the demonstrated disparities between black and white patients in the use of adjuvant therapy and because of the clear evidence-based guidelines recommending this treatment (26) . Findings from this work may generate systems-based interventions to reduce disparities in cancer care and motivate further research.

Methods

Data Sources

In this study, we used data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) cancer registries linked with Medicare claims for persons found in both files. The SEER-Medicare database is generated through the cooperative efforts of the Center for Medicare & Medicaid Services (CMS), the National Cancer Institute, and the SEER registries. The SEER registries included five state registries (Connecticut, Hawaii, Iowa, New Mexico, and Utah) and seven county-based registries (Atlanta, Detroit, rural Georgia, Los Angeles, San Francisco, San Jose, and Seattle/Puget Sound) in four other states. SEER data included patient demographics and cancer type and stage; Medicare data included enrollment dates, health maintenance organization (HMO) membership, and for fee- for- service beneficiaries, billed claims that included the timing, diagnoses, and procedures provided in hospitals, physician offices, and clinics.

We used unique physician identifiers from the Medicare claims data to link physicians who provided care to their demographic and practice characteristics as reported in the 1993 and 1997 American Medical Association (AMA) Masterfiles. Unique Medicare hospital numbers linked the hospital where the colon cancer resection occurred to hospital characteristics reported to Medicare via the 1996 Medicare Healthcare Reporting and Information System and 1996 Provider of Service surveys. Permission to conduct this study was granted by the Human Subjects Division at the University of Washington.

Study Population

We identified 8632 black and white patients aged 66 years and older who were diagnosed with stage III (27) colon cancer (adenocarcinomas located in the colon or rectosigmoid) between January 1, 1992, and December 31, 1996. We sequentially excluded patients with simultaneous stage IV colorectal cancer (n = 11), prior colorectal cancer (n = 253), and autopsy- or death certificate – based diagnoses (n = 2). We then excluded patients without complete enrollment in fee-for-service Medicare in the year before diagnosis (n = 1704),

because this situation precludes prior comorbidity measurement. We excluded patients who died or had incomplete enrollment in the 9 months after diagnosis (n = 1230), because this precludes ascertainment of chemotherapy receipt. Last, we excluded patients without a Medicare surgical resection claim within 6 months of diagnosis (n = 138) to ensure that all study patients were receiving colon cancer treatment through the Medicare system. Our final sample therefore included 5294 patients.

Study Variables

The study's outcome of interest was receipt of adjuvant chemotherapy within 9 months of colon cancer diagnosis. We searched claims from hospital inpatient and outpatient facilities and physician offices to identify chemotherapy administration. We defined chemotherapy administration broadly, using Health-care Common Procedure Coding System (HCPCS) codes specific to the agents 5-fluorouracil and leucovorin calcium that were used in treating colorectal cancer (HCPCS codes J0640 and J9190), as well as less specific codes that indicated chemotherapy administration (Current Procedural Terminology [CPT] codes 96408 – 96414, 96520, 96530, 96545, 96549, HCPCS codes Q0083-Q0085, International Classification of Diseases, Ninth Version, Clinical Modification [ICD-9-CM] diagnosis codes E0781, E933.1, V58.1, V66.2, V67.2, and ICD-9-CM procedure code 99.25). Black or white race, as designated in the SEER database, was the independent variable of interest. Race in the SEER program data is abstracted from medical records and registration information.

Patient characteristics—SEER data provided patient age, sex, and marital status. Residence location (urban, large rural city or town, small rural town, or isolated small rural town) based on Rural Urban Commuting Area codes was identified from the plurality ZIP codes on the Medicare claims in the diagnosis month or from the nearest ZIP code if there were none in that month (28 , 29) .

To measure comorbidity, we adapted the Romano – Charlson comorbidity index (30) , based on outpatient and inpatient diagnoses made during the 11 months prior to the month before colon cancer diagnosis. We identified four potential contraindications to chemotherapy (acute or prior myocardial infarction, congestive heart failure, liver disease, and kidney failure) from the 18-item index, separately examined their association with the outcome of interest, and created a weighted index from the remaining conditions. Length of stay during cancer resection hospitalization and readmission to an acute care hospital within 6 weeks of resection served as indicators of illness severity at the time of surgery and/or surgical complications that might influence ability to undergo chemotherapy.

Environmental characteristics—The SEER registry represented the region in which each patient received care. The median income of race- and age-matched individuals within each patient's census tract was used as a measure of socioeconomic status. The race-specific percentage of patients who were 25 years of age and older with a high school education within each patient's census tract measured a combination of socioeconomic status, social class, and education.

