

Racial and Ethnic Disparities in Cancer Survival: The Contribution of Tumor, Sociodemographic, Institutional, and Neighborhood Characteristics

Libby Ellis, Alison J. Canchola, David Spiegel, Uri Ladabaum, Robert Haile, and Scarlett Lin Gomez

Author affiliations and support information (if applicable) appear at the end of this article.

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Corresponding author: Libby Ellis, PhD, Cancer Prevention Institute of California, 2201 Walnut Ave, Suite 300, Fremont, CA 94538; e-mail: elizabeth.ellis@cpic.org.

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A B S T R A C T

Purpose

Racial/ethnic disparities in cancer survival in the United States are well documented, but the underlying causes are not well understood. We quantified the contribution of tumor, treatment, hospital, sociodemographic, and neighborhood factors to racial/ethnic survival disparities in California.

Materials and Methods

California Cancer Registry data were used to estimate population-based cancer-specific survival for patients diagnosed with breast, prostate, colorectal, or lung cancer between 2000 and 2013 for each racial/ethnic group (non-Hispanic black, Hispanic, Asian American and Pacific Islander, and separately each for Chinese, Japanese, and Filipino) compared with non-Hispanic whites. The percentage contribution of factors to overall racial/ethnic survival disparities was estimated from a sequence of multivariable Cox proportional hazards models.

Results

In baseline models, black patients had the lowest survival for all cancer sites, and Asian American and Pacific Islander patients had the highest, compared with whites. Mediation analyses suggested that stage at diagnosis had the greatest influence on overall racial/ethnic survival disparities accounting for 24% of disparities in breast cancer, 24% in prostate cancer, and 16% to 30% in colorectal cancer. Neighborhood socioeconomic status was an important factor in all cancers, but only for black and Hispanic patients. The influence of marital status on racial/ethnic disparities was stronger in men than in women. Adjustment for all covariables explained approximately half of the overall survival disparities in breast, prostate, and colorectal cancer, but it explained only 15% to 40% of disparities in lung cancer.

Conclusion

Overall reductions in racial/ethnic survival disparities were driven largely by reductions for black compared with white patients. Stage at diagnosis had the largest effect on racial/ethnic survival disparities, but earlier detection would not entirely eliminate them. The influences of neighborhood socioeconomic status and marital status suggest that social determinants, support mechanisms, and access to health care are important contributing factors.

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INTRODUCTION

Cancer mortality rates in the United States are declining,¹ but one in four deaths is still attributable to cancer,¹ and the burden on the population is not equal. Disparities in survival by race and ethnicity have been well documented,^{2,3} but the underlying causes are not well understood. Various factors have been implicated as contributors toward racial/ethnic survival disparities; these include differences in tumor characteristics at presentation,^{4,5} disease

management and treatment,^{6,7} factors that relate to the health care institution,⁸ and sociodemographic and neighborhood characteristics.⁹⁻¹¹ The influence of these factors varies for different types of cancer and may vary across racial/ethnic groups.

The persistent disparity in survival between non-Hispanic white (NHW) and black patients is particularly stark. For breast and colorectal cancers, this disparity is most commonly attributed to differences in tumor characteristics at diagnosis. Black patients are more likely than NHW patients to have later-stage disease, higher nodal

ASSOCIATED CONTENT



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Appendix
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involvement, hormone receptor–negative breast tumors, and cancers of the proximal colon.^{4,5,12-14} Differences in management and treatment also influence racial/ethnic disparities in survival,^{6,7,15-17} but these disparities are greatly reduced,^{18,19} or even eliminated,²⁰ in equal-access health care systems, which suggests that access to care and delivery of recommended treatments are important contributors to racial/ethnic disparities in cancer survival.

More recently, attention has focused on the contribution of social determinants and neighborhood characteristics to racial/ethnic disparities. Survival is known to increase with higher neighborhood socioeconomic status (SES), but it is among those with the highest neighborhood SES that the biggest disparities exist.⁹ Disparities in survival by health insurance status also differ according to a patient's racial/ethnic group. Some of the largest black-white survival disparities are found among patients with private insurance, but these disparities are absent among the uninsured, which suggests that the benefits of private health insurance are not experienced equally for all racial/ethnic groups.¹⁰ Married cancer patients have consistently lower mortality than unmarried patients,²¹ but the magnitude of this marriage-related survival advantage also varies: NHW patients gain the greatest benefit, and Asian Americans, the least.¹¹

So far, to our knowledge, no study has systematically considered the relative influence of a defined set of prognostic factors on racial/ethnic disparities in survival across different types of cancer. We investigated racial/ethnic disparities in cancer-specific survival for the four most common cancers in California, and we quantified the contribution of various tumor, sociodemographic, institutional, treatment, and neighborhood factors to disparities in survival.

PATIENTS AND METHODS

Data

California Cancer Registry (CCR) data were used to estimate population-based survival by racial/ethnic group. Analyses included all patients diagnosed in California between 2000 and 2013 with female breast, prostate, colorectal, or lung cancer as a first, primary malignancy. Of the 897,833 cases eligible for inclusion, those diagnosed at autopsy or from death certificates

(n = 7,887) and those with unknown follow-up time (n = 5,276) or unknown cause of death (n = 7,008) were excluded.

The vital status of the patient and cause of death were determined by routine linkage to state and national mortality files. Follow-up was computed as the number of days between diagnosis and either the date of death, the date of last known contact, or the end date of follow-up (December 31, 2013). Survival was estimated by using cancer-specific survival,²² and follow-up was censored at the date of death for those who died of a cause other than the primary cancer. Among the 877,662 included cancer cases, there were 222,042 cancer-specific deaths (25%). The validity of cancer-specific survival estimates was confirmed in a sensitivity analysis by using Fine and Gray competing risks regression models.²³

Race/ethnicity was classified as NHW, non-Hispanic black (black), Hispanic, or Asian American and Pacific Islander (AAPI).²⁴ The three largest AAPI subgroups by population (Chinese, Japanese, and Filipino) also were examined separately. Approximately 1% of patients had unknown race/ethnicity; results for these patients were not reported. A number of patient characteristics were considered as potential explanatory factors in the relationship between race/ethnicity and survival, and these were classified as either tumor or treatment related, sociodemographic, institutional, or contextual neighborhood characteristics (Table 1).

Neighborhood factors from the California Neighborhoods Data System²⁵ were based on the census block group of patients' residence at diagnosis. Neighborhood SES is a composite index developed with principal components analysis of 2000 census or 2007 to 2011 American Community Survey data on education, occupation, employment, household income, poverty, and rent and house values.²⁶ The components are summed, and the composite SES score is categorized according to quintiles of the state-wide distribution.

Statistical Analysis

Multivariable Cox proportional hazards models were used to examine cancer-specific survival by racial/ethnic group (compared with NHW patients) for each cancer site and by sex. Proportionality of hazards for key covariates was tested by examining the correlation between time and scaled Schoenfeld residuals, and by graphically assessing the log-log plots of survival. Because the assumption of proportional hazards was violated for age, Cox models were age-stratified to allow the baseline hazards to vary.

Mediation analysis was conducted to estimate the relative contribution of each covariable to racial/ethnic disparities in survival. The baseline model was defined as race/ethnicity plus age. The influence of each covariable on racial/ethnic survival disparities first was tested in a base model: race/ethnicity

Table 1. Covariables Included as Explanatory Factors in Racial/Ethnic Disparities in Survival

Tumor		Treatment*		Institutional†	
Variable	Abbreviation	Variable	Abbreviation	Variable	Abbreviation
Stage at diagnosis	Stage	Surgery	Surgery	NCI cancer center	NCI
Tumor size	T Size	Radiation	Radio	Hospital racial/ethnic composition	Hosp R/E comp
Grade‡	Grade	Chemotherapy	Chemotherapy		
Lymph node positive	Nodes	Sociodemographic		Hospital health insurance composition	Hosp insure comp
Histology (lung)	Histology				
Subsite (colorectal)	Subsite	Health insurance status§	Hlth insure	Hospital SES composition	Hosp SES comp
Hormone receptor status¶(breast)	HR stat	Marital status	Mar stat	Neighborhood	
Year of diagnosis	Year diag			SES	nSES
				Racial/ethnic composition	nR/E comp

NOTE. See Table 2 and Appendix Table A1 (online only) for covariable definitions and categorizations.

