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Changes in Colorectal Cancer 5-year Survival Disparities in California, 1997–2014

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Abstract

Background: Colorectal cancer (CRC) incidence and mortality have declined with increased screening and scientific advances in treatment. However, improvement in CRC outcomes have not been equal for all groups and disparities have persisted over time.

Methods: Data from the California Cancer Registry were used to estimate changes in 5-year CRC-specific survival over three diagnostic time periods 1997–2002, 2003–2008, and 2009–2014. Analyses included all patients in California with CRC as a first primary malignancy. Multivariable Cox proportional hazard regression models were used to evaluate the effect of race/ethnicity, insurance status, and neighborhood socioeconomic status (nSES) on 5-year CRC-specific survival.

Results: Based on a population-based sample of 197,060 CRC cases, racial/ethnic survival disparities decreased over time among non-Hispanic Blacks (NHB) compared to non-Hispanic Whites (NHW), after adjusting for demographic, clinical, and treatment characteristics. For cases diagnosed 1997–2002, CRC-specific hazard rates were higher for NHB (HR, 1.12; 95% CI, 1.06–1.19) and lower for Asians/Pacific Islanders (HR, 0.92; 95% CI, 0.87–0.96) and Hispanics (HR, 0.94; 95% CI, 0.90–0.99) compared to NHW. In 2009–2014, CRC-specific hazard rate for NHB was not significantly different to the rate observed for NHW (HR,1.03; 95% CI, 0.97–1.10). There were no changes in disparities in nSES, but increasing disparities by health insurance status.

Conclusions: We found a decrease in survival disparities over time by race/ethnicity, but a persistence of disparities by neighborhood socioeconomic status and health insurance status.

Impact: Further investigation into the drivers for these disparities can help direct policy and practice toward health equity for all groups.

Keywords

colorectal cancer; survival; disparities; race; ethnicity; health insurance; socioeconomic status; California

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INTRODUCTION

Colorectal cancer (CRC) is the third most common cancer in women and men in the United States, and the second leading cause of cancer mortality, with a total of 53,200 deaths estimated in the United States for 2020.[1] With increased screening and scientific advances in treatment and prevention, CRC incidence and mortality rates have declined in recent decades.[2,3] However, progress in CRC outcomes has not been equal for all groups. Patients without health insurance and those with Medicaid have more advanced stage at diagnosis, less access to treatment, more post-operative complications, and higher mortality than those with private insurance or Medicare.[4–10] Racial/ethnic disparities also persist for CRC outcomes including higher incidence, higher mortality, and diagnoses at more advanced stages in various racial/ethnic minority groups as compared to non-Hispanic Whites (NHW).[2,4–6,11–14] In addition, people of lower socioeconomic status (SES) are less likely to have access to treatment, have more post-operative complications, and have higher mortality than their more affluent counterparts.[7,10,15–17]

To examine the extent to which improvements in CRC survival were observed across sociodemographic and health insurance status groups over time, we analyzed California Cancer Registry (CCR) data from 1997–2014. California's sociodemographic diversity offers an opportunity to analyze disparities at multiple socioeconomic and racial/ethnic levels. Furthermore, the CCR is one of only five population-based cancer registries in the United States to have collected payer information since the 1990s, enabling an examination of trends in cancer survival disparities by health insurance status.[18] These factors make California uniquely suited to provide insight into the effect of advances in science and policy on CRC survival disparities over time.

MATERIALS AND METHODS

Data Source and Study Population

We used data from the CCR to estimate 5-year CRC-specific and overall (all causes of death) survival trends by race/ethnicity, insurance status, and neighborhood socioeconomic status (nSES) among CRC cases. Analyses included all patients diagnosed in California between January 1997 and December 2014 with CRC as a first primary malignancy with follow-up through December 2016. In order to evaluate disparities over time, three periods of six-year diagnoses were defined: January 1997 to December 2002 (1997–2002), January 2003 to December 2008 (2003–2008), and January 2009 to December 2014 (2009–2014). Of the 198,622 cases eligible for inclusion, we excluded 274 cases diagnosed at autopsy or from death certificate only.

This study received institutional review board approval as a part of the protocol for the Greater Bay Area Cancer Registry.