Physician characteristics—Primary and secondary specialty from the 1993 and 1997 AMA Masterfiles and specialty classification from the Medicare claims were used to designate a physician's specialty. Physicians listing medical oncology, hematology, hematology/oncology, or pediatric hematology/oncology in any of these sources were designated as medical oncologists. The first medical oncologist seen within 1 month before to 9 months after colon cancer diagnosis was designated as the oncologist responsible for chemotherapy initiation, and physician characteristics (age, sex, years in practice, board

certification in internal medicine, and solo versus group practice) were linked for this individual. We designated each oncologist's practice experience by calculating his or her volume of initial medical oncology consultations in each study year among the stage III colon and stage II and III rectal cancer patients aged 66 years and older who were reported to the SEER program. A medical oncology consultation included a claim submitted by a medical oncologist to the Medicare program within 1 month before to 9 months after colorectal cancer diagnosis.

We created a physician continuity-of-care variable to examine whether a patient saw the same primary care provider (primary or secondary specialty of general internal medicine, family medicine, or general practice) for at least two visits in the year before and one visit in the 9 months after cancer diagnosis.

Hospital characteristics—Even though chemotherapy is largely an outpatient service, we included treating hospital characteristics in our analysis because approximately 90% of patients' medical oncologists admitted patients to the same hospital where the resection had occurred, and the resection hospitalization could therefore represent a point of early education regarding the benefits of adjuvant chemotherapy. Hospital characteristics included average daily census, hospital ownership type, designation as a National Cancer Institute Cancer Center or cooperative oncology group participant, and teaching status. Teaching facilities received Indirect Medical Education pay ment for the colon cancer surgical admission. We calculated a year-specific colorectal cancer resection volume for each hospital based on the number of patients with colorectal cancer who were reported to the SEER program and had colorectal cancer surgery billed to Medicare by each hospital in each of the study years.

Statistical Analysis

We first compared the patient, environmental, physician, and hospital characteristics of black and white patients using overall chi-square tests. We then compared the unadjusted chemotherapy rates of black and white patients with different characteristics using a test of two binomial proportions. Using multivariable logistic regression, we identified the degree to which our study variables explained the black – white differences in chemotherapy use. We excluded the 183 patients with missing values for the three continuous variables in the regression — medical oncologist volume, patient census tract-based median income, and patient census tract-based percentage with high school education. We dropped variables from the regression that had no association with receipt of adjuvant chemotherapy, did not improve the model fit, and did not explain the black – white disparity. We tested for interactions between race and each of the variables in our final model. The sociodemographic variables in the final model included age (categorized as 66 – 70, 71 – 75, 76 – 80, or 81 years of age and older, to ensure relative homogeneity of age), sex, and marital status (married, single/separated/divorced, or widowed). The comorbidity and clinical variables in the model included the previously defined modification of the Romano – Charlson comorbidity measure with four individual conditions and an index score (categorized as 0, 1, or 2 and greater, based on score frequency), length of stay for the surgical resection hospitalization (categorized as <7 days, 7 – 13 days, or 14 days and longer, based on surgical practice patterns), and rehospitalization within 6 weeks. Environmental variables in the final model included SEER registry (Atlanta and rural Georgia registries were combined due to low case numbers in rural Georgia; San Francisco and San Jose were combined because of their geographic proximity), census tract – based race-specific percentage of patients who were 25 years of age and older with high school education, census tract – based race-/age-specific median income, and year of diagnosis. Variables describing the patients' medical oncologists included year-specific volume of

colorectal cancer chemotherapy consultations (MOVOLYR) and MOVOLYR [2] , board certification in internal medicine, number of years in practice (categorized as ≤ 10, 11 – 20, 21 – 30, or 31 and greater to represent level of practice experience), and practice in the patient's surgical resection hospital. Variables describing the patients' surgical resection hospitals included ownership type (nonprofit, for-profit, government) and status as a teaching hospital.

We applied General Estimating Equation (GEE) methods to our final models to account for clustering of patients by physician and hospital and found no substantial differences in our results compared with results generated without GEE. Because our outcome, the adjuvant chemotherapy rate, is common in the study population (more than 50%), the adjusted odds ratio derived from the logistic regression does not approximate the relative risk. We approximated relative risk from the adjusted odds ratios using published methods (31) . We calculated the c-statistic for each stage in the regression model as a measure of the model's ability to predict adjuvant chemotherapy use. All tests of statistical significance were two-sided, and differences between groups were considered to be statistically significant if $P \leq .05$.

Results

Patient Characteristics

Of the 5294 patients in our sample, 423 (8.0%) were black. Black patients were younger than white patients and more likely to be female, unmarried, and living in urban areas (Table 1). Although black patients' comorbidity and rehospitalization rates were similar to those of white patients, they had longer lengths of stay for their surgical resection. Black patients were concentrated in seven of the 12 SEER registries (Atlanta, Connecticut, Detroit, rural Georgia, Los Angeles, San Francisco, and San Jose). Black patients were more likely than white patients to live in census tracts with the lowest median incomes and the lowest rate of high school completion. Black and white patients were equally likely to consult with a medical oncologist; more than three-quarters received consultations (Table 1). Our subsequent analyses focused on the subgroups of black (n = 332) and white (n = 3833) patients who had consulted with a medical oncologist. These subgroups were similar in sociodemographic and clinical characteristics to the overall group of colon cancer patients, although both black and white patients who saw a medical oncologist were younger than those who did not (Table 2).

