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Differences Among the Elderly in the Treatment Costs of Colorectal Cancer:

How Important Is Race?

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Abstract

Background—Medical expenditures adjusted for price differences are a barometer of total resources devoted to patient care and thus may reflect treatment differentials.

Objective—We sought to estimate costs of the surgical and adjuvant treatment phases of colorectal cancer (CRC) care and cost differences by race (African American-white) and other patient characteristics.

Methods—We used the linked Surveillance, Epidemiology, and End Results (SEER)-Medicare database for stage II–III rectal and stage III colon cancer cases diagnosed in 1992–1996 to track Medicare approved payments for fee-for-service beneficiaries 66 and older in surgical (within 3 months of diagnosis) and postsurgical phases (13 months after the surgical phase). Net costs adjusted for expected noncancer expenditures were estimated with generalized linear models using pooled CRC and non-CRC cohorts. Using model results, we projected adjusted net costs for different patient groups (eg, by race, age).

Results—Total unstandardized CRC costs for African American recipients were $44,199, a statistically significant 15% higher than for white recipients ($38,378). Adjusting for covariates and expected non-CRC costs decreased the estimate for African American recipients to $34,588, a statistically insignificant $974 (2.9%) more than white recipients. Differential expenditures by age, urban-rural setting, region, and neighborhood median income were all much larger than differences by race, although only region was statistically significant.

Conclusions—African American CRC patients cost more than their white counterparts, but adjusted differences were nonsignificant and trivial. Several nonracial cost differences were considerably larger (but not all statistically significant), and suggest that future research pay more attention to these characteristics.

Keywords

cancer cost of care; Medicare; race and ethnicity; disparities; economics

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Colorectal cancer (CRC) is both the second most frequent and costly malignancy in the United States.[1,2] In the United States, treatment protocols for CRC call for resection followed by adjuvant chemotherapy and radiation therapy for stage II and III rectal cancer and adjuvant chemotherapy for stage III colon cancer.[3–5] However, through 1996, barely half of CRC patients older than 65 years of age received adjuvant therapy.[6,7]

Notably, racial and ethnic minorities, particularly those in impoverished urban communities, have higher CRC morbidity and mortality rates.[8–10] Most studies document lower rates of recommended CRC treatment among African American patients compared with white counterparts. Some studies have shown that African American patients are hospitalized with more advanced disease and are less likely than white patients to receive major therapeutic interventions such as colon resection.[9,11] Others have reported that African Americans are less likely to receive recommended adjuvant therapy than their white counterparts.[6,7]

Additional patient characteristics are associated with CRC care and outcomes. Increasing neighborhood poverty and lack of private insurance have been associated with higher CRC mortality.[12,13] Adjuvant chemotherapy and radiation therapy rates decline with advancing age, perhaps unrelated to actual health status.[6,7] Elderly living in areas with a less educated population are at risk for CRC under-treatment.[14] The relative importance of such barriers compared with race is unclear.

Medical expenditures adjusted for price differences are a barometer of total resources devoted to patient care and may reflect treatment differentials. However, no literature has examined whether costs reflect these apparent treatment differences. Cost analysis has been facilitated by the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database, which has spawned a series of large-sample studies of the direct cost (expenditures) of cancer care.[1,15–17] These estimates for Medicare fee-for-service patients have been complemented by studies of capitated Health Maintenance Organization (HMO) enrollees and other patient populations.[18–20] The comparability of these studies is limited by different methods, cost definitions, and observation periods.[16,18,19] Generally, previous cost studies divide care into an “initial phase” (the 6 months after diagnosis) and a variable-length “continuing phase” (until 6 months before death). This delineation does not allow separate cost estimates of surgical and adjuvant therapies. This study fills this information gap by estimating CRC treatment costs disaggregated by phase, and then examining cost variations among different patient groups.

METHODS

Data Sources

We used the National Cancer Institute’s SEER cancer registries linked with Medicare claims for persons found in both files. These data have previously been extensively tested and verified.[15,21,22] We also gathered claims data for a comparison cohort of non-CRC cases from the annual 5% random sample of Medicare beneficiaries who resided in the SEER registry counties. We included CRC cases diagnosed between 1992 and 1996 and their associated claims data from 1991 through 1998. The SEER data included 12 registries covering 14% of the US population at that time. SEER variables included cancer site, stage, date of diagnosis, most invasive surgery, and date of death.

Medicare claims files included inpatient hospitalization claims, hospital outpatient department claims, and claims from physicians, selected other providers, and suppliers of equipment and diagnostic services (Part B claims). Claims data do not cover Medicare beneficiaries enrolled in an HMO, most services at Veterans Health Administration medical centers, or noncovered services, most notably prescription drugs.

Study Populations

To define a patient cohort for whom both surgical resection and adjuvant therapy were expected, we included beneficiaries with a first diagnosis of stage III colon cancer or stage II or III rectal cancer who were at least 66 years old at diagnosis. We required cases to be enrolled in fee-for-service Medicare from 12 months before through 15 months after the diagnosis month, with costs 12 months prediagnosis used to control for health status. To mirror the month of CRC diagnosis, we assigned a random "pseudo diagnosis" date as an anchor point from which to measure pre-"diagnosis" and post-"diagnosis" costs for each non-CRC case. We required both CRC and non-CRC cases to be alive for 6 months after the observation period to avoid the known high cost of death swamping differences in postsurgical adjuvant care.[1,19]

The postdiagnosis period approximated the CRC clinical care phases. We specified a 3-month "surgical phase" starting with the month of diagnosis and a 13-month "post-surgical phase" for completion of adjuvant therapy.

Cohorts of 6108 CRC and 139,886 non-CRC comparison cases were drawn from initial samples of 13,168 and 222,395. For CRC cases, we sequentially excluded those with a simultaneous stage IV cancer (n = 16), a previous CRC diagnosis (n = 358), CRC diagnosis at autopsy only (n = 9), and incomplete enrollment in fee-for-service Medicare during the 12 months prediagnosis (n = 2967) and the 16-month observation period (n = 2625). We also excluded patients who died within 6 months of the observation period end (n = 873) and who had no surgical resection indicator within 6 months of diagnosis (n = 212). Non-CRC cases had no CRC recorded in the SEER registry data prior to or during the study period. We sequentially excluded non-CRC cases that lacked complete enrollment during the year before pseudo-diagnosis (n = 60,079), and during the observation period (n = 7178). Last, we excluded non-CRC cases that died within 6 months of the observation period end (n = 15,252). The primary CRC sample included 5308 Whites and 396 African Americans; the non-CRC population 118,950 Whites and 9542 African Americans. Data for Hispanics and Asians are not presented due to small numbers and inaccurate identification in Medicare enrollment files.[22]

Variables

Costs were defined as total Medicare-approved charges—the amounts paid by the program as well as copayments and deductibles from a third party or the patient. Since Medicare seeks to set payments according to average provider costs, we take Medicare approved charges as a measure of mean resource costs of care.[23] Since Medicare's payment rates reflect regional prices, we deflated claim amounts by provider types and the Medicare geographic price index. Payments were inflation-adjusted to year 2000 using the Medicare annual update factors by service type.