Study Variables

To ensure equal opportunity for follow-up, we right-truncated follow-up time at five years. Patient vital status was determined by routine linkage to state and national mortality and other follow-up files in addition to active follow-up efforts. For the analysis of CRC-specific

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survival, the underlying cause of death was obtained from death certificates, and follow-up time was censored at date of death for those who died from an underlying cause other than the primary cancer. There was a total of 58,414 CRC-specific deaths (29.4% of included cases) within 5 years of follow-up. Follow-up time for overall survival was computed as the number of days between date of diagnosis and the earliest of: date of death from any cause, date of last known contact, date five years after diagnosis, or December 31, 2016. In the 2009–2014 calendar period, only patients diagnosed in 2009–2011 were able to be followed for 5 years. Mean follow up was 3.4 years for 1997–2002, 3.5 years for 2003–2008, and 3.0 for 2009–2014.

Race/ethnicity was defined as NHW, non-Hispanic Black (NHB), Hispanic, Asian/Pacific Islander (API), and unknown, primarily according to patient medical records and also with the classification system used by the CCR which employs the North American Association of Central Cancer Registries' identification algorithm for Hispanics based on surnames. For health insurance, the most extensive patient-level insurance status at the time of treatment and diagnosis was based on primary and secondary payer source and categorized as no insurance; private insurance only (no Medicare); Medicare only; Medicare plus private insurance; any public, military, or any Medicaid and/or Medi-Cal insurance; and unknown. The validity of health insurance status in the CCR has been verified with three other data sources, demonstrating an agreement of more than 80%.[8]

For nSES, we employed an index that was developed for California using principal components analysis of 2000 Census (for cases diagnosed 1997–2005) or 2010 Census and 2007–2011 American Community Survey (for cases diagnosed 2006–2014) data on education, occupation, employment, household income, poverty, and rent and house values.[19] Patients' addresses at diagnosis were geocoded and assigned to a census block group and then linked to the nSES index. This composite nSES score was categorized according to quintiles of the statewide distribution, with higher quintiles categories representing higher nSES.

Statistical Analysis

Hazard rate ratios (HR) and 95% confidence intervals (CI) were calculated using multivariable Cox proportional hazard regression models to estimate the associations of race/ethnicity, insurance status, and nSES with 5-year CRC-specific and overall death.[20] Models were adjusted for clustering by block group, using a sandwich estimator of the covariance structure that accounts for intracluster dependence. The proportional hazards assumption was tested by examining the correlation between time and scaled Schoenfeld residuals for all covariates. The assumption of proportional hazards was violated for chemotherapy and thus all models included this variable as a stratification factor to allow hazards to vary by chemotherapy. Model covariates included year of diagnosis, age, sex, marital status, AJCC stage, subsite, lymph nodes positive, tumor size, tumor grade, surgery, radiation, urbanization level, and whether or not patients were seen at an NCI designated hospital. Sequential analyses were conducted adjusting for year and demographic characteristics (Model 1), Model 1 plus clinical and tumor characteristics (Model 2), Model 2 plus treatment (Model 3), and Model 3 plus neighborhood and hospital characteristics

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(Full Model). Wald global (and individual term) tests for interaction with time period were computed using cross-product terms in a fully-adjusted overall model additionally adjusted for all statistically significant ($p<0.05$) interactions with time-period (year of diagnosis, age, AJCC stage, subsite, lymph nodes, tumor size, tumor grade, radiation, insurance type, and whether or not patients were seen at an NCI designated hospital). All analyses were performed in SAS version 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

A total of 197,060 patients diagnosed with first primary invasive CRC were included in the analysis and followed for a mean of 3.3 years (SD=1.9). Mean age at diagnosis was 66.8 (SD=14.1). From 1997–2002 to 2009–2014, there was an increase in the proportion of cases reported in Hispanics (12.2% to 20.7%) and API (10.3% to 14.7%), and a decrease in proportion of cases reported in NHW (69.7% to 55.6%). Comparing the first and last time periods, the proportion of patients on Medicare only decreased from 14.9% to 7.7%, while the proportion of patients with any public insurance, Medicaid, or military insurance increased from 10.6% to 22.1%. The proportion of patients with private insurance only, Medicare plus private insurance, and the uninsured remained relatively stable. In the first time period, there was a lower proportion of CRC cases diagnosed in the lowest nSES quintile (14.0%) compared to the last time period (16.8%) (Table 1). From the first two to the last time period, there was a general decrease in the proportion of uninsured Black patients and a general increase in the proportion of API and Hispanic patients with private insurance, Medicare only, Medicare plus private insurance, or any public, Medicaid, or military insurance (Supplemental Table 1).

