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Age at Cancer Diagnosis, Amenability to Medical Interventions, and Racial/ethnic Disparities in Cancer Mortality

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Abstract

Purpose—Racial disparities in cancer mortality may be greater for cancers that are amenable to available early detection and treatment (amenability level). We investigated whether these patterns vary by age at cancer diagnosis.

Methods—Using five-year relative survival rates (5Y-RSR), we classified 51 cancer sites into least amenable, partly amenable and mostly amenable cancers (< 40%, 40–69%, 70% 5-YRS, respectively). We examined whether racial disparities in mortality rates (African Americans, Asian/Pacific Islanders, Hispanics, whites), as estimated through Cox regression models, were modified by age at diagnosis and amenability level in 516,939 cancer cases diagnosed in 1995–1999.

Results—As compared with whites, all racial minority groups experienced higher cancer mortality rates in the youngest age group of 20–34 years. African Americans and Hispanics diagnosed with partly and mostly amenable cancers had higher mortality rates relative to whites

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with cancers of the same amenability levels; further, these differences decreased in magnitude or reversed in direction with increasing age. In contrast, the racial differences in mortality were smaller and remained fairly constant across age groups for least amenable cancers. For example, in the youngest (20–34) and oldest (80–99) age groups, the adjusted hazard ratios (HRs) for African Americans vs. whites with least amenable cancers were respectively 1.25 (95% CI: 1.02, 1.54) and 0.90 (95% CI: 0.85, 0.96), while the HRs for African Americans vs. whites with mostly amenable cancers were 3.05 (95% CI: 2.59, 3.59) and 1.08 (95% CI: 0.99, 1.18).

Conclusions—Cancer survival disadvantage for racial minorities is larger in younger age groups for cancers that are more amenable to medical interventions.

Keywords

Age; racial/ethnic Disparities; cancer mortality; medical advances; survival factors

INTRODUCTION

With the exception of Asian and Pacific Islander (API) women, U.S. racial/ethnic (hereafter, racial) minority populations have lower cancer survival rates as compared with non-Hispanic whites [1]. However, there is considerable variation in the extent of racial disparities in survival from different cancer sites, with substantial disparities characterizing mortality experiences of patients with certain cancer sites, and minimal to no disparities for other cancer sites [1]. Considered a fundamental social cause of health in the U.S., race continues to shape access to important resources, including those embodied in socioeconomic status (SES, e.g., information, wealth, power, health insurance, useful social relationships) [2–5]. Racial inequalities in access to these resources may explain variations in survival across cancer sites. Specifically, SES-related resources may be more successful for delaying death from cancers with more effective early detection and treatment services than for cancers for which less knowledge and medical interventions are available [3,6,7]. Consistent with this hypothesis, we previously reported that cancer mortality disparities for most racial minorities relative to whites increase as cancers become more amenable to early detection and treatment (amenability level), as determined by five-year relative survival rates [8]. However, little is known about whether these patterns vary, or conversely remain stable, across age groups.

If racial disparities in cancer mortality reflect the underlying socioeconomic inequalities by race, they may follow variations in the health impact of these resources across the life course. Socioeconomic resources may accumulate over the life course such that the gap in access to resources between the more and less socially advantaged widen with increasing age, potentially leading to increasing health disparities with advancing age [9,10]. Other plausible explanations suggest decreasing health disparities with increasing age [11]. For example, government interventions such as the Medicare program in the U.S., which provides health insurance to those aged 65 and older, may partially reduce inequalities in healthcare coverage in later life periods and contribute to smaller health disparities in older ages. In addition, the universal phenomenon of increasing biological vulnerability that accompanies aging may make the use of socioeconomic resources for the purpose of protecting health less effective in older ages, leading to relatively smaller health disparities

in the oldest age groups. Current literature provides support for both decreasing and increasing age-related social disparities for different health outcomes [6,12–14,10,15], but this question has not been empirically examined for cancer survival.