Patient characteristics included age, sex, and race. We controlled for health status using Medicare total expenditures during the "prior phase"—the 11 months before the month before diagnosis or pseudodiagnosis. Prior expenditures are a more accurate predictor of current costs than diagnostic cost groupings such as DCGs.[24]

Beneficiary residence ZIP codes, the smallest geographic area available for non-CRC cases, were used to define neighborhood social characteristics for each individual. Neighborhood and individual characteristics are correlated,[25] although they can measure different influences.[26,27] For CRC cases, we used the most frequently listed ZIP code on diagnosis month claims, or, if this was unavailable, the ZIP or county code from the SEER data. For non-CRC cases, we used the ZIP code or, if unavailable, the county code in the enrollment file during the pseudo diagnosis month. We linked median household income and

educational attainment (percentage of 25+ year-olds with high school completion) from US Census data.

Community size and rurality were measured according to residence county and ZIP code, if available. Metropolitan county addresses were divided into 3 population categories (<250,000, 250,000 to <1,000,000, ≥1,000,000) using 1995 Rural/Urban Continuum Codes. Nonmetropolitan addresses were divided into 4 categories by ZIP code using Rural-Urban Commuting Area (RUCA) codes, which combine population density and commuting patterns.[28,29] Region was defined as SEER registry location.

CRC site and stage (stage III colon, stage II rectal, stage III rectal) were differentiated using SEER data. Sphincter-sparing surgery rates for rectal cancer patients were determined using SEER site-specific surgery codes. Receipt of adjuvant chemotherapy for colorectal cancer cases and adjuvant chemotherapy or radiation therapy for rectal cancer cases required at least one Healthcare Common Procedure Coding System (HCPCS) code, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis or procedure code, or Current Procedural Terminology (CPT) code specific to therapy administration among part B or outpatient facility claims within the observation period (Appendix A). Receipt of adjuvant radiation therapy for rectal cancer cases was determined using either SEER data or HCPCS, ICD-9-CM, and CPT codes. Previous research has demonstrated a high level of agreement (88% or more) between SEER reports of adjuvant radiation therapy and chemotherapy and Medicare claims.[30,31]

Analytical Approach

We first tested for underlying differences in the characteristics of African American and white study cohorts using standard *t* tests and χ^2 tests. Standard *t* tests also tested for differences between the unadjusted total costs of African American and white rectal and colon cancer patients in the surgical, postsurgical, and combined care phases. Because previous research has demonstrated systematic differences in underlying health status and expected costs of care for African American and white patients, measuring differences in the unadjusted total CRC treatment costs may erroneously attribute expenditure differences to cancer care differences. To measure net costs of CRC treatment, we subtract the mean costs of the non-CRC cohort from the means of our CRC cohort. We use the entire 5% sample of non-CRC cases because the coefficient of variation is much greater than the relatively high but uniform expenditures on CRC patients. To control for known systematic differences in relevant covariates between African American and white patients, we employ a multivariate model that pools CRC and non-CRC cases to estimate costs for different racial groups and other covariates.

Cost Estimation

Costs were modeled using a generalized linear model (GLM) with a log-link and gamma distributed variance function.[32,33] This approach uses log transformation to normalize the distribution of notably skewed costs, but allows interpretation of the parameters directly on a dollar scale. The expenditure data in this study pass the test for a gamma-distributed variance function.[32] The core estimating model is shown in Appendix B.

Total and non-CRC cost estimates of group differences are the joint product of main and interaction effects and not a single coefficient. Our generalized linear model determined whether there were statistically significant differences in the total adjusted estimated costs of African American and white CRC patients, and in the total estimated costs of African American and white non-CRC patients.

Estimation of Net Costs

To estimate net cost differences between patient groups, we pooled CRC and non-CRC observations and used a difference of differences model. Net CRC costs are the difference between the total projected costs of care for CRC patients and non-CRC patients, controlling for covariates.

Results from the GLM model were weighted on the log scale (a linear model) by the mean values from the total sample, thus reflecting per-patient cancer expenditures as if CRC patients had the same average profile as the sample as a whole (dominated by non-CRC patients).[33] These estimates were then converted back to the dollar scale separately for CRC and non-CRC cases to obtain expected costs for both groups as if they had the same characteristics (other than cancer). The net CRC cost (ie, incremental expenditures devoted to CRC treatment) is the difference in these estimates with standard errors determined by the delta method.[34] These standard errors allowed us to determine whether there were differences in net CRC costs between different patient groups.

Because of the complexity of the modeling used, we cannot compute standard power estimates for our net cost analysis. However, if only total cancer case costs were compared between African American (n = 396) and white (n = 5308) patients, effect sizes of 0.15 and 0.17 could be detected with 80% and 90% power, respectively. For example, if untransformed costs were compared and the standard deviation was $20,000, a difference of $3400 could be detected with 90% power at a 2-sided 5% significance level. On a log scale, the detectable difference at 90% power would be 0.0833 with a standard deviation of 0.49. This is roughly an 8.7% relative difference in costs. This shows that small differences in costs would be hard to detect, but major differences in costs between African American and white subjects are detectable using these direct cost measures. This power calculation is unable to take into account our measurement of net cost differences (difference between differences) and our inclusion of multiple covariates in the regressions, however. It is possible that this study's sample size does not provide adequate power to detect important net cost differences between African American and white populations. Nonetheless, the study used the largest sample from the SEER program available at the time of data acquisition, and our findings are the best indicator of cost differences between African American and white patients with CRC.

RESULTS

Population Characteristics

There are few meaningful differences between CRC and non-CRC cohort characteristics. Both African American and white patients with CRC were slightly older than their non-CRC counterparts. The white CRC group had a higher percentage of men (Table 1). There were no notable differences in geographic setting or neighborhood characteristics. African American patients in the non-CRC cohort had greater health care costs prior to diagnosis than whites. Among CRC patients, prior costs for African American patients were considerably below those of their non-CRC counterparts, a differential not true of white patients. Standardizing prior costs for covariates increased prior expenditure differences by race (not shown). For African American patients, the higher prior costs among non-CRC cases is consistent with a slightly higher hospitalization rate but not with the greater percent without Medicare claims.

Among CRC patients, African American patients were more likely than white patients to be diagnosed with colon rather than rectal cancer. Among rectal cancer patients, African American patients had lower rates of sphincter sparing surgery (36.4%) than white patients (52.2%). A lower proportion of African American (50.8%) compared with white (60.3%)

patients received some adjuvant therapy. Among those receiving therapy, African American recipients had slightly longer mean treatment durations, a finding with marginal statistical significance.