Results of the multivariable models by periods of diagnosis are shown in Table 2. A non-significant decreasing trend in racial/ethnic survival disparities was observed for the study period (p-interaction= 0.559). In 1997–2002, compared to NHW, the CRC-specific hazard rate was higher for NHB (HR, 1.12; 95% CI, 1.06–1.19) and lower for API (HR, 0.92; 95% CI, 0.87–0.96) and Hispanics (HR, 0.94; 95% CI, 0.90–0.99). In 2009–2014, however, CRC-specific hazard rate for NHB was not significantly different to the rate observed for NHW (HR, 1.03; 95% CI, 0.97–1.10). There were no significant changes in racial/ethnic disparities observed for API and HispanicsHazard ratios for all causes of death in the study period also reflected decreasing disparities for NHB and no significant changes for API and Hispanics, as compared to NHW (Supplemental Table 2). Sequential models indicate that disparities for NHB relative to NHW are largely due to clinical and tumor characteristics (subsite, AJCC stage, lymph nodes, tumor size, and tumor grade) (Tables 3a, 3b, 3c, 3d).

Disparities in CRC-specific hazard rates by health insurance status persisted throughout the study period. Compared to patients with private insurance, patients in all other insurance categories had a higher CRC-specific hazard rate, and these differences were not homogeneous across the three study periods (interaction p-value=0.003). In 1997–2002, patients with no insurance had a higher CRC-specific hazard rate than patients with private insurance (HR, 1.12; 95% CI, 1.01–1.25), and based on effect estimates these differences increased in 2009–2014 (HR, 1.24; 95% CI, 1.11–1.37). Similarly, the hazard ratio in patients with Medicare only increased from the first (HR 1.09; 95% CI 1.04–1.13) to the last

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time period (HR 1.26; 95% CI 1.18–1.34). The hazard ratio in patients with Medicare plus private insurance increased from non-significantly different from private insurance only in the first period (HR 1.03; 95% CI 0.99–1.07) to significantly higher in the last period (HR 1.11; 95% CI 1.06–1.16). Relative to the hazard rate among patients with private insurance, the hazard rate in patients with any public insurance, Medicaid, or military insurance also increased from the first (HR 1.06; 95% CI 1.01–1.12) to last time period (HR 1.20; 95% CI 1.16–1.26) (Table 2). Trends for overall survival also reflected increasing disparities for all non-private insurance groups (Supplemental Table 2). Sequential models indicate that while a considerable portion of the survival differences between uninsured, public, and Medicare only groups compared to private insurance were accounted for by differences in clinical and tumor characteristics, disparities remained constant over time. Treatment and neighborhood and institutional factors did not further explain the differences among the insurance groups. (Tables 3a, 3b, 3c, 3d). An inverse association between nSES and CRC-specific hazard rates was found, with patients in the lower nSES quintiles having a higher hazard rate than those in the highest nSES quintile. This disparity did not change by period of diagnosis (p-interaction=0.652). Trends for overall survival by nSES were similar to CRC-specific survival (Supplemental Table 2).

DISCUSSION

Using a population-based sample of nearly 200,000 individuals with incident CRC, we evaluated changes over three time periods from 1997 to 2014 in the relationship between sociodemographic and socioeconomic characteristics and CRC-specific survival. We found persistent disparities by nSES and insurance status over time but decreased CRC-specific survival differences between NHB and NHW, after adjusting for demographic, clinical, and treatment characteristics.

Historically, racial/ethnic survival disparities have been observed among CRC patients, with minorities and especially NHB having poorer outcomes than NHW.[2, 14, 21–23] However, our study shows a lack of significant difference in short-term survival (CRC and overall) between NHB and NHW in the most recent period of our study, after multivariable adjustment. This implies that survival disparities between NHB and NHW are in part due to known demographic, clinical, and treatment factors. A recent study by Sineshaw et al found that most of the difference in CRC survival between NHB and NHW was explained by insurance coverage (54%) and tumor characteristics (27%).[24] In addition, this pattern could reflect recent progress in California related to the uptake of CRC screening. Screening rates in California have improved for all racial/ethnic groups, but particularly in NHB. According to data from the Behavioral Risk Factor Surveillance System, adherence to screening recommendations of the United States Preventive Services Task Force have continuously increased, and indicate a very similar screening rate for NHB and NHW in recent years (67.5% vs 68.9% in 2012 and 77.5% vs 77.3% in 2016).[25,26]