Characteristics of Patients' Medical Oncologists and Surgical Hospitals

Black patients were more likely than white patients to receive care from the youngest and oldest medical oncologists, medical oncologists with the lowest practice volumes, those in solo practice, and those who were not board certified in internal medicine (Table 3). Black patients were also more likely than white patients to receive care in teaching hospitals and hospitals with the highest volumes and the highest average daily census (Table 4).

Adjuvant Chemotherapy Use

Overall, among patients who saw medical oncologists, black patients were less likely than their white counterparts to receive chemotherapy (59.3% versus 70.4%, difference = 10.9%, 95% confidence interval [CI] = 5.1% to 16.4%; $P < .001$) (Table 2). This difference was most pronounced in the youngest age group (66 – 70 years), in which 86.3% of white patients, but only 65.7% of black patients, received chemotherapy (difference = 20.6%, 95% CI = 10.7% to 30.4%, $P < .001$). The black – white disparity in chemotherapy use was consistent across most sociodemographic and clinical groups, except in patients who were over age 80 years; were single, separated, or divorced; had individual comorbidities or a

comorbidity index greater than one; had a continuity provider; were living in census tracts with lower and higher incomes and high school completion rates; were living in certain SEER registries (e.g., Atlanta/rural Georgia); and had a short or prolonged surgical hospitalization (Table 2).

The black – white disparity was also consistent across most types of medical oncologists (Table 3). However, differences in chemotherapy rates were minimal between black and white patients with medical oncologists who were age 60 and older (or in practice over 30 years) or were not board certified. The black – white dis parity was less consistent across different types of hospitals than across different types of medical oncologists (Table 4). Minimal black – white gaps in chemotherapy use were found at nonteaching and for-profit hospitals and at hospitals with lower volumes of colorectal resections and medium average daily census.

Overall, among patients who saw a medical oncologist, black patients were 0.84 times as likely as white patients to receive chemotherapy (Table 2). There was a strong interaction between race and age that demonstrated that the black – white disparity decreased with age (Table 5). The disparity in chemotherapy receipt was greatest among patients aged 66 – 70 years (relative risk [RR] = 0.74, 95% CI = 0.61 to 0.85); there was no statistically significant difference by race in chemotherapy receipt among patients over age 80 years (RR = 1.05, 95% CI = 0.69 to 1.45). The black – white disparity among patients aged 71 – 80 years seen in the un adjusted analysis was no longer statistically significant after con trolling for demographic characteristics (sex and marital status).

Further regression modeling examined whether other factors could explain the persistent black – white disparity among patients aged 66 – 70 years after adjustment for demographic characteristics (RR = 0.77) (for the final regression model, see Supplementary Table available at http://jncicancerspectrum.oxfordjournals.org/jnci/content/vol97/issue16). Prior comorbidity explained little of this disparity (RR increased to 0.78). Nearly 20% of the remaining black – white disparity in chemotherapy use among patients aged 66 – 70 years was explained by variables measuring surgical complication or severity (RR increased to 0.82). Length of stay alone accounted for all of this change. Adjusting for differences in the proportion of high school graduates in black and white patients' census tracts accounted for another 17% of the black – white disparity in chemotherapy use (RR increased to 0.85 after adjustment for education variable alone; no additional change with median income variable). Differences in the characteristics of black and white patients' medical oncologists and surgical hospitals explained little of the remaining black – white disparity (RR increased to 0.88 after adjusting for all six variables). Addition of the medical oncologist and hospital variables at an earlier point in the model did not explain more of the black – white disparity. Because many of the SEER areas had very low proportions of black patients (i.e., Hawaii, Iowa, New Mexico, and Utah), we reran our final logistic regression model without data from those four areas. However, we found no notable differences in our results. To ensure that our results broadly represented the U.S. population of white and black patients, we included all SEER areas in our final analysis.

Discussion

Prior studies have demonstrated differences between black and white patients in the use of chemotherapy for stage III colon cancer but have not determined which factors might explain the disparity. This study, which evaluated patient, environmental, physician, and hospital factors, showed no single or simple explanation.

We observed that black patients did not see medical oncologists at different rates than whites, suggesting that physicians were referring black and white patients to medical oncologists in a comparable manner and that both black and white patients adhered to these recommendations and/or considered chemotherapy. Black patients, however, were less likely than white patients to initiate chemotherapy after this consultation.

Patient age was one of the most powerful factors associated with the black – white disparity in chemotherapy use. The youngest black Medicare beneficiaries experienced the greatest dis parity in chemotherapy receipt. This is worrisome, because the " young " elderly are the most likely to derive a survival benefit from chemotherapy (32) . Older black patients had more similar care to older whites, in large part because of decreasing chemotherapy receipt with increasing age among both groups.