Abbreviations: NCI, National Cancer Institute; SES, socioeconomic status.

*Treatment factors were limited to the first course of treatment.

†Institutional factors were based on the hospital that first reported the occurrence.

‡For prostate cancer, grade was based on Gleason score.

§Health insurance status was based on primary and secondary payer sources.

¶Estrogen/progesterone receptor positive.

plus age plus covariable. Covariables then were ranked in order of their significance of influence on racial/ethnic survival disparities (ie, by how much the hazard ratio [HR] decreased when included in the model). The process was performed separately for each cancer site and sex. As the influence of each covariable on survival disparities differed by racial/ethnic group, a previously developed summary measure was used to describe the relative influence of a covariable on survival disparities across all racial/ethnic groups combined.²⁷ The derived summary measure is the standard deviation of log HR estimates (Cox regression coefficients) for the racial/ethnic groups from the base model, and it is independent of which group is chosen as the reference group.

Covariables then were added to the baseline model in a sequence of multivariable models, in the order of their significance of influence. With each addition to the multivariable model, the change in HR was assessed as a measure of the relative change in disparity (ie, the proportion of the total disparity contributed by that covariable, after accounting for previously added covariables). The model was defined simply as $(D_- - D_+ \div D_0) \times 100$, in which D_0 is the HR from the baseline model, D_- is the HR from the model without the covariable of interest, and D_+ is the HR from the model with the covariable of interest. The change in HR was assessed both for each racial/ethnic group and by using the summary measure for all racial/ethnic groups, as described above. All analyses were performed in STATA 14 (STATA, College Station, TX).

RESULTS

The cohort included 264,681 breast cancers, 270,101 prostate cancers, 181,060 lung cancers, and 161,820 colorectal cancers (Table 2 and Appendix Table A1). The racial/ethnic distribution generally was similar for each cancer: 62% to 71% were NHW, 6% to 9% were black, 10% to 17% were Hispanic, and 7% to 13% were AAPI. The majority of NHW and AAPI patients lived in high-SES neighborhoods, and the majority of black and Hispanic, in low-SES neighborhoods. Black, Hispanic, and AAPI patients had a younger age profile than NHW patients, a correspondingly lower proportion had Medicare insurance, and a higher proportion had public or no health insurance.

Breast Cancer

The largest racial/ethnic disparities in survival were among women with breast cancer; cancer-specific mortality in black women was two-fold higher than in NHW women in the baseline model (HR, 2.10; 95% CI, 2.02 to 2.19; Fig 1A). Stage at diagnosis had the greatest influence on overall survival disparities—accounting for 24% of disparities (Table 3)—but its influence varied by racial/ethnic group. Stage explained 11% to 18% of survival disparities for Hispanic and black women relative to NHW women, but it had no effect on the survival advantage experienced by AAPI women. Similarly, neighborhood SES influenced survival disparities in black and Hispanic women (by 6% and 7%, respectively), but not in AAPI women. Hormone receptor status reduced the HR for black and Hispanic women compared with NHW women (by 7% and 2.5%, respectively) but increased the survival advantage for AAPI women (Appendix Table A2, online only). After stage at diagnosis, hormone receptor status had the second largest influence on racial/ethnic disparities in breast cancer survival; it accounted for 9% of the overall disparity (Table 3). In total, adjustment for all covariables explained 54% of the overall disparities in breast cancer survival across all racial/ethnic groups.

Prostate Cancer

Cancer-specific mortality among black men with prostate cancer was 60% higher than among NHW men in the baseline model (HR, 1.60; 95% CI, 1.52 to 1.69; Fig 1B). A large proportion of this survival disparity was attributable to differences in stage at diagnosis, which accounted for almost a quarter of overall survival disparities across all racial/ethnic groups (Table 3). An additional 14% was explained by differences in marital status, and 7% was explained by neighborhood SES, though this largely was due to the influence of these factors on survival disparities in black and Hispanic men relative to NHW men (Appendix Table A2). Adjustment for differences in stage at diagnosis, marital status, and neighborhood SES reduced the survival disparity between black and NHW men with prostate cancer to nonsignificant levels. Adjustment for all covariables explained 48% of the overall disparities in prostate cancer survival across all racial/ethnic groups.

Lung Cancer

Racial/ethnic disparities in lung cancer survival were more pronounced in women than in men (Figs 1C and 1D). AAPI patients had significantly lower cancer-specific mortality than NHW patients; this survival advantage was evident for Chinese and Filipino patients but not for Japanese patients, whose cancer-specific mortality was similar to that of NHW patients (Appendix Table A3, online only). Adjusting for differences in stage at diagnosis increased the AAPI survival advantage by 9% to 14% and increased overall survival disparities across all racial/ethnic groups by 17% in men and 30% in women. Differences in neighborhood SES and marital status were the largest contributors to overall survival disparities across all racial/ethnic groups accounting for 18% and 21%, respectively, in men, and 17% and 14%, respectively, in women (Table 3). Tumor histology influenced survival disparities in women to a much greater extent than in men, and it accounted for 19% of the overall survival disparity.

Colorectal Cancer

Cancer-specific mortality among patients with colorectal cancer was 36% higher in black men (HR, 1.36; 95% CI, 1.30 to 1.43) and 34% higher in black women (HR, 1.34; 95% CI, 1.28 to 1.41) in the baseline model compared with NHW patients (Figs 1E and 1F). In women, sequential adjustment for all covariables reduced the black-white survival disparity to nonsignificant levels. AAPI patients had 8% to 10% lower cancer-specific mortality than NHW patients in the baseline model, and adjustment for covariables had little additional effect on this survival advantage in men (HR, 0.88; 95% CI, 0.84 to 0.92) or women (HR, 0.90; 95% CI, 0.86 to 0.94). Of the AAPI subgroups, Chinese men had the lowest cancer-specific mortality (HR, 0.80; 95% CI, 0.74 to 0.87). Stage at diagnosis explained 16% of overall survival disparities across all racial/ethnic groups in men and 28% in women (Table 3). Marital status had a slightly stronger influence on overall survival disparities in men, explaining 16% of disparities compared with 13% in women. Smaller contributions were made by differences in neighborhood SES (5% to 6%), surgery (5%), and tumor subsite (5% to 9%). In total, adjustment for all covariables explained 52% to 55% of overall disparities in colorectal cancer survival across all racial/ethnic groups.

HRs from baseline models estimated by using competing risks regression as an alternative to Cox regression differed by less than

Table 2. Distribution of Key Demographic and Clinical Characteristics of Patients With Cancer by Race/Ethnicity and Cancer Site: California, 2000 to 2013