Short-term survival disparities by health insurance status were consistently observed during the whole study period. In fact, CRC-specific and overall survival effect estimates for the uninsured and those with Medicare only, Medicare plus private insurance, or any public, Medicaid, or Military insurance, increased from one time period to another compared to

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patients with private coverage. This finding of higher mortality hazard for all insurance groups as compared to private insurance aligns with previous research using national SEER data that report that the uninsured and those with Medicaid are diagnosed at more advanced stages of disease, have less access to treatment, and have more post-operative complications than patients with private insurance.[5,6,9] These findings highlight the role of health insurance and type of coverage as a critical aspect for accessing care and facilitating both early diagnosis and optimal management of the disease.

In the context of California, we would have expected a reduction in disparities during the 2009–2014 time period due to the implementation of the Affordable Care Act. However, we instead observed an increase in insurance-related disparities. This may be due to improvements in survival among privately insured patients and/or due to early enrollment of cases with more advanced disease. California opted for early expansion of Medicaid to people with incomes as high as 200% of poverty level starting in 2011. Full implementation of the ACA began in January 2014;[27] thus, to the extent that lower SES is associated with less CRC screening and more advanced stage, the CRC cases included in the early expansion time period likely included more advanced cases who were not previously eligible for Medicaid. A previous study using CCR data up to 2014 also reflected this persistent disparity across multiple cancer sites.[8] Reasons for poor outcomes in people with Medicaid coverage in California may include limited physician access, unavailability of new therapies due a limited medications formulary and high costs, and a system requiring prior treatment authorizations. In order to eliminate these disparities, it has been proposed that a redesign of cancer care delivery is needed beyond extending health coverage for people of low income.[8,28]

Interpretation of results on race/ethnicity from the 2009–2014 time period in our study may be challenging as the effects of the ACA differed by race/ethnicity.[29] While Hispanic and API women experienced a decrease in uninsured rates from 2012 to 2014, Hispanic and API men experienced little change. Uninsured rates among NHB women remained low at 8–9%, and NHB men were the only group of men in California who experienced a large decrease in their uninsured rate (23% in 2012 to 13% in 2014). Both NHB women and men experienced an increase in coverage though employer-based insurance (45% to 64% among men, 45% to 53% among women).[29] This may partially explain why our results showed a decrease in disparities for NHB over time, but a persistence of disparities by insurance type.

Socioeconomic status is another important factor linked to CRC patients' survival.[10,15,30] Low SES has been linked to no access to care, late stage of disease at time of diagnosis, comorbidities, individual stressors, and poorer survival.[30] In this study, we found that patients living in areas with lower nSES at diagnosis had lower CRC-specific and overall short-term survival than patients residing in places with higher nSES. A dose-response association was observed across all three periods of diagnosis. An SES gradient in cancer survival has been reported before for CRC, other cancer types, and other health outcomes.[16,30,32] The diverse socioeconomic range among populations residing in California and access to patients' data with sociodemographic and tumor characteristics, allowed us to confirm this finding independently of other prognostic factors of survival (e.g., race/ethnicity, stage at diagnosis, health insurance coverage and treatment).

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Limitations to this study include factors inherent to cancer registry data. Patient health insurance status is determined by primary and secondary payer source which may change over time; in addition, cancer registry data capture the most extensive health insurance coverage during both diagnosis and initial treatment period, and thus may not reflect coverage at the time of diagnosis. Not knowing Medicaid enrollment information at diagnosis might have biased our results towards poorer survival in the "Any Public/ Medicaid/Military" group if those patients enrolled in Medicaid after diagnosis.[33] The survival experience of these patients resembles that of the uninsured since they may have been without continuous coverage until receiving a late-stage diagnosis. Previous research has shown differences in stage at diagnosis of CRC for patients with different versions of Medicaid coverage, with increasing odds of later stages (compared to private coverage) for continuous Medicaid, discontinuous Medicaid, and Medicaid at diagnosis.[34] Our study was also unable to account for other factors such as patient sociodemographic factors, comorbidity, receipt of detailed guideline concordant treatment, or managed and/or fee-for-service health care systems which may have influenced survival disparities in our study population.[8] CCR data on surgery, chemotherapy, and radiation is limited to first course and thus does not provide a full account of all treatment received. Furthermore, complete cancer registry data reporting and vital status determination is delayed and we were only able to obtain follow-up data up through 2016, resulting in incomplete 5-year follow up for part of our study population. Other limitations to our study include potential lead-time bias due to differential uptake of screening and the restriction to short-term 5-year survival due to the structure of the analysis.