In this paper, we used data from the Surveillance, Epidemiology, and End Results (SEER) program of the National Cancer Institute (NCI) to examine 1) whether racial differences in cancer mortality vary as a function of age at diagnosis, and 2) whether the observed age patterns in mortality across racial groups further depend on the degree to which cancers are amenable to medical interventions. This information can help to identify specific age groups and cancer sites for intensified cancer control efforts. Furthermore, it may improve our understanding of the role that inequalities in socioeconomic resources may play in shaping cancer health disparities.

METHODS

Study Population

We used de-identified data from population-based registries participating in the National Cancer Institute's (NCI) SEER program. The SEER registries collect information for cancer cases residing in selected states and metropolitan and rural areas (<http://seer.cancer.gov>). Data collected include patient demographic, cancer diagnosis, vital status and cause of death information. Socioeconomic data from the U.S. Census survey data, aggregated at the cancer patients' residential county, are also available. We selected cases diagnosed with only one cancer between 1995 and 1999 to allow for sufficient follow-up time through 2010 (average length of follow-up=7.2 years, standard deviation=5.7). We used data from the registries in the states of Connecticut, Iowa, New Mexico, and Utah, in the metropolitan areas of Atlanta, Detroit, San Francisco/Oakland and Seattle/Puget Sound, Los Angeles County, and several counties in the San Jose-/Monterey area and in rural Georgia (Registries in Hawaii and Alaska were excluded as they respectively lacked data on county level poverty and included cases with American Indian and Alaska Native racial background – see exclusion criteria below). We excluded cases meeting any of the following criteria: 1) diagnosis of in-situ cancers; 2) diagnosis of ill-defined, unspecified or unknown cancer site; 3) lack of microscopically confirmed diagnosis (e.g., based solely on death certificate, autopsy or radiological/imaging information); 4) younger than 20 years and older than 99 at the time of diagnosis; 5) lack of county-level poverty data; and 6) racial/ethnic identification of “other” and of American Indian and Alaska Native as small sample size for these groups did not allow for precise estimates. The final cohort included 516,939 cases and 51 cancer sites.

Measures

Outcome—The study outcome was cancer mortality, defined as the time interval (in months) between the dates of diagnosis and death from any cancer. We used death from any cancer as the event of interest to reduce the potential likelihood of differential accuracy of cancer cause of death by amenability level. Because cases with multiple cancers were excluded, death from any cancer was most likely due to the cancer site for which cases were selected. Cases that did not die or died of causes other than cancer were censored at the date of death or last follow-up.

Cancer Amenability Level—Using NCI’s SEER*Stat software [16], we calculated 5-year relative survival rates (5Y-RSRs) for 51 cancer sites among cases, aged ≥20 years and diagnosed in 1995–1999, excluding cases with multiple primary tumors or tumors that were not microscopically confirmed. The RSR is the ratio of the observed survival in the population of cancer cases and the expected survival of a population with similar characteristics as the population of cancer cases, and provides an estimate of effect of cancer alone on survival [17]. The 51 5Y-RSRs constituted a measure of the degree to which survival from a specific cancer is amenable to early detection and treatment services relative to other cancer sites; this measure has been previously described [8]. We then categorized this measure, which ranged from 5.3% for pancreatic cancer to 99.3% for prostate cancer, into three levels of least amenable, partly amenable and mostly amenable cancers corresponding to the following 5Y-RSRs respectively: <40% (e.g., pancreas, liver, lung, trachea and bronchus, esophagus), 40–69% (e.g., colon, rectum, ovary, kidney and other urinary organs) and ≥70% (e.g., cervix, prostate, breast, Hodgkin’s lymphoma) (see Table 1 footnote for a full list). We chose these cut-points to divide the index into three categories of nearly equal number of cancer sites, while also considering gaps in the index values.

Age at Diagnosis—We created five age groups as follows: 20–34, 35–49, 50–64, 65–79, 80–99 years.

Race/ethnicity—Cases reporting Hispanic ethnicity were classified as Hispanic. All other cases were considered non-Hispanic and categorized according to their recorded racial group as white, African American, and Asian and Pacific Islander (API).