Average Costs Unstandardized for Covariates

Unstandardized total per case expenditures for the first 16 months after CRC diagnosis, including both cancer and noncancer care, totaled $38,820 in year 2000 prices (Table 2). Rectal cancer cases cost 9.4% more than colon cancer cases ($41,439 vs. $37,884, $P \leq 0.001$). Of these expenditures, 62.7% ($24,328) occurred in the 3-month surgical phase for colorectal cancer overall (64.7% for colon cancer, 57.4% for rectal cancer). As expected, postsurgical expenditures for rectal cancer, which include adjuvant radiation therapy, were approximately $4000 greater than for colon cancer ($P \leq 0.001$).

Total unstandardized costs for African American patients were $5821 more than white patients—$44,199 versus $38,378, a statistically significant 15.2% difference. African American–white differentials were similarly significant in both phases—African American patients cost 13.9% more in the surgical phase and 17.3% more in the postsurgical phase.

Regression Estimates

Table 3 presents regression-standardized estimates of costs for CRC and non-CRC patients. Surgical, postsurgical, and total treatment costs are estimated separately. The consistency of the estimating model is illustrated by the fact that the sum of the estimated mean CRC costs for the 2 phases, $38,278, was only $299 less than the total cost estimate of $38,577. Detailed results and coefficients from the adjusted GLM models that allow estimation of net costs of CRC treatment are shown in Appendix B.

Net CRC costs were calculated by subtracting estimates of non-CRC costs from total expenditures for CRC patients. Average total CRC expenditures were reduced by estimated non-CRC care costs of $5126. The correction is low for the 3-month surgical phase ($850) but is 30.4% ($4270) of postsurgery phase costs. Postsurgical net cost estimates for CRC patients with and without adjuvant therapy were $11,856 and $6367 respectively, a statistically significant difference of $5489 (not shown).

Standardizing for differences in patient and environmental characteristics changes estimated racial differences in care costs. This adjustment reduces the total cost of African American CRC patients from $44,199 (Table 2, column 4) to $40,491 (Table 3, column 1). As a result, the mean African American-white difference drops to a statistically insignificant $1735—less than 1/3 of the unadjusted difference ($5821). Further adjusting to net costs (Table 3, column 3) reduces the differential to only $974, an insignificant difference. African American patients on average cost $1525 more than whites in the surgical phase, and $594 less in the postsurgical phase, but neither of these findings is statistically significant.

Table 4 examines whether net CRC treatment costs are associated with other patient characteristics, such as health care spending in the year before diagnosis. Prior spending per case of more than $9165 (top decile) represents poor health unrelated to CRC, contrasted with beneficiaries with no claims (lowest decile). These groups demonstrate a $6520 difference in the estimated total cost of care for CRC patients (column 1). However, this differential is due to higher non-CRC costs of $7023 (column 2). Subtracting these higher expected non-CRC expenditures results in slightly lower net cancer costs (−$504) for those in the highest compared with those in the lowest decile of prior spending.

Table 4 documents that some covariates are numerically of far greater import than race. The net costs for older patients (ie, 76–80 years old) are $3701 less than the youngest Medicare

cohort (ie, 66–70 years old). Beneficiaries living in neighborhoods in the lowest income decile cost $4177 more than those in the highest decile. However, none of these cost differences are statistically significant, except for variations by SEER registry. These geographic variations produce the largest cost differences ($9201), even though CRC resection is known as a low variation procedure.[35]

DISCUSSION

Cost Estimates of CRC Treatment

This study finds average CRC early treatment costs similar to previously published estimates. Brown and colleagues reported that in the early 1990s, net Medicare program expenditures for the first 6 treatment months for all stages of colorectal cancer averaged $18,100.[16] This cost estimate increases to $25,039 when adjusted to reflect 2000 CMS payment rates (an increase of 12%) and to include beneficiary deductibles and copayments (an increase of 22%). Our study's comparable 6-month estimate (the 3-month surgical phase cost and 3 months prorated postsurgical phase costs) was $25,647. However, our study reports higher net average monthly cost for the postsurgical phase ($751) than that reported by Brown et al ($173, if adjusted as above). Our higher estimate could be due to the inclusion of only stage III colon and stage II and III rectal cancer patients, the generally increasing intensity of care evident in our more recent data (eg, higher rates of adjuvant therapy), our focus on the immediate 13 months postsurgical treatment during which more costly adjuvant treatment may have occurred, or GLM estimation that avoids transformation bias in the logged cost estimates. In the future, the overall cost of CRC treatment and the contribution of postsurgical phase costs to the total costs is bound to increase, due to costly new chemotherapy agents.[36]

Our CRC cost estimates are based on actual treatment patterns, and thus are downward biased, as over 40% of our study patients did not receive adjuvant therapy. Expanding adjuvant therapy to this group would cost an estimated additional $5489 per case and would raise total Medicare-authorized CRC expenditures by 6.5% per case (since only 40% require the additional expenditure). However, our estimate of the incremental costs of adjuvant therapy is subject to selection bias. If healthier, lower-cost people differentially elect adjuvant therapy, we will underestimate the cost of expanding participation.

Cost Differences Among Patient Groups

Although unadjusted total African American-white cost differences are more than $5800, adjusting for noncancer costs and controlling for covariates reduces this differential to a nonsignificant $974. Our final adjusted cost estimates show African American patients with $593 lower postsurgical costs than white patients, a result that is consistent with previous findings of lower adjuvant therapy rates for minorities.[6,14] In sum, this analysis demonstrates that among this study's cohort of elderly CRC cases, there is little evidence that race per se is a source of disadvantage for African American CRC patients in the total incremental costs of treatment.

The literature on the social determinants of health suggests that social class and community characteristics influence costs more than race.[12,37,38] Although not statistically significant, our results show that the net cancer costs of CRC patients from low-income neighborhoods was a numerically meaningful $4177 more than patients from relatively affluent areas. The higher costs associated with low-income neighborhoods is specific to CRC treatment and not the costs of non-CRC comparison patients.

Our hypothesis that disadvantaged groups would receive fewer resources devoted to their care is not supported. This may indicate that our prior health expenditures variable does not

fully capture the health status gradient related to income. If lower-income cancer patients enter cancer treatment with unrecognized or poorly treated comorbidity, this could complicate their cancer treatment course, making it more expensive. In this case, CRC costs may reflect intensity of treatment, but not necessarily improved care. Our findings might also reflect the fact that Medicare-eligible patients have health insurance that facilitates care seeking. Other work has shown that cancer patients younger than 65 years of age include 10% to 20% of people who are uninsured and therefore use fewer services.[39] We also may not have adequately controlled for differences in price or underlying treatment patterns associated with region and town. Minorities may live in high-cost locations that have differential effects on different patient groups.

Our results suggest the need for further research on the importance of characteristics other than minority status on receipt of colorectal cancer treatment. These characteristics contribute substantially to apparent differentials by race. Indeed, characteristics such as age may be a more important disparity phenomenon in CRC treatment. In addition, expenditures need to be tested against treatment patterns. Are lower costs for defined conditions an indicator of undertreatment or of greater efficiency?