Variable	% Distribution by Cancer Type															
	Breast Cancer (n = 264,681)				Prostate Cancer (n = 270,101)				Lung Cancer* (n = 94,297 men; n = 86,763 women)				CRC* (n = 83,444 men; n = 78,376 women)			
	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI
Age at diagnosis, years																
15-44	9.6	15.8	22.0	18.8	0.4	1.3	0.8	0.3	1.4	2.7	4.2	3.4	4.4	6.1	11.0	7.3
45-54	21.3	26.6	28.6	29.1	8.4	15.1	9.7	6.2	7.4	14.7	10.3	10.1	12.8	18.7	19.0	17.0
55-64	25.7	25.2	23.0	25.1	31.5	37.5	29.6	26.2	20.6	28.3	20.1	20.6	20.0	25.9	23.6	22.3
65-74	22.1	18.0	16.0	16.8	37.1	32.6	38.5	41.9	32.2	30.2	31.5	29.5	24.3	24.6	23.0	25.1
≥ 75	21.3	14.4	10.4	10.2	22.6	13.5	21.4	25.4	38.4	24.1	33.9	36.4	38.5	24.7	23.4	28.3
Stage at diagnosis																
Local	63.7	53.9	54.8	62.4	78.9	76.7	75.1	77.9	15.4	12.3	12.7	13.0	39.3	36.0	37.3	38.1
Regional	30.3	36.4	38.2	32.2	13.1	12.7	13.2	12.5	20.5	20.6	18.1	18.5	36.4	34.0	36.9	38.5
Distant	4.5	7.8	5.4	4.1	4.6	6.4	5.8	5.3	56.8	61.7	62.4	63.1	19.9	25.3	21.5	19.2
Unknown	1.5	1.9	1.6	1.3	3.4	4.2	5.9	4.3	7.3	5.4	6.8	5.4	4.4	4.7	4.3	4.2
Marital status																
Married	55.6	34.7	56.0	66.2	69.7	53.5	66.4	77.1	49.5	32.6	51.8	65.9	53.5	38.5	55.4	65.0
Unmarried†	41.4	61.2	39.8	30.7	22.2	36.9	21.0	13.7	47.9	63.3	45.1	31.5	43.1	56.6	39.9	31.3
Unknown	3.0	4.1	4.2	3.1	8.1	9.6	12.6	9.2	2.6	4.1	3.1	2.6	3.4	4.9	4.7	3.7
Health insurance status																
None	0.7	1.5	1.9	1.3	0.9	2.1	2.2	1.3	1.5	3.4	3.6	2.5	1.3	2.8	4.1	2.7
Private only	59.8	54.3	51.0	63.0	51.3	50.7	45.0	45.9	37.6	32.8	32.4	34.7	47.0	44.2	43.7	45.4
Medicare‡	26.6	17.5	12.1	11.6	35.1	22.1	24.8	26.1	39.0	24.3	25.8	23.5	36.3	24.5	20.6	20.0
Other public§	9.5	23.9	31.4	21.2	8.4	21.8	20.9	23.2	15.8	34.9	32.6	35.4	12.8	26.1	28.1	29.4
Unknown	3.4	2.8	3.6	2.9	4.3	3.3	7.1	3.5	6.1	4.6	5.6	3.9	2.6	2.4	3.5	2.5
Neighborhood SES																
5 (high)	31.4	9.5	10.4	30.5	33.8	11.8	10.5	29.7	20.5	6.5	8.4	21.7	25.9	8.9	8.5	24.5
4	25.8	17.2	15.6	26.1	25.1	18.2	15.2	24.6	22.9	12.3	13.7	22.7	24.5	15.9	14.6	24.1
3	20.8	21.4	20.1	19.9	20.1	21.1	20.5	20.3	23.4	19.2	20.1	21.4	22.3	20.2	19.7	21.1
2	14.8	25.1	24.6	15.3	14.1	23.7	24.2	15.9	20.5	26.3	25.5	19.9	17.6	25.0	25.8	17.9
1 (low)	7.2	26.8	29.3	8.2	6.9	25.2	29.6	9.5	12.7	35.7	32.3	14.3	9.7	30.0	31.4	12.4
HR status¶ (breast)																
Positive	75.8	63.0	69.8	74.1												
Histology (lung)																
Small cell									13.9	11.3	12.5	7.7				
Squamous									16.7	18.5	15.9	12.9				
Adeno									35.6	37.5	39.4	51.4				
Large cell									2.5	2.7	2.5	2.5				
Non-small cell									24.4	25.1	23.5	21.1				
Unspecified									6.9	4.9	6.2	4.4				
Tumor subsite (CRC)																
Proximal colon													43.7	47.6	36.8	31.6
Distal colon													23.7	24.0	26.1	31.1
Rectum													28.8	24.3	33.6	34.6
Other													3.8	4.1	3.5	2.7

NOTE. See Appendix Table A1 (online only) for the distribution of covariables not included in Table 2. Abbreviations: AAPI, Asian American and Pacific Islander; CRC, colorectal carcinoma; HR, hormone receptor; NHW; non-Hispanic white; SES, socioeconomic status. *The distribution of key covariables was similar for men and women with lung and colorectal cancer, so percentages reported are for both sexes combined. †Unmarried included never married, separated, divorced, and widowed. ‡Medicare only or Medicare plus private insurance. §Any other public, military, or any Medicaid/Medi-Cal insurance. ¶Estrogen/progesterone receptor status.

1% for Hispanics and blacks for each of the cancer sites examined. They differed by less than 2% for AAPI patients for each of the cancer sites examined.

DISCUSSION

In a diverse, contemporary, population-based sample of 877,662 patients with cancer, we found continued disparities in survival for breast, prostate, lung, and colorectal cancer across racial/ethnic groups. By using mediation analysis as a novel approach to quantify

the contribution of patient and tumor characteristics to racial/ethnic survival disparities, we found that stage at diagnosis, neighborhood SES, and marital status were the most influential factors.

The substantial influence of stage at diagnosis on racial/ethnic survival disparities likely results from differences in both stage distribution and stage-specific survival across racial/ethnic groups. Black patients with breast, prostate, and colorectal cancer were all more likely than NHW patients to be diagnosed with late-stage tumors, and, among those with late-stage tumors, survival was lower (data not shown). The contribution of stage at diagnosis, therefore, is multifaceted. For the most part, stage can be seen as

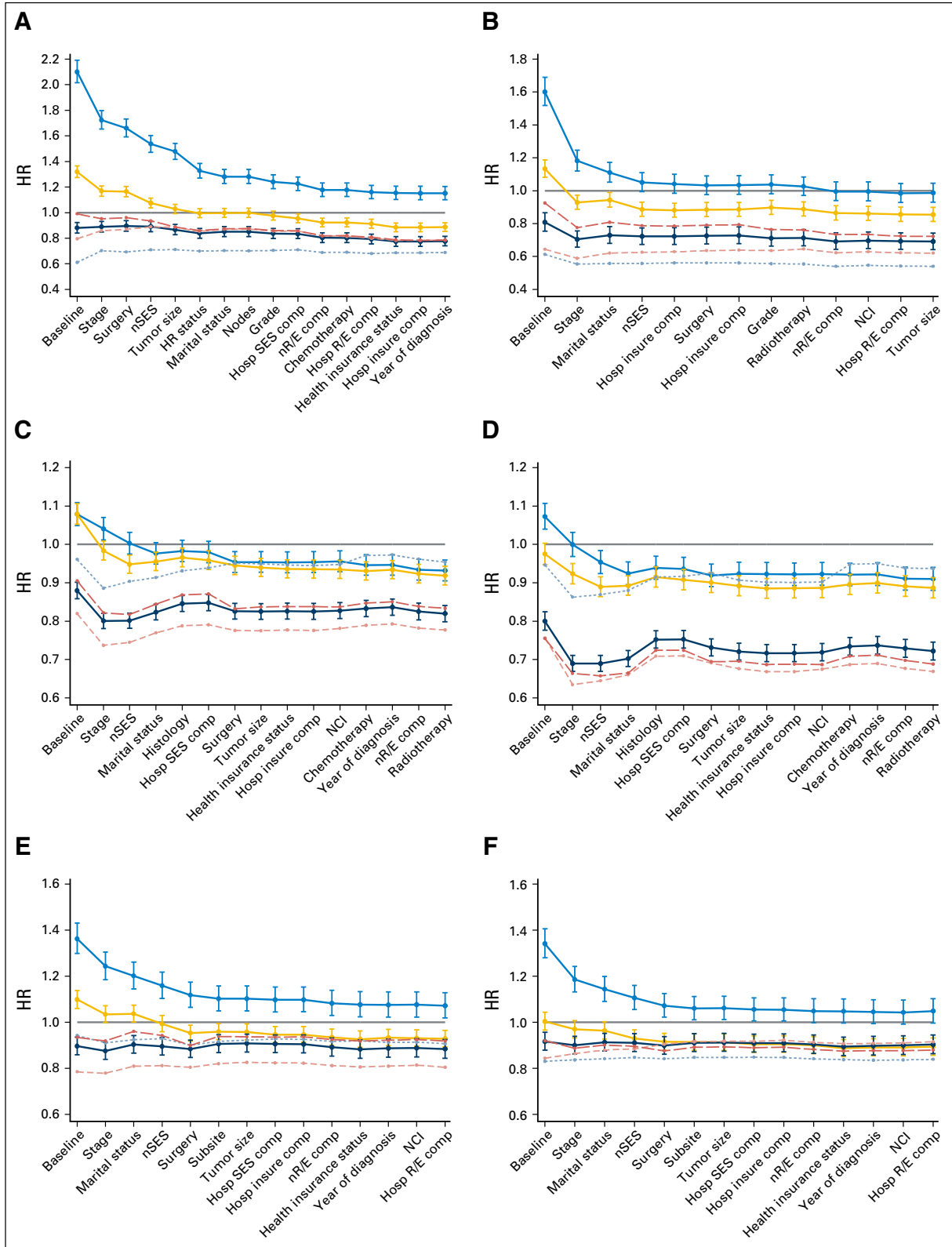


Fig 1. Change in hazard ratios (HRs) with addition of covariables into multivariable models for each racial/ethnic group, by cancer site and sex: (A) breast cancer, (B) prostate cancer, (C) men with lung cancer, (D) woman with lung cancer, (E) men with colorectal cancer, and (F) women with colorectal cancer. Solid gray line, non-Hispanic white (reference); blue line with 95% CIs, non-Hispanic black; yellow line with 95% CIs, Hispanic; dark blue line with 95% CIs, Asian American and Pacific Islander; light red dashed line, Chinese; light gray dotted line, Japanese; red long-dashed line, Filipino. Comp, composition; Hosp insure, hospital insurance composition; Hosp R/E, hospital racial/ethnic composition; Hosp SES, hospital SES composition; HR, hormone receptor; NCI, National Cancer Institute cancer center; nR/E, neighborhood racial/ethnic composition; nSES, neighborhood socioeconomic status.