About half of the black – white disparity in chemotherapy use among patients aged 66 – 70 years could be explained by our study variables. The factors with the greatest explanatory power were not related to treating physicians or hospitals but rather to the patients' severity of illness, social support, and environment. Surgical resection length of stay accounted for a substantial proportion of the black – white disparity. Black patients had longer lengths of stay than white patients. Length of stay could indicate underlying health status and/or the level of postoperative complication and thus provide a functional measure of health status at the time chemotherapy was being considered. Length of stay may also represent the level of home care support, because individuals with less support in their homes may require more care in the hospital before discharge. Poorer health status and less home care support could affect an oncologist's likelihood of recommending chemotherapy or a patient's perception of the ability to tolerate chemotherapy, although neither of these factors represents an absolute contraindication to receipt of chemotherapy.

Among the socioeconomic factors explored in the study, educational status in a patient's residence census tract explained a substantial proportion of the black – white disparity in chemotherapy use. A higher proportion of black patients lived in census tracts with lower high school graduate rates; these areas had lower chemotherapy rates. Several studies have found an association between education level and use of recommended medical care, such as cancer screening (33 – 40) and disease treatments (41 – 43) . Lower educational attainment is associated with lower income. For persons under age 65 years, lower income is associated with less insurance coverage (44) , which is highly correlated with receipt of less medical care, including cancer screening and treatment (34 , 45 – 48) . In this study of Medicare-insured individuals, it is Medicare-required cost sharing rather than a lack of insurance coverage that would have an impact on receiving medical care. Although most Medicare beneficiaries have supplemental private insurance to cover deductibles and copayments, the rate of private insurance coverage differs substantially by race. Only 11% of white patients have no supplemental coverage compared with 25% of black patients (49) . Chemotherapy for colon cancer would include copayments for at least 6 months of outpatient treatment, which could affect acceptance rates among those without supplemental insurance. Supplemental insurance status was unavailable in the SEER – Medicare database, however, and thus could not be included as a variable in our analysis.

We were unable to account for about half of the black – white disparity in chemotherapy receipt. What might explain this remaining disparity? Chemotherapy is a treatment with high morbidity and no guaranteed outcome. The literature suggests that black individuals are more likely than white individuals to have a fatalistic attitude toward medical illness (50 – 55) ; to experience stigma, fear, and denial related to a cancer diagnosis (54) ; to have an aversion to health care treatments such as surgery (56) ; to mistrust the health care system (51 , 54 , 57 – 59) ; and to have misperceptions about cancer that interfere with treatment

(50 , 54 , 60) . Black patients may place values on the projected benefits of chemotherapy that differ from those of white patients. It is also possible that black patients are more likely than white patients to misperceive chemotherapy for stage III colon cancer as palliative rather than adjunctive treatment. Oncologists may have difficulty communicating the benefits of chemotherapy alongside its risks in the context of these beliefs, perceptions, and experiences. Alternately, medical oncologists caring for black patients may provide a lower quality of care than those caring for white patients. Primary care physicians treating black patients have reported greater difficulty obtaining access for their patients to high-quality subspecialists than physicians treating white patients (61) . Oncologists may also view their black patients as less favorable chemotherapy candidates or may present chemotherapy less enthusiastically to black patients than to white patients. Several studies have shown that physicians are less likely to suggest (62 – 64) or to provide (12) recommended treatments to black patients than to white patients. Indeed, black patients perceive greater levels of racism or unfair treatment because of race in the health care system than white patients (59 , 65 , 66) . They have also rated their medical visits as less participatory than have white patients (67) .

Our study has several limitations. Study variables were limited to those available in the research database. No variables measuring patient attitudes toward cancer treatment or directly measuring social or home support were available. Our indicators of socioeconomic status, social class, and education were measured at the ecologic level. Although these measures may serve as proxies for individual-level indicators, they mix in neighborhood-based relationships and may only partially account for the individual-level effects (68 , 69) . Some colon cancer patients who receive chemotherapy are not identified by the Medicare claims data, although Warren et al. (70) reported the overall sensitivity of Medicare claims for identifying adjuvant chemotherapy use among colon cancer patients as 90%. There is no information on whether the sensitivity of Medicare claims for identifying chemotherapy varies by patient race. Our medical oncologist practice volume variables measured care related to colorectal cancer among individuals with SEER – Medicare data only, so they may not reflect medical oncologists' overall practice volumes. Patients cared for in teaching hospitals may have received care primarily from oncology fellows rather than the attending medical oncologists, although medical oncologist characteristics linked to the database via Unique Physician Identification Numbers (UPINs) were those of the attending physicians rather than those of the fellows. Last, none of our medical oncologist variables measure the quality of care that they delivered. Although black patients in our study were less likely than white patients to consult with board-certified physicians, this difference explained little of the black – white disparity in chemotherapy use.

Another limitation is the relatively small number of black patients in the SEER – Medicare database, although the proportion of black colon cancer patients reported to the SEER program in 1992 – 1996 (7.5%) was comparable to the proportion of black individuals aged 65 years and older in the United States population at the time of the study (7.8%) (71) . This small number of black patients precluded more detailed investigation into the intriguing finding of equivalent unadjusted rates of adjuvant chemotherapy among black and white patients in Atlanta/rural Georgia. Further study with additional data is needed to examine potential regional variation in black – white disparity in chemotherapy receipt.