Covariates—We selected covariates based on existing knowledge of factors associated with both cancer mortality and race. Stage at diagnosis was categorized into localized, regional, and distant categories, based on the extent of the spread of cancer from its original site, and into unstaged category for those with insufficient data for determining disease stage. As a proxy for socioeconomic status, we used county-level poverty concentration, measured by the percent of persons living below the federally defined poverty threshold in 1999 in the patient’s county of residence. This measure was categorized into three levels of <10%, 10–19%, and ≥20%. Areas with 20% or more persons living in poverty are considered to be socioeconomically distressed [18]. Additional covariates included gender and cancer registry site.

Statistical Analysis

We used Cox proportional hazards regression models to estimate the hazard ratios (HR) of cancer mortality and their 95% confidence intervals (CI) associated with each racial minority group as compared with whites as a function of age group and amenability level [19]. We built a model that included two-way interaction terms between age group and racial group, followed by another model that included three-way interaction terms between age group, racial group and amenability level; each of these models also included all the relevant lower order terms, including the covariates. We tested the potential for multiplicative interaction effects by examining the log likelihood ratio tests between the models with and without the relevant interaction terms. All tests were two-sided and conducted at the 0.05

level of significance. We performed all analyses using SAS version 9.4 (SAS Institute, Gary, NC).

RESULTS

Table 1 presents descriptive data on the study population. The proportion of cancer diagnoses before age 50 was relatively small (~ 18% for all cancer sites), but increased with increasing levels of amenability (10%, 20% and 21% for least-amenable, partly amenable and mostly amenable cancers, respectively). The majority of cases were diagnosed in localized stages (49%) followed by the regional stage (21%). Significant differences were observed for stage at diagnosis by amenability level, with the proportion of local stage at diagnosis for mostly amenable cancers at 74% as compared to 15% for least amenable cancer sites. Similarly, vital status varied substantially across amenability levels with only 18% of cases with mostly amenable cancers having died from cancer at the end of the follow-up as compared with 82% of cases with least amenable cancers.

The interaction between race and age was statistically significant as indicated by the likelihood ratio test comparing the model with and without the interaction term ($p < 0.0001$). The results of the models incorporating the interaction between age group and race are presented in Table 2, with adjustment for gender and registry site (Panel 1), and with further adjustment for county-level poverty concentration and stage at diagnosis (Panel 2 and Supplemental Figure 1). The adjustment for the covariates attenuated the relative rate estimates, but the overall patterns of associations remained the same in the fully adjusted model (Figure 1). Specifically, there was a steady decline in the higher HR for African Americans relative to whites across advancing age groups, ranging from HR=1.85 (95% CI: 1.69, 2.03) for the youngest age group of 20–34 years to HR=1.02 (95% CI: 0.97, 1.06) for the oldest age group of 80–99 years (Figure 1). APIs had higher HR of cancer mortality in the youngest age group (Adjusted HR=1.36, 95% CI: 1.20, 1.54), but had equivalent or better survival relative to whites in other age groups. Hispanics showed mortality rates similar to whites with only higher rates in the youngest age group (Adjusted HR=1.13, 95% CI 1.03, 1.26).

Table 3 presents the adjusted models for cancer mortality associated with each minority group as compared with whites across age groups and amenability levels. The model with a three-way interaction term between age, race and amenability level was a better fit for the data than the model with the two-way interaction between race and age (Likelihood ratio test, $p < 0.001$). Adjustment for county-level poverty concentration alone and together with stage at diagnosis (Table 3, Panel 2 and Supplemental Figure 2) resulted in small attenuation of association. For all amenability levels, differences in HRs between African Americans and whites were larger in younger age groups, and diminished in magnitude with increasing age for each level of amenability. This declining pattern was more pronounced for mostly amenable cancers. For example, the adjusted HRs for African Americans vs. whites with least-amenable cancers in the youngest and oldest age groups were respectively 1.25 (95% CI: 1.02, 1.54) and 0.90 (95% CI: 0.85, 0.96), while the same HRs for mostly amenable cancers were 3.05 (95% CI: 2.59, 3.59) and 1.08 (95% CI: 0.99, 1.18). APIs experienced poorer survival in the youngest age group of 20–34 of equivalent magnitude for least