Table 3. Percentage Contribution of Covariables to Overall Disparities in Survival Across All Racial/Ethnic Groups by Cancer Site and Sex: California, 2000 to 2013

Order	Breast cancer				Prostate cancer				Lung cancer				Colorectal cancer			
	Covariable	Cumulative % Change	% Change	Covariable	Cumulative % Change	% Change	Covariable	Cumulative % Change	% Change	Covariable	Cumulative % Change	% Change	Covariable	Cumulative % Change	% Change	
																Men
1	Stage	23.6	23.6	Stage	24.3	24.3	Stage	-17.3	-17.3	-30.6	-30.6	Stage	16.2	16.2	28.2	
2	Surgery	28.7	5.1	Mar stat	38.0	13.8	nSES	0.7	18.0	16.6	Mar stat	31.9	15.7	41.0	12.8	
3	nSES	36.3	7.6	nSES	45.2	7.1	Mar stat	21.3	20.6	0.1	14.0	nSES	38.0	6.1	46.4	
4	T size	37.4	1.1	Hosp SES comp	46.6	1.4	Histology	30.3	9.0	18.9	Surgery	42.8	4.9	51.2	4.8	
5	HR stat	46.6	9.2	Surgery	48.5	1.9	Hosp SES comp	33.8	3.5	21.1	2.1	Subsite	51.9	9.1	56.5	5.3
6	Mar stat	52.5	5.9	Hosp ins comp	48.6	0.1	Surgery	31.5	-2.2	15.4	-5.7	T size	52.3	0.4	56.1	-0.4
7	Nodes	52.6	0.2	Grade	44.5	-4.1	T size	32.3	0.7	10.1	-5.3	Hosp SES comp	52.0	-0.3	56.1	0.0
8	Grade	54.4	1.7	Radio	46.4	1.9	Hlth insure	33.7	1.5	9.2	-0.9	Hosp ins comp	51.6	-0.4	56.2	0.1
9	Hosp SES comp	55.3	0.9	nR/E comp	46.4	0.1	Hosp ins comp	33.3	-0.5	9.5	0.4	nR/E comp	51.6	0.0	56.2	0.0
10	nR/E comp	55.5	0.2	NCI	47.7	1.2	NCI	34.0	0.7	10.4	0.9	Hlth insure	50.5	-1.1	52.9	-3.2
11	Chemotherapy	55.4	-0.1	Hosp R/E comp	48.2	0.5	Chemotherapy	41.2	7.2	17.4	7.0	Year diag	52.2	1.7	54.8	1.9
12	Hosp R/E comp	55.8	0.4	T size	47.6	-0.6	Year diag	42.4	1.2	18.0	0.6	NCI	52.2	0.0	55.8	0.9
13	Hlth Insure	53.3	-2.5	nR/E comp	41.8	-0.6	nR/E comp	41.8	-0.6	18.0	-0.1	Hosp R/E comp	51.9	-0.3	55.4	-0.3
14	Hosp ins comp	53.5	0.2	Year diag	54.0	0.5	Radio	40.2	-1.6	15.3	-2.7					
15	Year diag	54.0	0.5													
Total contribution, %		54.0			47.6			40.2		15.3		51.9			55.4	

NOTE: Covariables were added to the multivariable model in the order stated. If a given covariable did not influence the relationship between race/ethnicity and survival in the base model, it was not included in the multivariable model. The percent change in overall disparity attributable to a given covariable was adjusted for covariables added earlier in the sequence. A negative percent change indicates an increase in overall disparities across all racial/ethnic groups when the covariable is added to the model. The final cumulative percent change indicates the total proportion of overall survival disparities across all racial/ethnic groups explained by all covariables. The change in hazard ratio with the addition of each covariable to the model, for each racial/ethnic group (relative to NHW patients), is shown in Figure 1 and in Appendix Tables A2 and A3 (online only). Abbreviations: Hlth insure, health insurance status; Hosp R/E comp, hospital racial/ethnic composition; Hosp SES comp, hospital socioeconomic status composition; HR stat, hormone-receptor status; Hosp ins comp, hospital health insurance composition; Mar stat, marital status; NCI, National Cancer Institute cancer center; nR/E comp, neighborhood racial/ethnic composition; nSES, neighborhood socioeconomic status; Radio, radiotherapy; T size, tumor size; Year diag, year of diagnosis.

a modifiable risk factor for cancer prognosis, particularly given that established early-detection modalities exist for most of the sites evaluated in this study. However, differences in stage-specific survival suggest that access to recommended treatment, especially for late-stage tumors, also may influence racial/ethnic survival disparities.

Interestingly, the contribution of stage to survival disparities in colorectal cancer was considerably larger in women than in men, and this finding is consistent with previous findings.²⁸ The influence of stage on survival disparities for lung cancer also was greatest in women, but the direction of the effect was different. AAPI patients had a substantial survival advantage, as has been reported previously,^{29,30} especially for late-stage cancers,³¹ and adjustment for this increased the overall disparity across all racial/ethnic groups. Stage at diagnosis, therefore, does not explain the racial/ethnic survival disparities in lung cancer reported here.

Hormone receptor status was the second largest contributor to overall racial/ethnic survival disparities for breast cancer, which adds to the evidence base that tumor characteristics at diagnosis are significant mediators of survival disparities, especially among black women.³² Racial/ethnic disparities in breast cancer survival vary considerably according to tumor subtype, however, and are likely to be explained by intrinsic biologic differences in tumors (eg, lymph node involvement, distant metastasis, and triple-negative tumors) rather than simply by earlier detection.^{33,34}

Tumor histology was an important contributing factor to racial/ethnic survival disparities in lung cancer, especially in women, and may reflect a differential distribution of tumor subtypes across racial/ethnic groups. AAPI women had a higher proportion of adenocarcinomas, which have a more favorable prognosis, and a lower proportion of small-cell tumors, for which prognosis is poor. The distribution of tumor subtypes in men did not differ across racial/ethnic groups to the same extent. Only a small percentage of overall racial/ethnic disparities in colorectal cancer survival was explained by anatomic location; black patients had a notably higher proportion of proximal tumors, which are associated with poorer survival than tumors in the distal colon or rectum.³⁵ The receipt of surgery, radiation, or chemotherapy had little additional effect on survival disparities, because these high-level treatment variables are likely to be highly correlated with stage at diagnosis.