Limitations

These results are limited by well-known imperfections in Medicare claims data. Not all costs are counted since claims data miss between 5% and 12% of adjuvant therapy reported in the SEER data, and a small fraction may receive therapy at facilities not charging Medicare (eg, the Veterans Administration). Necessary case exclusions limit the generalizability of results (eg, HMO enrollees, cancer cases not receiving surgical resection). Only patients living 22 months after diagnosis are included. ZIP code characteristics are only partial proxies for individual variables. More recent SEER data drawn from a larger number of registries may be more representative and increase the statistical significance of results.

In addition, net costs of CRC treatment may be misstated if we incorrectly estimated expected non-CRC costs. For example, net cost underestimation may occur if CRC patients postponed noncancer procedures or care during their treatment period, resulting in the subtraction of non-CRC costs that are too large. Differences in prior phase expenditures introduce a potential bias since African American CRC cases had lower prior expenditures than their non-CRC counterparts. This difference, not found among whites, is statistically significant, and not reduced when standardized for covariates. Thus, net CRC costs could be underestimated for African American patients.

Another important limitation is in modeling postsurgical costs. Our estimates do not correct for endogeneity inherent in the correlation between the decision to undertake adjuvant therapy and the prior health status and outcome of resection surgery. If healthier, lower cost patients are systematically more likely to receive adjuvant therapy, then we will underestimate the total cost of this care phase.

CONCLUSIONS

Medical expenditures adjusted for price differences are a barometer of the total resources devoted to patient care. This study examines the differences in CRC treatment costs between races and other patient characteristics among elderly Medicare fee-for-service beneficiaries. Since treatment of CRC is well standardized, we separately estimate costs for surgical and postsurgical phases. Total Medicare authorized treatment costs in year 2000 prices for the 2 phases are $38,577, and decrease to $33,451 when corrected for expected non-CRC costs. These are both higher than previously reported. African Americans' unstandardized total

costs are significantly greater than for whites, but corrected for covariates the differences are trivial (less than 3%) and not statistically significant.

For CRC treatment, widely accepted treatment protocols are consistent with the small and insignificant African American-white differences in treatment intensity as measured by net treatment costs. Indeed, nonracial cost differences related to geographic location, age, and neighborhood income are considerably larger, and although not statistically significant, suggest that future research pay more attention to these characteristics, which are also important correlates of racial gaps.

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References

1. Brown ML, Riley GF, Schussler N, et al. Estimating health care costs related to cancer treatment from SEER-Medicare data. Med Care. 2002; 40:IV-104–IV-117.
2. U.S. Cancer Statistics Working Group. [Accessed January 4, 2007.] United States cancer statistics: 2002 incidence and mortality. 2005. Available at: http://www.cdc.gov/cancer/npcr/uscs
3. Engstrom PF, Benson AB 3rd, Cohen A, et al. NCCN colorectal cancer practice guidelines. The National Comprehensive Cancer Network. Oncology (Williston Park). 1996; 10:140–175. [PubMed: 8953601]
4. National Institutes of Health. NIH consensus conference. Adjuvant therapy for patients with colon and rectal cancer. JAMA. 1990; 264:1444–1450. [PubMed: 2202842]
5. Brown ML, Nayfield SG, Shibley LM. Adjuvant therapy for stage III colon cancer: economics returns to research and cost-effectiveness of treatment. J Natl Cancer Inst. 1994; 86:424–430. [PubMed: 8120916]
6. Schrag D, Gelfand SE, Bach PB, et al. Who gets adjuvant treatment for stage II and III rectal cancer? Insight from surveillance, epidemiology, and end results—Medicare. J Clin Oncol. 2001; 19:3712–3718. [PubMed: 11533092]
7. Schrag D, Cramer LD, Bach PB, et al. Age and adjuvant chemotherapy use after surgery for stage III colon cancer. J Natl Cancer Inst. 2001; 93:850–857. [PubMed: 11390534]
8. Jemal A, Clegg LX, Ward E, et al. Annual report to the nation on the status of cancer, 1975–2001, with a special feature regarding survival. Cancer. 2004; 101:3–27. [PubMed: 15221985]
9. Ball JK, Elixhauser A. Treatment differences between blacks and whites with colorectal cancer. Med Care. 1996; 34:970–984. [PubMed: 8792784]
10. Freeman HP, Alshafie TA. Colorectal carcinoma in poor blacks. Cancer. 2002; 94:2327–2332. [PubMed: 12015756]
11. Cooper GS, Yuan Z, Landefeld CS, et al. Surgery for colorectal cancer: race-related differences in rates and survival among Medicare beneficiaries. Am J Public Health. 1996; 86:582–586. [PubMed: 8604797]
12. Singh, GK.; Miller, BA.; Hankey, BF., et al. NCI Cancer Surveillance Monograph Series, Number 4. NIH Publication No. 035417. Bethesda, MD: National Cancer Institute; 2003. Area Socioeconomic Variations In U.S. Cancer Incidence, Mortality, Stage, Treatment, and Survival, 1975–1999.