This study found that black and white patients begin their colon cancer therapy with an equal opportunity to learn about chemotherapy from a medical oncologist but do not receive this therapy at equal rates. We expected to identify specific health systems factors that explained the black-white disparity in chemotherapy receipt and that could be modified to improve care. Instead, we found that among the factors that could be analyzed in this study, patients' age, surgical hospitalization length of stay, and neighborhood educational level

were the most important. Although length of stay in the hospital after resection may be more difficult to affect, developing strategies to effectively educate and communicate the risks and benefits of chemotherapy may diminish some of the black – white treatment disparity. Further qualitative and quantitative research is needed to understand the mechanisms through which these and other factors, such as out-of-pocket costs, influence chemotherapy receipt. This research might begin with exploration of the interactions at colon cancer patients' visits with their medical oncologists and other physicians and then trace the complex decision-making process that follows those visits.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Characteristics of total study population by patient race *

	%		
Characteristic	**White (N = 4871)**	**Black (N = 423)**	***P***
Demographic			
Age, y			.001
66 – 70	20.8	28.1	
71 – 75	25.7	25.3	
76 – 80	24.5	25.1	
≥ 81	29.0	21.5	
Sex			.004
Female	55.3	62.7	
Male	44.7	37.4	
Marital status			<.001
Married	54.6	40.3	
Single, separated, or divorced	10.9	21.0	
Widowed	34.6	38.8	
Clinical			
Comorbidity			
Prior or acute myocardial infarction	4.0	3.6	.630
Congestive heart failure	6.4	7.6	.344
Renal failure	0.8	0.7	.909
Chronic liver disease	1.0	0.0	.040
Other comorbid conditions index			.065
0	57.6	54.6	
1	27.7	26.5	
≥ 2	14.7	18.9	
Length of stay for surgical resection, days			<.001
<7	16.9	9.2	
7 – 13	61.8	54.5	
≥ 14	21.3	36.4	

Characteristic	% White (N = 4871)	% Black (N = 423)	*P*
Rehospitalization within 6 weeks of surgical resection	10.0	9.5	.741
Environmental			
SEER Registry			<.001
Atlanta/rural Georgia	5.1	16.8	
Connecticut	17.6	7.1	
Hawaii	0.7	0.0	
Iowa	19.0	0.7	
Los Angeles	12.8	16.1	
Detroit	15.6	42.1	
New Mexico	2.9	0.5	
San Francisco/San Jose	11.8	14.2	
Seattle	10.1	2.4	
Utah	4.4	0.2	
Residence location			<.001
Isolated small rural town	6.0	1.2	
Small rural town	6.6	1.0	
Large rural city/town	6.7	0.5	
Urban	80.7	97.4	
Race- and age-specific median income in census tract			<.001
≤ $20 000	28.0	52.0	
$20 001 – $25 000	20.5	23.1	
$25 001 – $30 000	17.8	11.1	
≥ $30 001	33.6	13.8	
Race-specific % of ≥ 25-year-olds with high school education in census tract			<.001
≤ 50	1.3	14.5	
50.1 – 75	22.0	56.1	
>75	76.7	29.4	
Physician care			
Saw a medical oncologist	78.7	78.5	.922
Had continuity primary care provider	34.5	35.5	.700

* Some values were missing as follows: marital status 93, race-/age-specific median income in census tract 247, race-specific % of ≥ 25-year-olds with high school education in census tract 213, length of stay 78. *P* values (two-sided) were calculated using overall chi-square tests.

Table 2

Characteristics and unadjusted chemotherapy rates of study subpopulation that saw a medical oncologist stratified by patient race *

Characteristic	% † Black (N = 332)	% † White (N = 3833)	Unadjusted chemotherapy rate Black	Unadjusted chemotherapy rate White	Relative risk (95% CI)	*p* ‡
Total	8.0	92.0	59.3	70.4	0.84 (0.77 to 0.92)	<.001
Demographic						
Age, y §						
66 – 70	31.6	25.0	65.7	86.3	0.76 (0.66 to 0.88)	<.001
71 – 75	27.7	29.1	70.7	80.9	0.87 (0.76 to 1.00)	.006
76 – 80	25.3	24.9	53.6	70.5	0.76 (0.62 to 0.93)	<.001
≥ 81	15.4	20.9	35.3	36.5	0.97 (0.66 to 1.42)	.430
Sex ‖						
Female	63.0	53.4	56.9	66.4	0.86 (0.76 to 0.97)	.002
Male	37.0	46.6	63.4	74.9	0.85 (0.74 to 0.97)	.001
Marital status ¶						
Married	41.5	58.4	66.4	77.5	0.86 (0.76 to 0.97)	.001
Single, separated, divorced	21.5	10.5	60.3	65.6	0.92 (0.75 to 1.13)	.193
Widowed	37.0	31.1	51.3	59.3	0.86 (0.72 to 1.04)	.037
Clinical						
Comorbidity						
Prior or acute myocardial infarction						
Yes	3.3	3.7	45.5	67.8	0.67 (0.35 to 1.29)	.038
No	96.7	96.3	59.8	70.5	0.85 (0.77 to 0.93)	<.001
Congestive heart failure						
Yes	7.5	5.1	48.0	51.3	0.94 (0.61 to 1.44)	.376
No	92.5	94.9	60.3	71.4	0.84 (0.77 to 0.93)	<.001
Renal failure						
Yes	0.6	0.6	50.0	56.5	0.88 (0.21 to 3.70)	.426
No	99.4	99.4	59.4	70.5	0.84 (0.77 to 0.92)	<.001
Chronic liver disease						