Marital status had one of the biggest effects on racial/ethnic survival disparities, and, consistent with the literature, this was most notable among men.^{11,21} The survival benefit associated with being married often is attributed to increased social support; higher psychological well-being; and instrumental support, such as help in navigation of the health care system.^{36,37} Interestingly, health insurance status was not a significant contributor of racial/ethnic survival disparities, despite evidence that black-white disparities differ by type of health insurance.¹⁰

In this study, neighborhood SES was an important explanatory factor, but its effect was limited exclusively to disparities in survival for black and Hispanic patients relative to NHW patients. AAPI patients have a neighborhood socioeconomic profile similar to NHW patients, and the survival advantage experienced by this group is unlikely to be explained by factors related to SES and more likely to be related to underlying genetic and biologic differences.²⁹ The characteristics of a patient's neighborhood has the potential to

affect cancer survival disparities through a number of mechanisms, including its influence on behavioral risk factors, social support, and access to health care.^{9,38}

Conversely, neighborhood racial/ethnic composition had only negligible effects on racial/ethnic survival disparities. Prior research has shown that residence in ethnic-concordant neighborhoods may confer protective survival effects,³⁹⁻⁴² although other studies found opposite effects of residence in high-minority neighborhoods.⁴³⁻⁴⁵

The influence of hospital characteristics on racial/ethnic survival disparities also was negligible after analysis had been adjusted for individual tumor and sociodemographic factors. Hospital characteristics often contributed less than 1% toward overall racial/ethnic survival disparities, and this finding is consistent with previous findings.⁸

After adjustment for a wide variety of patient and tumor characteristics, a large proportion of the overall racial/ethnic survival disparities remained unexplained. The survival advantage experienced by AAPI patients in particular was largely unaffected by the factors investigated. This suggests that we lacked potentially important genetic and tumor information, such as molecular markers known to be prognostic and/or used to determine treatment (eg, *EGFR* for lung cancer or *KRAS* for colorectal cancer). We also lacked detailed clinical information about treatment, as well as information about recurrence or disease progression. This study also may be affected by limitations inherent to cancer registry data, such as misclassification of race/ethnicity, although prior research has shown this to be minimal^{46,47} and validated algorithms are used to improve the classification of Hispanic ethnicity and AAPI race/ethnicity.^{48,49} Despite these limitations, we were able to leverage a large, population-based data set to quantify the relative contribution of multilevel factors—clinical, patient, hospital, and neighborhood—to racial/ethnic disparities in cancer survival and to demonstrate the importance of modifiable factors and targets for intervention to reduce survival disparities.

In conclusion, stage at diagnosis had the largest effect on racial/ethnic disparities in survival for breast, prostate, and colorectal cancers. Stage is itself influenced by a myriad of factors, which include socioeconomic status, health insurance, uptake of screening, and access to health care. Although earlier detection alone will not entirely eliminate these disparities, strategies to address the low uptake of cancer screening among black and Hispanic populations could make an important contribution. The effect of differences in care after diagnosis was limited, but a more nuanced investigation into the contribution of treatment differences across racial/ethnic groups, with more detailed information than was available in this study, is required. The considerable influence of neighborhood SES and marital status on racial/ethnic disparities in survival, even after analysis is controlled for stage at diagnosis, suggests that social determinants, support mechanisms, and access to health care cannot be overlooked. SES and marital status are not themselves modifiable, but more equitable access to care for underserved groups could substantially reduce racial/ethnic disparities in cancer outcomes. In clinical settings, ensuring that these social determinants are assessed, and that barriers to care for vulnerable populations are addressed, may go a long way toward the reduction of cancer survival disparities.^{21,36,50,51}

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Disclosures provided by the authors are available with this article at jco.org.

AUTHOR CONTRIBUTIONS

Conception and design: Libby Ellis, David Spiegel, Uri Ladabaum, Robert Haile, Scarlett Lin Gomez

Collection and assembly of data: Libby Ellis, Alison J. Canchola, Scarlett Lin Gomez

Financial support: Scarlett Lin Gomez

Administrative support: Scarlett Lin Gomez

Provision of study materials or patients: Scarlett Lin Gomez

Data analysis and interpretation: Libby Ellis, Alison J. Canchola, Scarlett Lin Gomez

Manuscript writing: All authors

Final approval of manuscript: All authors

Accountable for all aspects of the work: All authors

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Affiliations

Libby Ellis, Alison J. Canchola, and Scarlett Lin Gomez, Cancer Prevention Institute of California, Fremont; Libby Ellis, David Spiegel, and Uri Ladabaum, Stanford Cancer Institute; David Spiegel, Uri Ladabaum, and Robert Haile, Stanford University School of Medicine, Stanford; Robert Haile, Cedars-Sinai Medical Center, Los Angeles; and Scarlett Lin Gomez, University of California, San Francisco, San Francisco, CA.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Racial and Ethnic Disparities in Cancer Survival: The Contribution of Tumor, Sociodemographic, Institutional, and Neighborhood Characteristics

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Libby Ellis

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Alison J. Canchola

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David Spiegel

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Appendix

Table A1. Distribution of Additional Demographic and Clinical Characteristics of Patients With Cancer by Race/Ethnicity and Cancer Site: California, 2000 to 2013

Covariable	Distribution (%) by Cancer Type															
	Breast Cancer (n = 264,681)			Prostate Cancer (n = 270,101)			Lung Cancer (n = 94,297 men; n = 86,763 women)			Colorectal Cancer (n = 83,444 men; n = 78,376 women)						
	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI	NHW	Black	Hispanic	AAPI
Tumor size, cm																
< 1	18.3	12.0	12.8	16.2	3.8	3.6	4.0	3.8	1.0	0.9	0.9	0.8	3.3	3.8	3.8	4.3
1-4	64.9	62.8	65.0	65.4	12.0	11.0	11.0	10.2	38.1	35.5	33.2	38.2	34.3	29.7	30.0	36.2
> 4	9.9	16.2	14.2	11.6	0.6	0.6	0.5	0.5	30.2	34.1	32.2	31.4	37.9	39.2	40.0	34.0
Unknown	6.9	9.0	8.0	6.8	83.6	84.8	84.5	85.5	30.7	29.5	33.7	29.6	24.5	27.3	26.2	25.5
Grade																
Well differentiated	23.6	13.7	16.0	17.2	1.5	1.4	1.8	1.6	4.5	3.1	4.7	5.4	9.2	8.7	9.6	8.0
Moderately well differentiated	40.0	32.9	37.1	39.5	51.8	48.4	49.3	46.1	12.9	12.9	13.0	15.5	57.8	58.7	58.5	60.3
Poorly differentiated/undifferentiated	28.2	44.8	39.0	35.6	41.4	44.4	43.0	46.4	28.2	29.4	28.3	25.2	17.8	14.6	15.9	16.5
Not stated	8.2	8.6	7.9	7.7	5.3	5.8	5.9	5.9	54.4	54.6	54.0	53.9	15.2	18.0	16.0	15.2
Positive lymph nodes	31.0	39.2	40.0	33.5					46.6	49.8	48.1	48.0	23.0	22.2	21.9	23.9
Treatment																
Surgery	93.3	88.6	92.2	93.9	42.0	36.5	40.6	37.4	20.4	16.2	17.5	19.8	85.3	80.8	83.9	86.2
Radiation	48.7	43.0	44.4	43.9	33.4	32.4	30.3	35.5	32.5	34.8	30.8	32.5	12.2	10.0	15.0	14.0
Chemotherapy	36.0	47.6	49.8	45.4					37.1	39.9	38.9	44.5	32.4	33.5	39.0	37.0
NCI cancer center	5.1	4.6	4.8	7.4	11.6	7.7	6.3	10.4	4.7	6.6	5.2	8.7	4.6	4.6	4.6	6.8
Hospital racial/ethnic composition*																
Minority predominant	20.9	61.9	51.8	50.9	21.0	55.6	49.0	47.9	23.2	63.0	51.4	58.8	23.7	63.4	54.3	59.9
Mixed	67.6	37.4	45.0	47.6	70.8	43.5	48.3	51.1	65.1	36.0	44.9	40.0	65.0	35.6	42.8	38.7
White predominant	11.5	1.0	3.2	1.5	8.2	0.9	2.7	1.0	11.7	1.0	3.7	1.2	11.3	1.0	2.9	1.4
Hospital health insurance composition†																
Public predominant	8.6	15.4	22.5	12.0	10.7	21.1	17.1	10.5	15.7	25.3	23.1	15.5	13.0	19.7	23.8	15.3
Mixed	43.7	38.2	41.3	42.7	39.5	32.6	39.1	40.8	44.8	42.0	45.7	52.7	44.2	40.1	41.1	49.0
Private/Medicare predominant	47.7	46.4	36.2	45.3	49.8	46.3	43.8	48.7	39.5	32.7	31.2	31.8	42.8	40.2	35.1	35.7
Hospital SES composition‡																
Low SES	16.3	26.5	33.1	15.2	12.0	19.1	23.7	10.9	22.7	32.1	34.7	19.8	20.2	29.8	35.4	21.2
Medium SES	28.9	37.8	34.1	30.5	27.3	42.3	33.2	28.3	33.4	28.2	34.8	35.2	31.8	40.1	35.8	34.3
High SES	54.8	35.7	32.8	54.3	60.7	38.6	43.1	60.8	43.9	29.7	30.5	45.0	48.0	30.1	28.8	44.5
Neighborhood racial/ethnic composition§																
Minority predominant	29.5	84.0	76.0	69.3	27.8	80.6	75.9	71.1	36.2	86.8	76.0	77.3	33.6	84.1	78.0	74.8
Mixed	43.9	13.7	17.8	26.3	43.2	16.0	17.6	25.0	38.4	11.2	17.2	19.4	41.1	13.6	16.4	21.7
White predominant	26.6	2.3	6.2	4.4	29.0	3.4	6.5	3.9	25.4	2.0	6.8	3.3	25.3	2.3	5.6	3.5

* Institutional factors are based on the distribution of characteristics of patients with cancer who attended the hospital between 2000 and 2013. The categories of hospital racial/ethnic composition were defined by the median values of the distribution of race/ethnicity during the time period.