amenable cancers (HR = 1.50, 95%: 1.22, 1.84) and partly amenable cancers (HR = 1.47 95% CI: 1.21, 1.78), but had comparable or better survival than whites for all other age groups and amenability levels (e.g., HRs and 95% CI for the age group 80–99 years were 0.83 (0.77, 0.89), 0.91 (0.84, 1.00) and 0.71 (0.61, 0.83) respectively for least, partly, and mostly amenable cancers). As compared with whites, Hispanics had better survival for least amenable cancers across the age groups although these differences diminished slightly with increasing age. However, higher cancer mortality were observed in Hispanics relative to whites for mostly amenable and partly amenable cancers, which showed a pattern of decline in magnitude with advancing age before age 65 (e.g., for mostly amenable cancers HR and 95% CI for age group 20–34, 35–49 and 50–64 were 1.28 (1.10, 1.50), 1.12 (1.04, 1.21) and 1.15 (1.08, 1.23) respectively), after which age, Hispanics experienced similar or better survival than whites (e.g., for mostly amenable cancers HRs and 95% CIs for age groups 65–70 and 80–99 years were 1.01 (0.96, 1.08) and 0.88 (0.79, 0.98) respectively).

We examined the prevalence of non-cancer deaths across racial and age groups to assess whether our results may have been affected by differential likelihood of non-cancer deaths by race and age. We found relatively similar prevalence of non-cancer deaths for African American (22.1%) and white cases (22.0%) with somewhat lower prevalence among Hispanic (16.6%) and API cases (13.9%). African Americans had higher prevalence of non-cancer deaths in the three youngest age groups (e.g., range of 8.9%–17.9% as compared with the range of 3.3%–9.3% among whites for ages 20–64 years), but had similar prevalence in the older age two groups. Other racial groups had mostly similar prevalence of non-cancer deaths, with somewhat lower prevalence in APIs in older age groups (e.g., range of 20.0%–37.4% as compared with 28.2%–48.0% among whites in ages 65–99 years).

DISCUSSION

We investigated whether racial differences in mortality from cancer changed with increasing age at diagnosis, and whether these associations further differed by the extent to which cancers are more amenable to medical interventions. Our results showed that the cancer mortality disadvantage experienced by African Americans as compared with whites decreased with increasing age at diagnosis, and that these mortality differences for younger age groups increased as cancers became more amenable to medical interventions. We observed a similar overall pattern for Hispanics with the mortality differences between Hispanics and whites diminishing in magnitude or reversing in direction with advancing age at diagnosis, particularly for partly and mostly amenable cancers. These patterns were less clear for APIs, who experienced higher mortality rates for least and part-amenable cancers in young adulthood only.

The cancer amenability level, as measured by five-year relative survival rate, largely reflect the extent of availability of effective early detection and treatment services for each cancer relative to other cancers. As demonstrated in this and our prior research, the larger racial disparities in cancer survival for more amenable cancers are consistent with the proposition that medical interventions affording better control over a disease may also contribute to cancer health disparities, as individuals with more socioeconomic and related resources can better access and benefit from these medical interventions [3,8,20]. The results of the current

analysis add new information by illustrating that these patterns are not stable over the life course, and contribute to greater disparities in cancer survival in younger ages, particularly for African Americans and Hispanics.