13. Kelz RR, Gimotty PA, Polsky D, et al. Morbidity and mortality of colorectal carcinoma surgery differs by insurance status. Cancer. 2004; 101:2187–2194. [PubMed: 15382089]
14. Baldwin LM, Dobie SA, Billingsley K, et al. Explaining black-white differences in receipt of recommended colon cancer treatment. J Natl Cancer Inst. 2005; 97:1211–1220. [PubMed: 16106026]
15. Potosky AL, Riley GF, Lubitz JD, et al. Potential for cancer related health services research using a linked Medicare-tumor registry database. Med Care. 1993; 31:732–748. [PubMed: 8336512]
16. Brown ML, Riley GF, Potosky AL, et al. Obtaining long-term disease specific costs of care: application to Medicare enrollees diagnosed with colorectal cancer. Med Care. 1999; 37:1249–1259. [PubMed: 10599606]
17. Riley GF, Potosky AL, Lubitz JD, et al. Medicare payments from diagnosis to death for elderly cancer patients by stage at diagnosis. Med Care. 1995; 33:828–841. [PubMed: 7637404]
18. Taplin SH, Barlow W, Urban N, et al. Stage, age, comorbidity, and direct costs of colon, prostate, and breast cancer care. J Natl Cancer Inst. 1995; 87:417–426. [PubMed: 7861461]
19. Fireman BH, Quesenberry CP, Somkin CP, et al. Cost of care for cancer in a health maintenance organization. Health Care Financ Rev. 1997; 18:51–76. [PubMed: 10175613]
20. Barlow WE, Taplin SH, Yoshida CK, et al. Cost comparison of mastectomy versus breast-conserving therapy for early-stage breast cancer. J Natl Cancer Inst. 2001; 93:447–455. [PubMed: 11259470]
21. Warren, J. Overview of the SEER-Medicare data. Paper Delivered at the SEER Medicare Data Users Workshop. Bethesda, MD: National Cancer Institute; 1998.
22. Bach PB, Guadagnoli E, Schrag D, et al. Patient demographic and socioeconomic characteristics in the SEER-Medicare database applications and limitations. Med Care. 2002; 40:IV-19–IV-25.
23. Medicare Prospective Payment Commission. Annual Report to Congress. Washington, DC: 2003.
24. Lamers LM. Health-based risk adjustment: is inpatient and outpatient diagnostic information sufficient? Inquiry. 2001; 38:423–431. [PubMed: 11887959]
25. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. Am J Public Health. 1992; 82:703–710. [PubMed: 1566949]
26. Fiscella K, Franks P. Impact of patient socioeconomic status on physician profiles: a comparison of census-derived and individual measures. Med Care. 2001; 39:8–14. [PubMed: 11176539]
27. Geronimus AT, Bound J. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. Am J Epidemiol. 1998; 148:475–486. [PubMed: 9737560]
28. Morrill R, Cromartie J, Hart LG. Metropolitan, urban, and rural commuting areas: toward a better depiction of the US settlement system. Urban Geography. 1999; 20:727–748.
29. WWAMI Rural Health Research Center. [Accessed January 4, 2007.] Rural-urban commuting area codes (RUCAs). Available at: http://depts.washington.edu/uwrhrc/
30. Warren JL, Harlan LC, Fahey A, et al. Utility of the SEER-Medicare data to identify chemotherapy use. Med Care. 2002; 40:IV-55–IV-61.
31. Virnig BA, Warren JL, Cooper GS, et al. Studying radiation therapy using SEER-Medicare-linked data. Med Care. 2002; 40:IV-49–IV-54.
32. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. J Health Econ. 1999; 18:153–171. [PubMed: 10346351]
33. Escarce JJ, Kapur K. Racial and ethnic differences in public and private medical care expenditures among aged Medicare beneficiaries. Milbank Q. 2003; 81:249–275. 172. [PubMed: 12841050]
34. Oehlert GW. A note on the delta method. Am Stat. 1992; 46:27–29.
35. The Dartmouth Atlas of Health Care in the United States, 1999. Chicago, IL: American Hospital Association; 1999.
36. Schrag D. The price tag on progress—chemotherapy for colorectal cancer. N Engl J Med. 2004; 351:317–319. [PubMed: 15269308]
37. Barbeau EM, Krieger N, Soobader MJ. Working class matters: socioeconomic disadvantage, race/ethnicity, gender, and smoking in NHIS 2000. Am J Public Health. 2004; 94:269–278. [PubMed: 14759942]

38. Nilunger L, Diderichsen F, Burstrom B, et al. Using risk analysis in Health Impact Assessment: the impact of different relative risks for men and women in different socio-economic groups. Health Policy. 2004; 67:215–224. [PubMed: 14720639]

39. Thorpe KE, Howard D. Health insurance and spending among cancer patients. Health Aff (Millwood). 2003 Suppl Web Exclusives:W3-189–198.

TABLE 1

Characteristics of CRC and Non-CRC Cohorts by African American-White Race

	CRC Cohort			Non-CRC Cohort		
	African American	**White**	**Total**[§]	**African American**	**White**	**Total**[§]
Total sample size	396	5308	6108	9542	118,950	139,886
Characteristics						
Demographic						
Age,[¶] mean (SD[//])	**75.4** (6.2)[†]	**76.0** (6.6)	75.9 (6.5)	**73.9** (7.0)[*]	**74.5** (7.1)	74.3 (7.1)
Sex, % female	64.4%[*]	**52.4%**	**52.7%**	62.8%[*]	**60.3%**	**60.1%**
Size/rurality of community[**]						
MSA[//] ≥1 million	**88.1%**[*]	57.0%	59.1%	**88.9%**[*]	58.1%	60.2%
MSA 250K to <1 million	8.6%	17.7%	17.7%	7.0%	17.2%	17.2%
MSA <250K	1.0%	5.3%	4.7%	0.6%	5.3%	4.7%
Non-MSA, urban-focused ZIP	0.0%	1.6%	1.4%	0.1%	1.4%	1.2%
Non-MSA, large rural city/town-focused ZIP	0.5%	6.6%	6.1%	0.7%	6.4%	6.2%
Non-MSA, small rural town-focused ZIP	1.3%	6.1%	5.6%	1.1%	5.9%	5.4%
Non-MSA, remote small rural town-focused ZIP	0.5%	5.8%	5.3%	1.7%	5.6%	5.1%
Residential ZIP code characteristics[¶]						
Median household income (SD)	$23,791 (9944)[*]	$36,906 (13,541)	$35,981 (13,647)	$24,177 (10,500)[*]	$37,192 (14,063)	$36,156 (14,167)
% African American	**61.2%**[*]	5.1%	8.8%	**59.9%**[*]	5.3%	9.2%
% 25+ year-olds not completing high school	35.5%[*]	19.7%	21.1%	34.8%[*]	19.6%	21.1%
Indicators of health status and medical care utilization before diagnosis						
Mean Medicare payments—before (SD)	**$3309** (5701)	$3364 (7305)	$3310 (7157)	**$4525** (10,709)[*]	$3563 (8571)	$3574 (8707)
% with no Medicare claims	**9.1%**	**8.2%**	**8.4%**	**16.1%**[*]	**10.1%**	**11.0%**
% with institutionalization	13.9%	14.2%	14.0%	16.9%	14.2%	14.1%
Cancer site						
% stage III colon cancer	83.3%	72.9%	73.7%	NA	NA	NA
% stage II rectal cancer	9.1%	15.4%	15.0%	NA	NA	NA
% stage III rectal cancer	7.6%	11.7%	11.3%	NA	NA	NA
Surgical treatment type (rectal cancer only)						

	CRC Cohort			Non-CRC Cohort		
	African American	**White**	**Total[§]**	**African American**	**White**	**Total[§]**
% sphincter sparing surgery	36.4%[†]	52.2%	51.2%	NA	NA	NA
Adjuvant therapy[††]						
% any adjuvant	50.8%[*]	60.3%	59.7%	NA	NA	NA
Mean no. chemotherapy months (SD)	8.7 (4.56)[‡]	8.0 (4.41)	8.0 (4.4)	NA	NA	NA
Mean no. radiation therapy weeks (SD)	8.4 (2.33)[‡]	7.6 (2.37)	7.6 (2.3)	NA	NA	NA

Differences by race within CRC and non-CRC cohorts using overall χ^2 tests or standard t tests:

[*] $P \leq 0.01$,

[†] $P \leq 0.05$,

[‡] $P \leq 0.10$.

Differences between CRC and non-CRC patients of the same race shown in boldface at $P \leq 0.05$.