† The categories of hospital health insurance composition were defined by the median values of the distribution of insurance status during the time period.

‡ The categories of hospital SES composition were defined as high SES (≥ 50% patients in SES quintiles 5 and 4 and < 50% patients in SES quintiles 1 and 2); low SES (< 50% patients in SES quintiles 5 and 4 and ≥ 50% patients in SES quintiles 1 and 2); and mixed: equal distribution of SES.

§ The categories of neighborhood racial/ethnic composition were defined by the median values of the state-wide distribution of race/ethnicity during the time period.

Racial and Ethnic Disparities in Cancer Survival

Table A2. HRs With Addition of Covariables Into Multivariable Models, by Cancer Site, Sex, and Racial/Ethnic Group

Order by Cancer Type	Covariable	NH Black		Hispanic		AAPI	
		HR	95% CI	HR	95% CI	HR	95% CI
Breast cancer							
Baseline		2.10	2.02 to 2.19	1.32	1.27 to 1.36	0.88	0.84 to 0.92
1	Stage at diagnosis	1.72	1.65 to 1.80	1.17	1.13 to 1.21	0.89	0.85 to 0.93
2	Surgery	1.66	1.59 to 1.73	1.16	1.12 to 1.20	0.90	0.85 to 0.94
3	nSES	1.54	1.47 to 1.60	1.07	1.04 to 1.11	0.89	0.85 to 0.93
4	Tumor size	1.48	1.42 to 1.54	1.03	0.99 to 1.07	0.87	0.83 to 0.91
5	HR status	1.33	1.27 to 1.38	1.00	0.96 to 1.03	0.84	0.80 to 0.88
6	Marital status	1.28	1.23 to 1.34	1.00	0.96 to 1.03	0.85	0.81 to 0.89
7	Lymph nodes	1.28	1.23 to 1.34	1.00	0.96 to 1.04	0.85	0.81 to 0.89
8	Grade	1.24	1.19 to 1.29	0.98	0.94 to 1.01	0.84	0.80 to 0.88
9	SES composition	1.23	1.17 to 1.28	0.96	0.92 to 0.99	0.83	0.80 to 0.87
10	nR/E composition	1.18	1.13 to 1.23	0.92	0.89 to 0.96	0.80	0.77 to 0.84
11	Chemotherapy	1.18	1.13 to 1.23	0.92	0.89 to 0.96	0.80	0.77 to 0.84
12	R/E composition	1.16	1.11 to 1.21	0.91	0.88 to 0.95	0.79	0.76 to 0.83
13	Health insurance status	1.15	1.10 to 1.21	0.88	0.85 to 0.92	0.77	0.74 to 0.81
14	Insurance composition	1.15	1.10 to 1.21	0.88	0.85 to 0.92	0.77	0.74 to 0.81
15	Year of diagnosis	1.15	1.10 to 1.20	0.89	0.85 to 0.92	0.78	0.74 to 0.82
Prostate cancer							
Baseline		1.60	1.52 to 1.69	1.13	1.08 to 1.19	0.81	0.75 to 0.87
1	Stage at diagnosis	1.18	1.12 to 1.25	0.93	0.89 to 0.97	0.70	0.66 to 0.76
2	Marital status	1.11	1.05 to 1.17	0.94	0.90 to 0.99	0.73	0.68 to 0.78
3	nSES	1.05	0.99 to 1.11	0.89	0.85 to 0.93	0.72	0.67 to 0.77
4	SES composition	1.04	0.99 to 1.10	0.88	0.84 to 0.92	0.72	0.67 to 0.77
5	Surgery	1.03	0.98 to 1.09	0.88	0.84 to 0.93	0.73	0.68 to 0.78
6	Insurance composition	1.03	0.98 to 1.09	0.89	0.84 to 0.93	0.73	0.68 to 0.78
7	Grade	1.04	0.98 to 1.10	0.90	0.86 to 0.94	0.71	0.66 to 0.76
8	Radiation	1.03	0.97 to 1.08	0.89	0.85 to 0.93	0.71	0.66 to 0.76
9	nR/E composition	1.00	0.94 to 1.05	0.86	0.82 to 0.91	0.69	0.64 to 0.74
10	NCI cancer center	1.00	0.94 to 1.05	0.86	0.82 to 0.91	0.70	0.65 to 0.75
11	R/E composition	0.98	0.93 to 1.04	0.86	0.81 to 0.90	0.69	0.64 to 0.74
12	Tumor size	0.99	0.93 to 1.05	0.86	0.81 to 0.90	0.69	0.64 to 0.74
Men with lung cancer							
Baseline		1.08	1.05 to 1.11	1.08	1.05 to 1.11	0.88	0.86 to 0.90
1	Stage at diagnosis	1.04	1.01 to 1.07	0.98	0.96 to 1.01	0.80	0.78 to 0.82
2	nSES	1.00	0.97 to 1.03	0.95	0.92 to 0.97	0.80	0.78 to 0.82
3	Marital status	0.98	0.95 to 1.00	0.96	0.93 to 0.98	0.82	0.80 to 0.84
4	Histology	0.98	0.96 to 1.01	0.97	0.94 to 0.99	0.85	0.82 to 0.87
5	SES composition	0.98	0.95 to 1.01	0.96	0.93 to 0.98	0.85	0.83 to 0.87
6	Surgery	0.95	0.93 to 0.98	0.94	0.92 to 0.97	0.83	0.81 to 0.85
7	Tumor size	0.95	0.93 to 0.98	0.94	0.92 to 0.96	0.82	0.80 to 0.85
8	Health insurance status	0.95	0.93 to 0.98	0.94	0.91 to 0.96	0.83	0.81 to 0.85
9	Insurance composition	0.95	0.93 to 0.98	0.94	0.91 to 0.96	0.82	0.80 to 0.85
10	NCI cancer center	0.96	0.93 to 0.98	0.93	0.91 to 0.96	0.83	0.81 to 0.85
11	Chemotherapy	0.95	0.92 to 0.97	0.93	0.91 to 0.95	0.83	0.81 to 0.85
12	Year of diagnosis	0.95	0.92 to 0.97	0.93	0.91 to 0.96	0.84	0.82 to 0.86
13	nR/E composition	0.93	0.91 to 0.96	0.92	0.90 to 0.95	0.82	0.80 to 0.85
14	Radiation	0.93	0.90 to 0.96	0.92	0.89 to 0.94	0.82	0.80 to 0.84
Women with lung cancer							
Baseline		1.07	1.04 to 1.11	0.97	0.95 to 1.00	0.80	0.78 to 0.82
1	Stage at diagnosis	1.00	0.97 to 1.03	0.92	0.90 to 0.95	0.69	0.67 to 0.71
2	nSES	0.95	0.92 to 0.98	0.89	0.86 to 0.92	0.69	0.67 to 0.71
3	Marital status	0.92	0.90 to 0.95	0.89	0.87 to 0.92	0.70	0.68 to 0.72
4	Histology	0.94	0.91 to 0.97	0.91	0.89 to 0.94	0.75	0.73 to 0.78
5	SES composition	0.94	0.91 to 0.97	0.91	0.88 to 0.93	0.75	0.73 to 0.78
6	Surgery	0.92	0.89 to 0.95	0.90	0.87 to 0.93	0.73	0.71 to 0.75
7	Tumor size	0.92	0.89 to 0.95	0.89	0.87 to 0.92	0.72	0.70 to 0.74
8	Health insurance status	0.92	0.89 to 0.95	0.89	0.86 to 0.91	0.72	0.69 to 0.74
9	Insurance composition	0.92	0.89 to 0.95	0.89	0.86 to 0.91	0.72	0.69 to 0.74
10	NCI cancer center	0.92	0.89 to 0.95	0.89	0.86 to 0.91	0.72	0.70 to 0.74
11	Chemotherapy	0.92	0.89 to 0.95	0.90	0.87 to 0.92	0.73	0.71 to 0.76
12	Year of diagnosis	0.92	0.89 to 0.95	0.90	0.87 to 0.93	0.74	0.71 to 0.76
13	nR/E composition	0.91	0.88 to 0.94	0.89	0.86 to 0.92	0.73	0.71 to 0.75
14	Radiation	0.91	0.88 to 0.94	0.89	0.86 to 0.91	0.72	0.70 to 0.75