Characteristic	% †		Unadjusted chemotherapy rate			
	Black (N = 332)	White (N = 3833)	Black	White	Relative risk (95% CI)	P ‡
Yes	0.0	0.9	NA	72.7	NA	NA
No	100.0	99.1	59.3	70.3	0.84 (0.77 to 0.92)	<.001
Other comorbid condition index #						
0	56.3	59.1	62.0	73.9	0.84 (0.75 to 0.94)	<.001
1	25.3	27.7	57.1	67.6	0.85 (0.70 to 1.02)	.018
2+	18.4	13.2	54.1	60.2	0.90 (0.71 to 1.14)	.170
Length of stay for surgical resection, days ¶						
<7	9.2	18.6	76.7	80.8	0.95 (0.78 to 1.16)	.285
7 – 13	54.5	62.8	64.4	73.3	0.88 (0.79 to 0.98)	.004
≥ 14	36.3	18.7	50.0	49.6	1.01 (0.83 to 1.23)	.534
Rehospitalization within 6 weeks of surgical resection						
Yes	9.0	9.5	36.7	60.4	0.61 (0.38 to 0.98)	.001
No	91.0	90.5	61.6	71.4	0.86 (0.79 to 0.95)	<.001
Environmental						
SEER Registry ¶						
Atlanta/rural Georgia	18.4	5.3	68.9	70.8	0.97 (0.80 to 1.18)	.385
Connecticut	6.3	17.2	66.7	72.0	0.93 (0.68 to 1.26)	.288
Hawaii	0.0	0.6	NA	66.7	NA	NA
Iowa	0.6	19.0	100.0	71.6	1.40 (1.33 to 1.46)	.774
Los Angeles	16.0	12.9	58.5	70.2	0.83 (0.66 to 1.05)	.030
Detroit	44.0	17.4	56.2	68.6	0.82 (0.70 to 0.95)	.001
New Mexico	0.3	2.7	100.0	71.4	1.40 (1.24 to 1.58)	.704
San Francisco/San Jose	12.7	10.9	52.4	65.6	0.80 (0.59 to 1.08)	.032
Seattle	1.8	9.7	50.0	71.8	0.70 (0.31 to 1.55)	.082
Utah	0.0	4.3	NA	74.2	NA	NA
Residence location ¶						
Isolated small rural town	1.2	5.9	75.0	75.3	1.00 (0.56 to 1.76)	.494
Small rural town	0.9	6.8	66.7	69.6	0.96 (0.43 to 2.14)	.455

J Natl Cancer Inst. Author manuscript; available in PMC 2011 July 18.

Characteristic	% †		Unadjusted chemotherapy rate			
	Black (N = 332)	White (N = 3833)	Black	White	Relative risk (95% CI)	*P* ‡
Large rural city/town	0.3	6.2	100.0	74.5	1.34 (1.25 to 1.45)	.693
Urban	97.6	81.1	59.0	69.8	0.85 (0.77 to 0.93)	<.001
Race- and age-specific median income in census tract ¶						
≤ $20 000	53.0	26.0	56.0	59.9	0.93 (0.81 to 1.08)	.168
$20 001 – $25 000	23.0	20.3	55.1	70.2	0.78 (0.63 to 0.98)	.002
$25 001 – $30 000	10.3	17.8	77.4	72.5	1.07 (0.88 to 1.30)	.722
≥ $30 001	13.7	35.8	73.2	77.0	0.95 (0.79 to 1.15)	.277
Race-specific % of ≥ 25-year-olds with high school education in census tract ¶						
≤ 50	14.5	1.3	52.2	55.1	0.95 (0.65 to 1.38)	.387
50.1 – 75	56.9	21.8	54.7	67.3	0.81 (0.71 to 0.94)	<.001
>75	28.6	76.9	71.4	71.5	1.00 (0.88 to 1.14)	.492
Physician care						
Had continuity of primary care provider						
Yes	37.0	34.6	65.9	69.7	0.95 (0.83 to 1.08)	.185
No	63.0	65.4	55.5	70.7	0.78 (0.69 to 0.89)	<.001

*NA, not applicable.

†Missing values: marital status 77, race-/age-specific median income in census tract 182, race-specific % of ≥ 25-year-olds with high school education in census tract 155, length of stay 59.