[§] Total sample includes Asians, Hispanics, and other races as well as African American and white patients. Data are not presented for these other races and ethnicities separately because of data limitations as described in the Methods section.

[¶] Age and ZIP code characteristics are specified as categorical variables in the regression models (see Appendix B).

[//] SD indicates standard deviation; MSA, metropolitan statistical area.

[**] Rural classification of ZIP codes are RUCA classifications.[28] Three individuals with missing RUCA classifications were designated as urban focused.

[††] Any adjuvant therapy is measured as chemotherapy for colon cancer and chemotherapy or radiation therapy for rectal cancer.

TABLE 2

Total Unadjusted Expenditures per CRC Case by Cancer Site, Phase, and Race

		Mean Expenditures per Case (Year 2000 Prices)		
Cancer Site and Race	**No. Observations**	**Surgical Phase (3 Mo)**	**Postsurgical Phase (13 Mo)**	**Total (16 Mo)**
Colon				
All patients	4499	24,521	13,363	37,884
African American	330	$27,927*	$16,165*	$44,092*
White	3870	24,195	13,168	37,363
Rectal				
All patients	1609	23,788	17,651	41,439
African American	66	24,577	20,162	44,739
White	1438	23,568	17,541	41,109
All CRC cases				
All patients	6108	24,328	14,493	38,821
African American	396	27,368*	16,831†	44,199*
White	5308	24,025	14,353	38,378

Significance levels: differences from whites within colon, rectal, and combined colorectal cancer cohorts:

*$P \leq 0.01$,

†$P \leq 0.05$.

Costs are Medicare authorized payments whether paid by Medicare, the beneficiary or another third party. They are total payments received by providers and exclude noncovered service.

Payments are geographic and inflation-adjusted to the year 2000 using Medicare geographic adjusters and annual update factors.

Study population consists of patients who survived and were fully eligible for 16 mo following diagnosis, and who received an index surgery.

Recommended adjuvant therapy for stage III colon cancer is chemotherapy only, for stage II and III rectal cancer is both chemotherapy and radiation therapy.

TABLE 3

Regression-Standardized Estimates of Medicare Treatment Expenditures per Colorectal Cancer Case

Population Group	Total Estimated Cost for CRC Patients ($)	Total Estimated Cost for Non-CRC Patients ($)	Net Estimated Cost of CRC Care for CRC Patients ($)
Surgical and postsurgical treatment phase (16 mo)			
All patients	38,577	5126	33,451
White	38,756	5142	33,614
African American	40,491	5903	34,588
Differences			
African American-white	1735	761*	974
Surgery phase (3 mo)			
All patients	24,244	850	23,394
White	24,174	857	23,317
African American	25,810	968	24,842
Differences			
African American-white	1636	111*	1525
Postsurgery phase (13 mo)			
All patients	14,034	4270	9764
White	14,323	4280	10,043
African American	14,384	4935	9449
Differences			
African American-white	61	655*	−594

*$P \leq 0.01$.

Values are predicted costs as if each racial group had same profile of personal characteristics as the total sample average. See Appendix B for estimating model.

Costs are calculated as sum of all Medicare approved payments to providers including beneficiary copayments and deductibles as well as other third-party payments.

Costs are adjusted to 2000 prices and for geographic price variations in Medicare payment methodology.

Because costs for each phase are estimated separately, total costs do not equal sum of surgical and postsurgical phases.

TABLE 4

Regression-Standardized Estimates of Medicare Treatment Expenditures per Colorectal Cancer Case by Patient Characteristics

Patient Characteristics	Total Estimated Cost for CRC Patients[§] ($)	Total Estimated Cost for Non-CRC Patients[§] ($)	Net Estimated Cost of CRC Care for CRC Patients[§] ($)
Prior health care spending			
Top 10% (>$9165)	40,769	8675	32,094
Bottom 10% ($0)	34,250	1652	32,598
Top-bottom difference ($)	6519[†]	7023[*]	(504)
Top-bottom difference (%)			−1.5%
Sex			
Male	38,577	5126	33,451
Female	37,973	4695	33,278
Male-female difference ($)	604	431[*]	173
Male-female difference (%)			0.5%
% 25+ year-olds who are high school graduates in ZIP code			
Low (<63%)	39,456	5327	34,129
High (>92%)	38,705	4754	33,951
Low-high difference ($)	751	573[*]	178
Low-high difference (%)			0.5%
Race			
African American	40,491	5903	34,588
White	38,756	5142	33,614
African American-white difference ($)	1735	761[*]	974
African American-white difference (%)			2.9%
Town size[¶]			
Large metro ≥1 million	39,276	5,184	34,092
Small rural town	36,764	4,909	31,855
Large metro-small rural difference ($)	2512	275[†]	2237
Large metro-small rural difference (%)			7.0%
Age, yrs[//]			
66–70	40,227	4415	35,812
76–80	37,489	5377	32,112
66–70 to 76–80 difference ($)	2738[‡]	(962)[*]	3700
66–70 to 76–80 difference (%)			11.5%
Year			
1996	40,806	5127	35,679
1992	36,934	5106	31,828
1996–1992 difference ($)	3872	21[*]	3851
1996–1992 difference (%)			12.1%
Median household income in ZIP code			

Patient Characteristics	Total Estimated Cost for CRC Patients[§] ($)	Total Estimated Cost for Non-CRC Patients[§] ($)	Net Estimated Cost of CRC Care for CRC Patients[§] ($)
Bottom 10% <$21k	41,031	5164	35,867
Top 10% >$53k	36,570	4880	31,690
Bottom-top difference ($)	4461	284[†]	4177
Bottom-top difference (%)			13.2%
Registry[**]			
High (Los Angeles)	43,168	5950	37,218
Low (Utah)	32,392	4375	28,017
Los Angeles-Utah difference ($)	10,776	1575[*]	9201[†]
Los Angeles-Utah difference (%)			32.8%

Significance levels:

[*] $P \leq 0.01$,

[†] $P \leq 0.05$,

[‡] $P \leq 0.10$.

[§] All projected values based on a single model controlling for variables shown (see Appendix B).

[¶] The lowest cost category was small MSAs <250,000 with net estimated costs of $28,553, but it was not used because of the small number of cases.

[//] The lowest cost category for age was “over 85” = $28,583 or a difference of $7230. It was not used because of a higher probability of unmeasured clinical characteristics.

[**] The highest cost registry was Hawaii at $38,318 or a difference of $10,301. It was not used because of its unique location.