In summary, using population-based cancer registry data spanning two decades from a large, diverse state, we found a decrease in survival disparities over time by race/ethnicity but a persistence of disparities by nSES and health insurance status. As more years of cancer data and other types of data on underlying causes are available, further investigation into the drivers for these disparities can help direct policy and practice toward health equity for all groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Demographic and clinical characteristics of patients diagnosed with invasive colorectal cancer, by period of diagnosis in California, 1997–2014

	Period of diagnosis					
	1997–2002		2003–2008		2009–2014	
	N	%	N	%	N	%
All	65,752	100.0%	66,186	100.0%	65,122	100.0%
Mean follow-up in years (±SD)	3.4 (1.9)		3.5 (1.9)		3.0 (1.7)	
Age at diagnosis						
mean (±SD)	68.2 (13.7)		66.8 (14.1)		65.2 (14.3)	
Age at diagnosis						
<50	6,667	10.1%	7,708	11.6%	8,472	13.0%
50–75	34,789	52.9%	36,264	54.8%	38,264	58.8%
76+	24,296	37.0%	22,214	33.6%	18,386	28.2%
Sex						
Male	33,706	51.3%	34,095	51.5%	34,026	52.2%
Female	32,046	48.7%	32,091	48.5%	31,096	47.8%
Race/Ethnicity						
Non-Hispanic White	45,849	69.7%	41,150	62.2%	36,234	55.6%
Non-Hispanic Black	4,509	6.9%	5,055	7.6%	4,779	7.3%
Hispanic	8,046	12.2%	10,906	16.5%	13,452	20.7%
Asian/Pacific Islander	6,790	10.3%	8,346	12.6%	9,576	14.7%
Unknown	558	0.8%	729	1.1%	1,081	1.7%
Marital status at diagnosis						
Unmarried	26,866	40.9%	27,356	41.3%	27,430	42.1%
Married	36,915	56.1%	36,786	55.6%	33,930	52.1%
Unknown	1,971	3.0%	2,044	3.1%	3,762	5.8%
AJCC stage						
I	15,609	23.7%	15,122	22.8%	15,477	23.8%
II	18,429	28.0%	16,729	25.3%	15,534	23.9%
III	15,631	23.8%	16,177	24.4%	17,217	26.4%
IV	11,503	17.5%	12,636	19.1%	12,828	19.7%
Unknown	4,580	7.0%	5,522	8.3%	4,066	6.2%
Subsite						
Proximal Colon	27,261	41.5%	28,026	42.3%	26,760	41.1%
Distal Colon	17,310	26.3%	16,652	25.2%	15,787	24.2%
Rectum	19,593	29.8%	19,733	29.8%	20,711	31.8%
Not otherwise specified	1,588	2.4%	1,775	2.7%	1,864	2.9%
Lymph nodes positive						
No	35,537	54.0%	37,258	56.3%	37,502	57.6%