‡Two-sided *P* value is for the test of two binomial proportions comparing unadjusted chemotherapy rates between black patients and white patients.

§*P* = .018 (two-sided) for overall chi-square test comparing percentage of black patients and white patients with different characteristics.

‖*P* = .001 (two-sided) for overall chi-square test comparing percentage of black patients and white patients with different characteristics.

¶*P* < .001 (two-sided) for overall chi-square test comparing percentage of black patients and white patients with different characteristics.

#*P* = .028 (two-sided) for overall chi-square test comparing percentage of black patients and white patients with different characteristics.

Table 3

Unadjusted chemotherapy rates and distribution of study patients by treating medical oncologist characteristics by patient race

Characteristic	No. of medical oncologists * (N = 927)	% *		Unadjusted chemotherapy rate		Relative risk (95% CI)	*p* †
		Black (N = 332)	White (N = 3833)	Black	White		
Medical oncologist demographic							
Age, y ‡							
<40	229	23.0	19.2	54.0	68.7	0.79 (0.63 to 0.97)	.002
40 – 49	417	53.5	53.5	59.9	71.3	0.84 (0.74 to 0.95)	<.001
50 – 59	208	15.4	21.8	54.9	70.1	0.78 (0.61 to 1.01)	.006
≥ 60	66	8.2	5.5	77.8	66.8	1.16 (0.93 to 1.45)	.860
Sex							
Female	116	13.0	10.3	53.5	71.0	0.75 (0.57 to 1.00)	.004
Male	804	87.0	89.7	60.1	70.2	0.86 (0.78 to 0.94)	<.001
Race/ethnicity §							
Asian/Pacific Islander	78	16.4	14.8	66.7	77.6	0.86 (0.66 to 1.11)	.073
Black	13	14.2	0.9	65.4	58.3	1.12 (0.72 to 1.74)	.696
Hispanic	16	2.2	2.5	25.0	73.4	0.34 (0.06 to 1.87)	.001
White	441	66.7	80.3	57.4	72.5	0.79 (0.68 to 0.92)	<.001
Other	10	0.5	1.5	100.0	75.7	1.32 (1.10 to 1.59)	.689
Medical oncologist practice							
Years in practice							
0 – 10	115	8.8	8.1	41.4	63.3	0.65 (0.42 to 1.02)	.003
11 – 20	381	45.3	45.6	60.7	71.2	0.85 (0.75 to 0.97)	.002
21 – 30	289	32.9	34.2	60.6	71.5	0.85 (0.73 to 0.99)	.005
>30	135	13.0	12.1	62.8	68.3	0.92 (0.72 to 1.17)	.224
Year-specific volume of CRC chemotherapy consultations §							
1 – 2	586	44.0	33.6	59.6	67.6	0.88 (0.77 to 1.01)	.020
3 – 4	230	32.5	30.1	60.2	69.6	0.87 (0.74 to 1.01)	.016
≥ 5	111	23.5	36.3	57.7	73.6	0.78 (0.65 to 0.95)	<.001

Characteristic	No. of medical oncologists * (N = 927)	% *		Unadjusted chemotherapy rate		Relative risk (95% CI)	P †
		Black (N = 332)	White (N = 3833)	Black	White		
Solo practice ‖							
Yes	209	29.9	21.8	58.6	71.2	0.82 (0.69 to 0.98)	.003
No	711	70.1	78.2	59.5	70.1	0.85 (0.76 to 0.95)	<.001
Board-certified in internal medicine §							
Yes	763	75.8	86.6	59.8	71.4	0.84 (0.75 to 0.93)	<.001
No	157	24.2	13.4	57.5	63.2	0.91 (0.75 to 1.11)	.155

* Missing values: age, sex, solo practice, board certified in internal medicine, years in practice: seven medical oncologists, 14 patients; race/ethnicity: 369 medical oncologists, 1449 patients.

† Two-sided *P* value is for the test of two binomial proportions comparing unadjusted chemotherapy rates between black patients and white patients.

‡ *P* = .019 (two-sided) for overall chi-square test comparing percentage of black patients and white patients receiving care from different types of medical oncologists.

§ *P* < .001 (two-sided) for overall chi-square test comparing percentage of black patients and white patients receiving care from different types of medical oncologists.

‖ *P* = .003 (two-sided) for overall chi-square test comparing percentage of black patients and white patients receiving care from different types of medical oncologists.

J Natl Cancer Inst. Author manuscript; available in PMC 2011 July 18.