APPENDIX A

Codes Used to Identify Adjuvant Therapy

Treatment Modality	Codes	Time Frame
Chemotherapy	ICD-9: V58.1, E933.1, V66.2, V67.2 ICD-9-P: 99.25 CPT: 96408, 96410, 96412, 96414, 96520, 96530, 96545, 96549 HCPCS: J9190, J0640, J9200, Q0083, Q0084, Q0085	At least 1 claim within 6 mo of diagnosis month
Radiation	ICD-9: V66.1, V67.1, V58.0 ICD-9-P: 92.20-29 CPT: 77261-63, 77280, 77285, 77290, 77295, 77299, 77300, 77305, 77310, 77315, 77321, 77326-8, 77331-4, 77336, 77370, 77399, 77419-32, 77470, 77490, 77499, 77401-17, 77750, 77761-3, 77776-8. 77781-4, 77789-90, 77797, 77799 Revenue Center: 0333	At least 1 claim within 10 mo of diagnosis month

ICD-9 indicates *International Classification of Diseases*, Ninth Revision, Clinical Modification diagnosis codes; ICD-9-P, *International Classification of Diseases*, Ninth Revision, Clinical Modification procedure codes; CPT, Current Procedural Terminology codes; HCPCS, Healthcare Common Procedure Coding System codes.

Revenue centers are Medicare codes for type of hospital facility or ancillary service assigned by providers on outpatient claims.

APPENDIX B

Core Cost Estimating Model by Treatment Phase[†]

	Surgical Phase			Postsurgical Phase			Total Treatment Period		
Independent Variables[‡]	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***
Intercept	5.2722	0.0425	<0.0001	7.0136	0.0355	<0.0001	7.1760	0.0341	<0.0001
Cancer									
None	ref			ref			ref		
Colon	4.8267	0.2176	<0.0001	2.3163	0.1807	<0.0001	3.3090	0.1747	<0.0001
Rectal	4.8099	0.2184	<0.0001	2.6222	0.1814	<0.0001	3.4141	0.1754	<0.0001
Diagnosis year									
1992	ref			ref			ref		
1993	−0.0381	0.0162	0.0187	−0.0568	0.0135	<0.0001	−0.0539	0.0130	<0.0001
1994	−0.0867	0.0164	<0.0001	−0.0785	0.0137	<0.0001	−0.0808	0.0132	<0.0001
1995	−0.0370	0.0162	0.0225	−0.0731	0.0135	<0.0001	−0.0683	0.0130	<0.0001
1996	−0.0680	0.0157	<0.0001	−0.0465	0.0131	0.0004	−0.0498	0.0126	<0.0001
Cancer*92	ref			ref			ref		
Cancer*93	0.0210	0.0762	0.7832	0.0198	0.0639	0.7573	0.0301	0.0613	0.6242
Cancer*94	0.1032	0.0767	0.1788	0.0792	0.0644	0.2190	0.0909	0.0618	0.1412
Cancer*95	0.0987	0.0770	0.2003	0.0289	0.0647	0.6556	0.0931	0.0621	0.1336
Cancer*96	0.1424	0.0782	0.0687	0.1206	0.0659	0.0671	0.1257	0.0631	0.0462
Race/ethnicity									
White	ref			ref			ref		
African American	0.1224	0.0232	<0.0001	0.1423	0.0190	<0.0001	0.1380	0.0184	<0.0001
Asian	0.0803	0.0627	0.2005	0.1590	0.0521	0.0023	0.1472	0.0501	0.0033
Hispanic	−0.2351	0.0534	<0.0001	−0.2307	0.0448	<0.0001	−0.2320	0.0431	<0.0001
Other	−0.2182	0.0238	<0.0001	−0.1714	0.0191	<0.0001	−0.1774	0.0185	<0.0001
Cancer*White	ref			ref			ref		
Cancer*African American	−0.0569	0.1161	0.6240	−0.1380	0.0991	0.1640	−0.0942	0.0940	0.3163
Cancer*Asian	−0.0293	0.2363	0.9014	−0.0060	0.1977	0.9757	−0.0472	0.1900	0.8037
Cancer*Hispanic	0.2747	0.1748	0.1159	0.0436	0.1489	0.7697	0.1920	0.1413	0.1743
Cancer*other	0.1822	0.1639	0.2665	−0.1402	0.1380	0.3097	0.0534	0.1320	0.6859

	Surgical Phase			Postsurgical Phase			Total Treatment Period		
Independent Variables‡	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***
Sex									
Female	ref			ref			ref		
Male	0.2050	0.0105	<0.0001	0.2203	0.0087	<0.0001	0.2185	0.0084	<0.0001
Cancer*female	ref			ref			Ref		
Cancer*male	−0.1844	0.0502	0.0002	−0.1450	0.0420	0.0006	−0.1792	0.0404	<0.0001
Age, yrs									
66–69	ref			ref			ref		
70–74	0.0831	0.0136	<0.0001	0.1184	0.0113	<0.0001	0.1129	0.0109	<0.0001
75–79	0.2062	0.0147	<0.0001	0.1955	0.0123	<0.0001	0.1972	0.0118	<0.0001
80–84	0.3550	0.0163	<0.0001	0.3475	0.0135	<0.0001	0.3488	0.0130	<0.0001
85+	0.3414	0.0198	<0.0001	0.3768	0.0165	<0.0001	0.3708	0.0159	<0.0001
Cancer*66–69	ref			ref			ref		
Cancer*70–74	−0.0843	0.0736	0.2518	−0.1175	0.0618	0.0574	−0.1158	0.0593	0.0508
Cancer*75–79	−0.2209	0.0753	0.0034	−0.3555	0.0632	<0.0001	−0.2677	0.0607	<0.0001
Cancer*80–84	−0.3689	0.0808	<0.0001	−0.6155	0.0678	<0.0001	−0.4556	0.0651	<0.0001
Cancer*85+	−0.3266	0.1012	0.0013	−0.8251	0.0848	<0.0001	−0.5106	0.0814	<0.0001
Ln total prior payments + $1	0.2166	0.0017	<0.0001	0.1753	0.0014	<0.0001	0.1818	0.0014	<0.0001
Cancer*ln total prior payments + $1	−0.2086	0.0100	<0.0001	−0.1356	0.0082	<0.0001	−0.1627	0.0080	<0.0001
Geographic location									
MSA ≥1 million	ref			ref			ref		
MSA 250K to <1 million	−0.0549	0.0193	0.0044	0.0032	0.0162	0.8425	−0.0052	0.0156	0.7364
MSA <250K	−0.0057	0.0297	0.8490	−0.0863	0.0247	0.0005	−0.0744	0.0238	0.0017
Non-MSA, urban-focused ZIP	0.0976	0.0487	0.0451	−0.0752	0.0407	0.0646	−0.0465	0.0391	0.2350
Non-MSA, large rural-focused ZIP	−0.0578	0.0283	0.0413	−0.0181	0.0237	0.4449	−0.0236	0.0228	0.3013
Non-MSA, small rural-focused ZIP	−0.1409	0.0295	<0.0001	−0.0373	0.0243	0.1252	−0.0544	0.0234	0.0202
Non-MSA, remote rural-focused ZIP	−0.0548	0.0305	0.0725	−0.0322	0.0253	0.2028	−0.0362	0.0244	0.1373
Cancer*MSA ≥1 million	ref			ref			ref		
Cancer*MSA 250K to <1 million	0.0369	0.0950	0.6974	−0.0476	0.0801	0.5525	−0.0257	0.0767	0.7379
Cancer*MSA <250K	−0.0828	0.1473	0.5740	−0.2097	0.1237	0.0899	−0.0887	0.1186	0.4548
Cancer*non-MSA, urban-focused ZIP	−0.1468	0.2210	0.5064	0.1355	0.1844	0.4625	0.0325	0.1777	0.8548