(continued on following page)

Table A2. HRs With Addition of Covariables Into Multivariable Models, by Cancer Site, Sex, and Racial/Ethnic Group (continued)

Order by Cancer Type	Covariable	NH Black		Hispanic		AAPI	
		HR	95% CI	HR	95% CI	HR	95% CI
Men with colorectal cancer							
Baseline		1.36	1.30 to 1.43	1.10	1.06 to 1.14	0.90	0.86 to 0.94
1	Stage at diagnosis	1.24	1.18 to 1.30	1.03	1.00 to 1.07	0.88	0.84 to 0.91
2	Marital status	1.20	1.14 to 1.26	1.04	1.00 to 1.07	0.90	0.87 to 0.94
3	nSES	1.16	1.10 to 1.22	0.99	0.96 to 1.03	0.90	0.86 to 0.93
4	Surgery	1.12	1.06 to 1.17	0.95	0.92 to 0.99	0.88	0.85 to 0.92
5	Subsite	1.10	1.05 to 1.16	0.96	0.93 to 0.99	0.91	0.87 to 0.95
6	Tumor size	1.10	1.05 to 1.16	0.96	0.92 to 0.99	0.91	0.87 to 0.95
7	SES composition	1.10	1.04 to 1.15	0.95	0.91 to 0.98	0.91	0.87 to 0.95
8	Insurance composition	1.10	1.05 to 1.15	0.95	0.91 to 0.98	0.90	0.87 to 0.94
9	nR/E composition	1.08	1.03 to 1.14	0.93	0.90 to 0.97	0.89	0.85 to 0.93
10	Health insurance status	1.08	1.02 to 1.13	0.93	0.89 to 0.96	0.88	0.84 to 0.92
11	Year of diagnosis	1.08	1.02 to 1.13	0.93	0.90 to 0.97	0.89	0.85 to 0.93
12	NCI cancer center	1.08	1.02 to 1.13	0.93	0.90 to 0.97	0.89	0.85 to 0.93
13	R/E composition	1.07	1.02 to 1.13	0.93	0.89 to 0.96	0.88	0.84 to 0.92
Women with colorectal cancer							
Baseline		1.34	1.28 to 1.41	1.00	0.97 to 1.04	0.92	0.88 to 0.96
1	Stage at diagnosis	1.19	1.13 to 1.24	0.97	0.93 to 1.01	0.90	0.86 to 0.94
2	Marital status	1.14	1.09 to 1.20	0.96	0.93 to 1.00	0.91	0.87 to 0.95
3	nSES	1.11	1.05 to 1.16	0.93	0.89 to 0.97	0.91	0.87 to 0.95
4	Surgery	1.07	1.02 to 1.12	0.91	0.88 to 0.95	0.90	0.86 to 0.94
5	Subsite	1.06	1.01 to 1.11	0.91	0.88 to 0.95	0.91	0.87 to 0.95
6	Tumor size	1.06	1.01 to 1.11	0.91	0.88 to 0.95	0.91	0.87 to 0.95
7	SES composition	1.05	1.01 to 1.11	0.90	0.87 to 0.94	0.91	0.87 to 0.95
8	Insurance composition	1.05	1.01 to 1.11	0.90	0.87 to 0.94	0.91	0.87 to 0.95
9	nR/E composition	1.05	1.00 to 1.10	0.90	0.86 to 0.94	0.90	0.86 to 0.94
10	Health insurance status	1.05	1.00 to 1.10	0.89	0.85 to 0.92	0.89	0.85 to 0.94
11	Year of diagnosis	1.04	0.99 to 1.10	0.89	0.85 to 0.93	0.90	0.86 to 0.94
12	NCI cancer center	1.04	0.99 to 1.10	0.89	0.85 to 0.93	0.90	0.86 to 0.94
13	R/E composition	1.05	1.00 to 1.10	0.89	0.86 to 0.93	0.90	0.86 to 0.94

NOTE. Reference category: NHW patients.

Abbreviations: AAPI, Asian American and Pacific Islander; HR, hazard ratio; NCI, National Cancer Institute; NHW, non-Hispanic white; nR/E, neighborhood racial/ethnic composition; nSES, neighborhood socioeconomic status; R/E, racial/ethnic; SES, socioeconomic status.

Racial and Ethnic Disparities in Cancer Survival

Table A3. HRs With Addition of Covariables Into Multivariable Models, by Cancer Site, Sex, and AAPI Subgroup