Table 4

Unadjusted chemotherapy rates and distribution of study patients by surgical hospital characteristics by patient race

Characteristic	No. of hospitals (N = 444)	% * Black (N = 332)	% * White (N = 3833)	Unadjusted chemotherapy rate Black	Unadjusted chemotherapy rate White	Relative risk (95% CI)	*P* †
Average daily census ‡							
0 – 65	221	13.6	25.2	60.5	70.4	0.86 (0.67 to 1.10)	.069
>65 – 110	91	8.9	24.4	53.6	71.5	0.75 (0.53 to 1.06)	.010
>110 – 195	77	29.1	25.4	66.3	70.5	0.94 (0.81 to 1.09)	.192
>195	43	48.4	25.0	55.6	68.9	0.81 (0.70 to 0.93)	<.001
Ownership §							
Government	90	8.9	10.3	41.4	62.4	0.66 (0.43 to 1.03)	.004
Nonprofit	277	75.5	79.4	61.4	71.4	0.93 (0.76 to 1.16)	<.001
For-profit	76	15.6	10.3	64.7	69.2	0.86 (0.78 to 0.95)	.251
Volume of colorectal cancer resections in year of patient's surgery							
1 – 15	275	27.4	25.3	62.9	69.6	0.90 (0.77 to 1.07)	.089
16 – 27	88	19.4	24.6	68.3	70.9	0.96 (0.81 to 1.15)	.327
28 – 40	51	24.0	24.5	56.4	71.6	0.79 (0.65 to 0.96)	.001
≥ 41	29	29.2	25.6	55.8	69.1	0.81 (0.67 to 0.97)	.002
Teaching hospital ‡							
Yes	139	67.7	49.5	57.3	69.0	0.83 (0.74 to 0.93)	<.001
No	303	32.3	50.5	66.7	71.5	0.93 (0.81 to 1.07)	.136
NCI Cancer Center or member of Oncology Group							
Yes	209	70.6	74.7	60.4	70.7	0.85 (0.77 to 0.95)	<.001
No	234	29.4	25.3	59.4	68.9	0.86 (0.73 to 1.02)	.021

* Missing values: average daily census 12 hospitals, 122 patients; ownership, National Cancer Institute Center or member of Oncology Group one hospital, 56 patients; received Indirect Medical Education funds two hospitals, 59 patients.

† Two-sided *P* value is for the test of two binomial proportions comparing unadjusted chemotherapy rates between black patients and white patients.

‡ $P < .001$ for overall chi-square tests comparing percentage of black patients and white patients with a surgical resection in different types of hospitals.

$^{\S}P = .021$ for overall chi-square tests comparing percentage of black patients and white patients with a surgical resection in different types of hospitals.

Table 5

Risk ratios of the four age cohorts of black patients receiving chemotherapy compared with same age white patients

Model components	Risk ratio (95% CI) * for 66 – 70-year-olds	Risk ratio (95% CI) * for 71 – 75-year-olds	Risk ratio (95% CI) * for 76 – 80-year-olds	Risk ratio (95% CI) * for 81+-year -olds	C statistics
1. Age	0.74 (0.61 to 0.85)	0.88 (0.74 to 0.99)	0.83 (0.65 to 0.99)	1.05 (0.69 to 1.45)	0.723
2. Model 1 + demographic characteristics †	0.77 (0.64 to 0.88)	0.91 (0.78 to 1.01)	0.86 (0.68 to 1.01)	1.08 (0.72 to 1.49)	0.735
3. Model 2 + comorbidity variables ‡	0.78 (0.65 to 0.89)	0.92 (0.79 to 1.02)	0.86 (0.68 to 1.01)	1.08 (0.72 to 1.49)	0.742
4. Model 3 + clinical variables §	0.82 (0.69 to 0.92)	0.94 (0.81 to 1.04)	0.93 (0.76 to 1.08)	1.17 (0.78 to 1.59)	0.764
5. Model 4 + SEER registry	0.82 (0.69 to 0.92)	0.94 (0.80 to 1.04)	0.94 (0.77 to 1.09)	1.17 (0.78 to 1.60)	0.768
6. Model 5 + environmental socioeconomic status measures ‖	0.85 (0.73 to 0.95)	0.96 (0.83 to 1.06)	0.98 (0.81 to 1.13)	1.30 (0.89 to 1.73)	0.770
7. Model 6 + medical oncologists' characteristics ¶	0.87 (0.75 to 0.97)	0.96 (0.83 to 1.06)	0.98 (0.81 to 1.13)	1.32 (0.90 to 1.76)	0.776
8. Model 7 + treating hospital characteristics #	0.88 (0.77 to 0.98)	0.97 (0.84 to 1.07)	0.98 (0.80 to 1.13)	1.39 (0.95 to 1.82)	0.779

*Because our outcome, the adjuvant chemotherapy rate, is common in the study population (more than 50%), the adjusted odds ratio derived from the logistic regression does not approximate the risk ratio. We approximated risk ratios from the adjusted odds ratios using published methods (31) .

†Sex, marital status.

‡Comorbidity measured as adaptation of Romano – Charlson index.

§Clinical variables: length of stay for surgical resection, rehospitalization within 6 weeks of surgical resection.

‖Race-specific median income, race-and age-specific percentage of ≥ 25-year-olds with high school education in residence census tract, year of diagnosis.

¶Year-specific volume of colorectal cancer chemotherapy consultations, board certification, practicing in surgical hospital, years of practice.

#Hospital ownership, teaching status.