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	Period of diagnosis					
	1997–2002		2003–2008		2009–2014	
	N	%	N	%	N	%
Yes	22,671	34.5%	23,838	36.0%	23,702	36.4%
Unknown	7,544	11.5%	5,090	7.7%	3,918	6.0%
Tumor Size						
0.1–2.00 cm	5,471	8.3%	6,986	10.6%	8,776	13.5%
2.01–5.00 cm	27,588	42.0%	27,447	41.5%	25,537	39.2%
>5.00 cm	17,226	26.2%	16,577	25.0%	17,259	26.5%
Other/Unknown	15,467	23.5%	15,176	22.9%	13,550	20.8%
Tumor Grade						
Well-differentiated	5,949	9.0%	5,827	8.8%	6,451	9.9%
Moderately differentiated	40,436	61.5%	40,135	60.6%	39,634	60.9%
Poorly/Undifferentiated	12,310	18.7%	12,016	18.2%	10,887	16.7%
Unknown	7,057	10.7%	8,208	12.4%	8,150	12.5%
Surgery						
No	6,785	10.3%	8,361	12.6%	10,786	16.6%
Tumor excision	1,044	1.6%	360	0.5%	343	0.5%
Colectomy	54,073	82.2%	53,001	80.1%	49,092	75.4%
Unknown	3,850	5.9%	4,464	6.7%	4,901	7.5%
Chemotherapy						
No	41,738	63.5%	40,849	61.7%	38,709	59.4%
Yes	21,620	32.9%	23,771	35.9%	24,900	38.2%
Unknown	2,394	3.6%	1,566	2.4%	1,513	2.3%
Radiation therapy						
No	57,719	87.8%	57,350	86.6%	55,741	85.6%
Yes	8,020	12.2%	8,799	13.3%	9,296	14.3%
Unknown	13	0.0%	37	0.1%	85	0.1%
Neighborhood SES quintile						
1st (lowest)	9,220	14.0%	9,838	14.9%	10,908	16.8%
2nd	12,508	19.0%	12,816	19.4%	13,259	20.4%
3rd	14,386	21.9%	14,219	21.5%	13,715	21.1%
4th	14,764	22.5%	14,800	22.4%	13,961	21.4%
5th (highest)	14,874	22.6%	14,513	21.9%	13,279	20.4%
Insurance status						
No insurance	1,212	1.8%	1,387	2.1%	1,349	2.1%
Private only	30,849	46.9%	30,638	46.3%	29,326	45.0%
Medicare only	9,807	14.9%	5,712	8.6%	4,982	7.7%
Medicare+Private	14,742	22.4%	14,219	21.5%	13,556	20.8%
Any Public/Medicaid/Military	6,948	10.6%	12,508	18.9%	14,402	22.1%
Unknown	2,194	3.3%	1,722	2.6%	1,507	2.3%
Urbanization level						
Urban	41,698	63.4%	41,732	63.1%	41,129	63.2%

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	Period of diagnosis					
	1997–2002		2003–2008		2009–2014	
	N	%	N	%	N	%
Rural	23,812	36.2%	24,274	36.7%	23,834	36.6%
Unknown	242	0.40%	180	0.30%	159	0.20%
Seen at an NCI-designated cancer center						
No	62,546	95.1%	61,370	92.7%	58,007	89.1%
Yes	3,206	4.9%	4,816	7.3%	7,115	10.9%

All chi-square p-values <0.01

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Table 2.

Multivariable adjusted hazard ratios (HR) and 95% confidence interval (CI) estimates for 5-year colorectal cancer specific death by period of diagnosis, California 1997–2014, with follow-up through 2016.

	Period of diagnosis 1997–2002		Period of diagnosis 2003–2008		Period of diagnosis 2009–2014		Interaction
	No. of deaths	HR (95% CI)	No. of deaths	HR (95% CI)	No. of deaths	HR (95% CI)	p-value
Race/Ethnicity							
Non-Hispanic White	14282	Reference	12,326	Reference	9,994	Reference	0.559
Non-Hispanic Black	1,740	1.12 (1.06–1.19)	1,845	1.09 (1.04–1.15)	1,554	1.03 (0.97–1.10)	
Hispanic	2,588	0.94 (0.90–0.99)	3,275	0.94 (0.90–0.98)	3,621	0.93 (0.89–0.97)	
Asian/Pacific Islander	1,997	0.92 (0.87–0.96)	2,275	0.88 (0.84–0.92)	2,417	0.94 (0.89–0.98)	
Neighborhood SES quintile							0.652
1st (lowest)	3255	1.23 (1.17–1.30)	3,265	1.19 (1.13–1.26)	3,349	1.20 (1.14–1.27)	
2nd	4,176	1.17 (1.12–1.22)	4,128	1.20 (1.14–1.26)	3,816	1.16 (1.11–1.22)	
3rd	4,583	1.11 (1.06–1.16)	4,337	1.15 (1.10–1.20)	3,766	1.11 (1.05–1.17)	
4th	4,472	1.05 (1.01–1.10)	4,274	1.09 (1.04–1.14)	3,619	1.03 (0.98–1.08)	
5th (highest)	4,221	Reference	3,829	Reference	3,150	Reference	
Insurance status							
No insurance	459	1.12 (1.01–1.25)	488	1.22 (1.09–1.35)	420	1.24 (1.12–1.37)	0.003
Private only	9,114	Reference	8,185	Reference	6,609	Reference	
Medicare only	3,275	1.09 (1.04–1.13)	1,966	1.21 (1.15–1.28)	1,651	1.26 (1.18–1.34)[a]	
Medicare+Private	4,509	1.03 (0.99–1.07)	4,184	1.04 (1.00–1.09)	3,828	1.11 (1.06–1.16) [a]	
Any Public/Medicaid/Military	2,500	1.06 (1.01–1.12)	4,381	1.16 (1.11–1.21)	4,771	1.20 (1.16–1.26) [a]	