Order	Covariable	Chinese		Japanese		Filipino	
		HR	95% CI	HR	95% CI	HR	95% CI
Breast cancer							
Baseline		0.80	0.73 to 0.87	0.61	0.53 to 0.71	0.99	0.92 to 1.07
1	Stage at diagnosis	0.86	0.78 to 0.94	0.70	0.61 to 0.81	0.95	0.88 to 1.03
2	Surgery	0.87	0.79 to 0.95	0.69	0.60 to 0.80	0.96	0.89 to 1.04
3	nSES	0.89	0.81 to 0.97	0.71	0.61 to 0.82	0.94	0.87 to 1.01
4	Tumor size	0.89	0.81 to 0.97	0.71	0.61 to 0.82	0.89	0.82 to 0.96
5	HR status	0.85	0.78 to 0.94	0.70	0.60 to 0.81	0.86	0.80 to 0.93
6	Marital status	0.87	0.79 to 0.95	0.70	0.61 to 0.81	0.87	0.81 to 0.94
7	Lymph nodes	0.87	0.79 to 0.96	0.70	0.61 to 0.81	0.88	0.81 to 0.94
8	Grade	0.86	0.78 to 0.94	0.70	0.61 to 0.82	0.86	0.80 to 0.93
9	SES composition	0.86	0.78 to 0.94	0.71	0.61 to 0.82	0.86	0.80 to 0.92
10	nR/E composition	0.82	0.74 to 0.90	0.69	0.59 to 0.80	0.82	0.76 to 0.88
11	Chemotherapy	0.82	0.74 to 0.90	0.69	0.59 to 0.80	0.82	0.76 to 0.89
12	R/E composition	0.80	0.73 to 0.88	0.68	0.59 to 0.79	0.81	0.75 to 0.87
13	Health insurance status	0.78	0.71 to 0.86	0.69	0.59 to 0.80	0.79	0.73 to 0.85
14	Insurance composition	0.79	0.71 to 0.86	0.69	0.59 to 0.80	0.78	0.72 to 0.85
15	Year of diagnosis	0.79	0.72 to 0.87	0.69	0.59 to 0.80	0.78	0.73 to 0.85
Prostate cancer							
Baseline		0.64	0.56 to 0.74	0.61	0.50 to 0.75	0.92	0.82 to 1.04
1	Stage at diagnosis	0.59	0.51 to 0.67	0.55	0.45 to 0.68	0.78	0.69 to 0.87
2	Marital status	0.62	0.54 to 0.71	0.56	0.46 to 0.68	0.81	0.72 to 0.91
3	nSES	0.63	0.55 to 0.72	0.56	0.46 to 0.68	0.79	0.70 to 0.89
4	SES composition	0.63	0.55 to 0.72	0.56	0.46 to 0.69	0.79	0.70 to 0.88
5	Surgery	0.64	0.55 to 0.73	0.56	0.46 to 0.69	0.79	0.70 to 0.89
6	Insurance composition	0.64	0.56 to 0.73	0.56	0.46 to 0.68	0.79	0.70 to 0.89
7	Grade	0.64	0.56 to 0.73	0.56	0.46 to 0.68	0.76	0.68 to 0.86
8	Radiation	0.65	0.56 to 0.74	0.55	0.45 to 0.68	0.76	0.68 to 0.86
9	nR/E composition	0.62	0.54 to 0.71	0.54	0.44 to 0.66	0.73	0.65 to 0.83
10	NCI cancer center	0.63	0.55 to 0.72	0.55	0.45 to 0.67	0.73	0.65 to 0.83
11	R/E composition	0.62	0.54 to 0.71	0.54	0.44 to 0.66	0.72	0.64 to 0.82
12	Tumor size	0.62	0.54 to 0.71	0.54	0.44 to 0.66	0.72	0.64 to 0.82
Men with lung cancer							
Baseline		0.82	0.79 to 0.85	0.96	0.89 to 1.04	0.91	0.87 to 0.95
1	Stage at diagnosis	0.74	0.71 to 0.77	0.89	0.82 to 0.96	0.82	0.79 to 0.86
2	nSES	0.74	0.71 to 0.78	0.90	0.84 to 0.98	0.82	0.78 to 0.86
3	Marital status	0.77	0.74 to 0.80	0.91	0.85 to 0.99	0.84	0.81 to 0.88
4	Histology	0.79	0.75 to 0.82	0.93	0.86 to 1.01	0.87	0.83 to 0.91
5	SES composition	0.79	0.76 to 0.83	0.94	0.87 to 1.01	0.87	0.83 to 0.91
6	Surgery	0.78	0.74 to 0.81	0.95	0.88 to 1.03	0.83	0.80 to 0.87
7	Tumor size	0.78	0.74 to 0.81	0.95	0.88 to 1.03	0.84	0.80 to 0.88
8	Health insurance status	0.78	0.74 to 0.81	0.95	0.88 to 1.02	0.84	0.80 to 0.88
9	Insurance composition	0.78	0.74 to 0.81	0.94	0.87 to 1.02	0.84	0.80 to 0.88
10	NCI cancer center	0.78	0.75 to 0.82	0.95	0.88 to 1.02	0.84	0.80 to 0.88
11	Chemotherapy	0.79	0.76 to 0.82	0.97	0.90 to 1.05	0.85	0.81 to 0.89
12	Year of diagnosis	0.79	0.76 to 0.83	0.97	0.90 to 1.05	0.85	0.81 to 0.89
13	nR/E composition	0.78	0.75 to 0.82	0.96	0.89 to 1.04	0.84	0.80 to 0.88
14	Radiation	0.78	0.74 to 0.81	0.95	0.88 to 1.03	0.83	0.80 to 0.87
Women with lung cancer							
Baseline		0.76	0.72 to 0.8	0.95	0.88 to 1.02	0.75	0.71 to 0.80
1	Stage at diagnosis	0.63	0.60 to 0.67	0.86	0.80 to 0.93	0.66	0.63 to 0.70
2	nSES	0.64	0.61 to 0.68	0.87	0.81 to 0.94	0.66	0.62 to 0.70
3	Marital status	0.66	0.63 to 0.70	0.88	0.82 to 0.95	0.66	0.63 to 0.71
4	Histology	0.71	0.67 to 0.75	0.91	0.85 to 0.99	0.72	0.68 to 0.77
5	SES composition	0.71	0.67 to 0.75	0.92	0.85 to 0.99	0.72	0.68 to 0.77
6	Surgery	0.69	0.66 to 0.73	0.93	0.86 to 1.00	0.69	0.65 to 0.74
7	Tumor size	0.68	0.64 to 0.71	0.91	0.84 to 0.98	0.70	0.65 to 0.74
8	Health insurance status	0.67	0.63 to 0.70	0.90	0.84 to 0.97	0.69	0.65 to 0.73
9	Insurance composition	0.67	0.63 to 0.70	0.90	0.84 to 0.97	0.69	0.65 to 0.73
10	NCI cancer center	0.68	0.64 to 0.71	0.90	0.84 to 0.97	0.69	0.65 to 0.73
11	Chemotherapy	0.69	0.65 to 0.72	0.95	0.88 to 1.02	0.71	0.67 to 0.75
12	Year of diagnosis	0.69	0.65 to 0.73	0.95	0.88 to 1.02	0.71	0.67 to 0.76
13	nR/E composition	0.68	0.64 to 0.71	0.94	0.87 to 1.01	0.70	0.66 to 0.74
14	Radiation	0.67	0.63 to 0.71	0.94	0.87 to 1.01	0.69	0.65 to 0.73

(continued on following page)

Table A3. HRs With Addition of Covariables Into Multivariable Models, by Cancer Site, Sex, and AAPI Subgroup (continued)

Order	Covariable	Chinese		Japanese		Filipino	
		HR	95% CI	HR	95% CI	HR	95% CI
Men with colorectal cancer							
Baseline		0.78	0.73 to 0.85	0.94	0.85 to 1.05	0.93	0.86 to 1.01
1	Stage at diagnosis	0.78	0.72 to 0.84	0.91	0.82 to 1.01	0.92	0.85 to 1.00
2	Marital status	0.81	0.75 to 0.87	0.92	0.83 to 1.03	0.96	0.88 to 1.04
3	nSES	0.81	0.75 to 0.88	0.93	0.84 to 1.03	0.94	0.87 to 1.02
4	Surgery	0.80	0.74 to 0.87	0.90	0.81 to 1.00	0.90	0.83 to 0.98
5	Subsite	0.82	0.76 to 0.89	0.92	0.83 to 1.02	0.94	0.86 to 1.02
6	Tumor size	0.83	0.76 to 0.89	0.92	0.83 to 1.02	0.94	0.86 to 1.02
7	SES composition	0.82	0.76 to 0.89	0.93	0.83 to 1.03	0.94	0.86 to 1.02
8	Insurance composition	0.82	0.76 to 0.89	0.93	0.83 to 1.03	0.94	0.86 to 1.02
9	nR/E composition	0.81	0.75 to 0.88	0.92	0.83 to 1.02	0.92	0.85 to 1.01
10	Health insurance status	0.81	0.74 to 0.87	0.92	0.83 to 1.02	0.92	0.84 to 1.00
11	Year of diagnosis	0.81	0.75 to 0.88	0.91	0.82 to 1.01	0.92	0.85 to 1.00
12	NCI cancer center	0.81	0.75 to 0.88	0.91	0.82 to 1.02	0.92	0.85 to 1.01
13	R/E composition	0.80	0.74 to 0.87	0.91	0.82 to 1.01	0.92	0.84 to 1.00
Women with colorectal cancer							
Baseline		0.84	0.78 to 0.91	0.83	0.75 to 0.92	0.92	0.85 to 1.00
1	Stage at diagnosis	0.86	0.80 to 0.93	0.84	0.76 to 0.93	0.89	0.82 to 0.96
2	Marital status	0.88	0.82 to 0.95	0.84	0.76 to 0.93	0.90	0.83 to 0.98
3	nSES	0.88	0.82 to 0.95	0.85	0.76 to 0.94	0.90	0.82 to 0.97
4	Surgery	0.90	0.84 to 0.97	0.84	0.76 to 0.93	0.87	0.80 to 0.95
5	Subsite	0.92	0.85 to 0.99	0.85	0.76 to 0.94	0.89	0.82 to 0.97
6	Tumor size	0.92	0.85 to 0.99	0.85	0.76 to 0.94	0.89	0.82 to 0.97
7	SES composition	0.92	0.85 to 0.99	0.85	0.77 to 0.94	0.89	0.82 to 0.97
8	Insurance composition	0.92	0.86 to 0.99	0.85	0.76 to 0.94	0.89	0.82 to 0.97
9	nR/E composition	0.91	0.85 to 0.99	0.84	0.76 to 0.93	0.88	0.81 to 0.96
10	Health insurance status	0.91	0.84 to 0.98	0.84	0.76 to 0.93	0.87	0.80 to 0.95
11	Year of diagnosis	0.91	0.84 to 0.98	0.83	0.75 to 0.93	0.88	0.80 to 0.96
12	NCI cancer center	0.91	0.84 to 0.98	0.84	0.75 to 0.93	0.88	0.75 to 0.93
13	R/E composition	0.92	0.85 to 0.99	0.84	0.76 to 0.93	0.88	0.81 to 0.96

NOTE. Reference category: NHW patients.

Abbreviations: AAPI, Asian American and Pacific Islander; HR, hazard ratio; NCI, National Cancer Institute; NHW, non-Hispanic white; nR/E, neighborhood racial/ethnic composition; nSES, neighborhood socioeconomic status; R/E, racial/ethnic; SES, socioeconomic status.