	Surgical Phase			Postsurgical Phase			Total Treatment Period		
Independent Variables‡	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***
Cancer*non-MSA, large rural-focused ZIP	0.0249	0.1387	0.8575	0.0998	0.1173	0.3948	0.0281	0.1121	0.8019
Cancer*non-MSA, small rural-focused ZIP	0.0879	0.1471	0.5504	−0.0301	0.1231	0.8066	−0.0117	0.1183	0.9209
Cancer*non-MSA, remote rural-focused ZIP	0.0148	0.1518	0.9224	0.0292	0.1270	0.8183	0.0078	0.1222	0.9490
Registry									
San Francisco	ref			ref			ref		
Connecticut	0.0196	0.0264	0.4567	−0.0732	0.0218	0.0008	−0.0586	0.0210	0.0053
Detroit	0.0995	0.0229	<0.0001	0.0889	0.0190	<0.0001	0.0908	0.0183	<0.0001
Hawaii	0.1821	0.0432	<0.0001	−0.1529	0.0352	<0.0001	−0.1029	0.0340	0.0024
Iowa	−0.0778	0.0316	0.0139	−0.0442	0.0262	0.0909	−0.0487	0.0252	0.0532
New Mexico	−0.0572	0.0360	0.1119	−0.1163	0.0301	0.0001	−0.1080	0.0289	0.0002
Seattle/Puget Sound	0.0013	0.0269	0.9620	−0.0967	0.0227	<0.0001	−0.0813	0.0218	0.0002
Utah	−0.0929	0.0326	0.0044	−0.1794	0.0271	<0.0001	−0.1653	0.0261	<0.0001
Georgia (Atlanta + rural Georgia)	0.0742	0.0274	0.0067	0.0090	0.0229	0.6948	0.0220	0.0221	0.3192
San Jose	−0.0465	0.0308	0.1316	−0.0931	0.0257	0.0003	−0.0826	0.0248	0.0009
Los Angeles	0.1428	0.0231	<0.0001	0.1421	0.0192	<0.0001	0.1422	0.0185	<0.0001
Cancer*San Francisco	ref			ref			ref		
Cancer*Connecticut	−0.0340	0.1251	0.7858	0.1301	0.1048	0.2146	0.0698	0.1007	0.4879
Cancer*Detroit	−0.0783	0.1095	0.4743	0.1568	0.0923	0.0895	0.0071	0.0883	0.9355
Cancer*Hawaii	−0.1400	0.2157	0.5162	0.4707	0.1831	0.0101	0.2336	0.1742	0.1799
Cancer*Iowa	0.0292	0.1537	0.8493	0.0774	0.1286	0.5470	0.0255	0.1236	0.8367
Cancer*New Mexico	−0.0501	0.1924	0.7944	0.0299	0.1611	0.8528	−0.0018	0.1549	0.9909
Cancer*Seattle/Puget Sound	−0.0455	0.1336	0.7335	0.0617	0.1130	0.5851	0.0379	0.1079	0.7252
Cancer*Utah	0.0151	0.1614	0.9256	−0.1042	0.1348	0.4397	0.0133	0.1298	0.9181
Cancer*Georgia (Atlanta + rural Georgia)	−0.1304	0.1387	0.3470	0.1695	0.1166	0.1461	0.0001	0.1118	0.9993
Cancer*San Jose	0.0316	0.1460	0.8285	0.2268	0.1223	0.0638	0.1155	0.1175	0.3256
Cancer*Los Angeles	−0.0941	0.1110	0.3965	0.1577	0.0934	0.0912	−0.0070	0.0895	0.9380
Median income									
<$21K	ref			ref			ref		
$21K–<$31K	−0.0098	0.0222	0.6599	0.0106	0.0186	0.5671	0.0071	0.0179	0.6891
$31K–<$43K	−0.0196	0.0260	0.4527	0.0135	0.0218	0.5364	0.0075	0.0209	0.7205

	Surgical Phase			Postsurgical Phase			Total Treatment Period		
Independent Variables‡	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***	**Beta**	**SE**	***P***
$43K–<$53K	−0.0685	0.0314	0.0293	−0.0425	0.0263	0.1058	−0.0461	0.0253	0.0679
>$53K	−0.1943	0.0356	<0.0001	−0.0298	0.0297	0.3158	−0.0566	0.0286	0.0474
Cancer*<$21K	ref			ref			ref		
Cancer*$21K–<$31K	−0.0073	0.1120	0.9479	−0.1047	0.0949	0.2697	−0.0492	0.0904	0.5861
Cancer*$31K–<$43K	−0.0062	0.1312	0.9624	−0.1387	0.1107	0.2102	−0.0691	0.1058	0.5135
Cancer*$43K–<$53K	0.0256	0.1566	0.8701	−0.1781	0.1320	0.1770	−0.0582	0.1262	0.6445
Cancer*>$53K	0.1175	0.1798	0.5135	−0.1536	0.1511	0.3095	−0.0585	0.1449	0.6862
% Non-high school graduate									
<8	ref			ref			ref		
8–<18	−0.0249	0.0201	0.2166	0.0762	0.0168	<0.0001	0.0601	0.0162	0.0002
18–<27	0.0247	0.0235	0.2935	0.0991	0.0195	<0.0001	0.0875	0.0188	<0.0001
27–<37	−0.0562	0.0270	0.0373	0.1441	0.0224	<0.0001	0.1147	0.0216	<0.0001
>37	−0.0356	0.0326	0.2746	0.1418	0.0271	<0.0001	0.1138	0.0261	<0.0001
Cancer*<8	ref			ref			ref		
Cancer*8–<18	−0.0054	0.1036	0.9583	−0.0123	0.0864	0.8867	−0.0548	0.0834	0.5112
Cancer*18–<27	−0.0548	0.1186	0.6439	−0.0994	0.0983	0.3121	−0.1030	0.0952	0.2796
Cancer*27–<37	0.0065	0.1345	0.9612	−0.1139	0.1121	0.3093	−0.1330	0.1083	0.2194
Cancer*>37	0.0411	0.1631	0.8010	−0.0933	0.1369	0.4956	−0.0946	0.1315	0.4716
Scale	0.2829	0.0008		0.4041	0.0012		0.4363	0.0013	

†Number of individuals in the regression model is 145,994.

‡All interaction terms use diagnosis of either colon or rectal cancer vs. none along with other variables in the regression.

MSA indicates metropolitan statistical area.