Cox regression models with underlying stratification by chemotherapy and adjusted for year of diagnosis, age, sex, marital status, AJCC stage, subsite, lymph nodes positive, tumor size, tumor grade, surgery, radiation, urbanization level, whether or not patients were seen at an NCI-designated cancer center, and clustering by block group. Cases with unknown race/ethnicity, neighborhood SES quintile, and insurance status were included in the models (results not shown).

[a]Significantly different from 1997–2002 (individual cross-product interaction term p-value <0.05 in the overall model)

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Table 3a, 3b, 3c, 3d.

Sequentially adjusted multivariate adjusted hazard ratios (HR) and 95% CI estimates for 5-year colorectal cancer specific death by period of diagnosis, California 1997–2014.

3a. Model 1: Adjusted for year, age, sex, and marital status.

	Period of diagnosis 1997–2002	Period of diagnosis 2003–2008	Period of diagnosis 2009–2014
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Race/Ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.24 (1.17–1.30)	1.21 (1.15–1.28)	1.16 (1.10–1.23)
Hispanic	0.95 (0.91–1.00)	0.93 (0.89–0.97)	0.93 (0.89–0.97)
Asian/Pacific Islander	0.89 (0.85–0.94)	0.86 (0.82–0.90)	0.91 (0.87–0.95)
Neighborhood SES quintile			
1st (lowest)	1.29 (1.23–1.35)	1.26 (1.20–1.33)	1.29 (1.22–1.35)
2nd	1.21 (1.16–1.26)	1.24 (1.18–1.30)	1.22 (1.16–1.28)
3rd	1.16 (1.11–1.21)	1.18 (1.13–1.23)	1.16 (1.10–1.21)
4th	1.08 (1.04–1.13)	1.13 (1.08–1.18)	1.09 (1.04–1.15)
5th (highest)	Reference	Reference	Reference
Insurance status			
No insurance	1.42 (1.29–1.57)	1.45 (1.31–1.59)	1.62 (1.46–1.79)
Private only	Reference	Reference	Reference
Medicare only	1.12 (1.07–1.17)	1.29 (1.23–1.36)	1.42 (1.34–1.50)
Medicare+Private	1.00 (0.96–1.04)	1.03 (0.99–1.07)	1.12 (1.08–1.17)
Any Public/Medicaid/Military	1.18 (1.13–1.23)	1.30 (1.25–1.35)	1.45 (1.39–1.51)

3b. Model 2: Adjusted for model 1 variables, subsite, AJCC stage, lymph nodes, tumor size, and tumor grade.

	Period of diagnosis 1997–2002	Period of diagnosis 2003–2008	Period of diagnosis 2009–2014
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Race/Ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.11 (1.05–1.17)	1.11 (1.06–1.17)	1.05 (0.99–1.11)
Hispanic	0.93 (0.89–0.98)	0.94 (0.90–0.98)	0.93 (0.89–0.97)

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3b. Model 2: Adjusted for model 1 variables, subsite, AJCC stage, lymph nodes, tumor size, and tumor grade.			
	Period of diagnosis 1997–2002	**Period of diagnosis 2003–2008**	**Period of diagnosis 2009–2014**
	HR (95% CI)	**HR (95% CI)**	**HR (95% CI)**
Asian/Pacific Islander	0.89 (0.85–0.94)	0.86 (0.82–0.90)	0.91 (0.87–0.95)
Neighborhood SES quintile			
1st (lowest)	1.27 (1.21–1.34)	1.23 (1.17–1.29)	1.25 (1.19–1.32)
2nd	1.19 (1.13–1.24)	1.22 (1.16–1.27)	1.20 (1.14–1.26)
3rd	1.14 (1.09–1.19)	1.16 (1.11–1.21)	1.14 (1.09–1.20)
4th	1.06 (1.01–1.10)	1.10 (1.05–1.15)	1.05 (1.00–1.10)
5th (highest)	Reference	Reference	Reference
Insurance status			
No insurance	1.13 (1.02–1.26)	1.27 (1.14–1.40)	1.30 (1.17–1.45)
Private only	Reference	Reference	Reference
Medicare only	1.08 (1.04–1.13)	1.19 (1.13–1.26)	1.26 (1.19–1.34)
Medicare+Private	1.02 (0.98–1.06)	1.02 (0.98–1.06)	1.11 (1.06–1.16)
Any Public/Medicaid/Military	1.06 (1.01–1.12)	1.16 (1.11–1.21)	1.23 (1.18–1.28)

3c. Model 3: Adjusted for Model 2 variables, surgery, and radiation.			
	Period of diagnosis 1997–2002	**Period of diagnosis 2003–2008**	**Period of diagnosis 2009–2014**
	HR (95% CI)	**HR (95% CI)**	**HR (95% CI)**
Race/Ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.10 (1.04–1.17)	1.08 (1.03–1.14)	1.03 (0.98–1.10)
Hispanic	0.94 (0.89–0.98)	0.93 (0.89–0.97)	0.93 (0.89–0.97)
Asian/Pacific Islander	0.90 (0.85–0.95)	0.86 (0.82–0.91)	0.92 (0.88–0.97)
Neighborhood SES quintile			
1st (lowest)	1.25 (1.19–1.32)	1.22 (1.16–1.28)	1.24 (1.17–1.31)
2nd	1.19 (1.13–1.24)	1.22 (1.16–1.28)	1.20 (1.14–1.26)
3rd	1.13 (1.08–1.18)	1.17 (1.12–1.22)	1.13 (1.08–1.19)
4th	1.06 (1.01–1.11)	1.10 (1.05–1.15)	1.04 (0.99–1.10)
5th (highest)	Reference	Reference	Reference
Insurance status			

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3c. Model 3: Adjusted for Model 2 variables, surgery, and radiation.

	Period of diagnosis 1997–2002	Period of diagnosis 2003–2008	Period of diagnosis 2009–2014
	HR (95% CI)	HR (95% CI)	HR (95% CI)
No insurance	1.11 (1.00–1.23)	1.19 (1.07–1.32)	1.21 (1.09–1.34)
Private only	Reference	Reference	Reference
Medicare only	1.08 (1.04–1.13)	1.20 (1.14–1.27)	1.24 (1.17–1.32)
Medicare+Private	1.03 (0.99–1.07)	1.04 (1.00–1.09)	1.10 (1.06–1.16)
Any Public/Medicaid/Military	1.05 (1.00–1.11)	1.14 (1.09–1.19)	1.18 (1.13–1.23)

3d. Full Model (Table 2): Adjusted for Model 3 variables, urbanization level, NCI cancer center.

	Period of diagnosis 1997–2002	Period of diagnosis 2003–2008	Period of diagnosis 2009–2014
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Race/Ethnicity			
Non-Hispanic White	Reference	Reference	Reference
Non-Hispanic Black	1.12 (1.06–1.19)	1.09 (1.04–1.15)	1.03 (0.97–1.10)
Hispanic	0.94 (0.90–0.99)	0.94 (0.90–0.98)	0.93 (0.89–0.97)
Asian/Pacific Islander	0.92 (0.87–0.96)	0.88 (0.84–0.92)	0.94 (0.89–0.98)
Neighborhood SES quintile			
1st (lowest)	1.23 (1.17–1.30)	1.19 (1.13–1.26)	1.20 (1.14–1.27)
2nd	1.17 (1.12–1.22)	1.20 (1.14–1.26)	1.16 (1.11–1.22)
3rd	1.11 (1.06–1.16)	1.15 (1.10–1.20)	1.11 (1.05–1.17)
4th	1.05 (1.01–1.10)	1.09 (1.04–1.14)	1.03 (0.98–1.08)
5th (highest)	Reference	Reference	Reference
Insurance status			
No insurance	1.12 (1.01–1.25)	1.22 (1.09–1.35)	1.24 (1.12–1.37)
Private only	Reference	Reference	Reference
Medicare only	1.09 (1.04–1.13)	1.21 (1.15–1.28)	1.26 (1.18–1.34)
Medicare+Private	1.03 (0.99–1.07)	1.04 (1.00–1.09)	1.11 (1.06–1.16)
Any Public/Medicaid/Military	1.06 (1.01–1.12)	1.16 (1.11–1.21)	1.20 (1.16–1.26)