Prior research on age-related patterns in health disparities has primarily considered educational and African American-white differences in relation to non-disease specific outcomes (e.g., self-rated health, functional health, overall morality), and have revealed two general patterns [6,12–14,10,15]. One pattern demonstrates progressively diverging disparities in health with increasing age while another shows converging disparities in health in later life. Our findings are more consistent with the latter pattern. As described earlier, there are two main explanations for decreasing health disparities by age. The first involves variations in access to socioeconomic resources across the life course. For example, government interventions for the elderly may partially reduce inequalities in later life periods. The second centers on the role of increasing biological vulnerability associated with advancing age, which make the use of socioeconomic resources for protecting health less effective in older ages [21]. Our data do not specifically support either of these explanations as we generally observed a steady decline in racial differences by age (e.g., no drastic changes around age 65, the eligibility age for Medicare) or among the oldest age group of 80–99 years – patterns which would have respectively supported the former and latter explanations. Since the cases included in this study were diagnosed over a relative short period of five years, the age groups considered in our analysis also represent separate birth cohorts. Therefore, it is also possible that the observed age patterns reflect differences in the associations between race and cancer mortality across birth cohorts [21–23]. Of note, a recent study of mortality changes in U.S. blacks and whites demonstrated birth cohort trends, with smaller black-white differences in relative risk of mortality in birth cohorts born after World War II as compared to older birth cohorts as well as 1970s–1980s birth cohorts [24]. Although not directly comparable to the results of our survival analysis, such birth cohort effects would suggest larger racial differences in mortality in the youngest and oldest age groups. This is an important area for future investigations of age-related racial disparities in cancer mortality.

Harper and Lynch have recently highlighted that different measures of cancer health disparities can lead to different conclusions, as they are affected by various factors including the measurement scale, subgroup population size and reference group [25]. We chose a relative measure of disparities as our research question involved the comparison of relative size of racial disparities across age groups. Given that cancer incidence increases with age, an absolute measure of racial differences in cancer mortality such as arithmetic differences in cancer mortality rates across racial groups, is likely to become larger with increasing age, suggesting a larger population-level impact of cancer mortality disparities by race in the older age groups. It is also worth noting that notwithstanding the declines in relative cancer survival disparities with age, the survival disadvantage for African Americans continued into old age for partly and mostly -amenable cancers.

Examining racial and age differences in non-cancer deaths showed mostly similar rates, lowering the possibility that our observations with regards to relative risk of cancer mortality could be due to differences in non-cancer mortality risk. We expect that racial differences in

cancer mortality largely reflect differential access to important and varied SES-related resources [26,27], but the limitations of SES measurement in our analysis did not allow for a robust evaluation of the contribution of SES to observed disparities patterns. Specifically, our analysis was limited by the use of a single measure of poverty that was aggregated at the county level. Adjustment for this crude proxy of SES resulted in small reduction in the estimates of the associations between race and mortality. Further studies with more detailed SES data, particularly data that capture different dimensions of SES with varying health implications by age as well as longitudinal data that also reflect change(s) in SES across the lifecourse would provide the best evidence for elucidating these associations. The strengths of our study include the use of a large sample of patients with reliable follow-up and mortality data, representation of 4 major racial groups in the U.S., and a large age span ranging from the youngest to the very old adult life, which enabled us to comprehensively examine racial differences in cancer survival across the full spectrum of adult lifecourse.

CONCLUSIONS

In conclusion, we found that racial differences in cancer mortality vary by age as well as by cancer amenability level, with the higher cancer mortality in African Americans and Hispanics relative to whites diminishing in magnitude or reversing in direction with increasing age for more amenable cancers. These findings provide further evidence in support of the theory that medical advances can contribute to increasing relative health disparities [3,28,6,29,30], and further add that these patterns may be more significant in young and middle adulthood. Efforts to lessen the burden of cancer in young and middle-aged racial minorities may be an important target area for reducing relative cancer health disparities. In order to achieve the dual goals of lowering the overall population burden of cancer and reducing cancer health disparities, progress in diagnosing and treating cancers more effectively must also be simultaneously supplemented by efforts that attend to the equal distribution of medical and public health interventions across population subgroups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Racial differences in cancer mortality by age at diagnosis. Data are provided as hazard ratios (and 95% confidence intervals) adjusted for gender, registry site, county-level poverty concentration, stage at diagnosis and amenability level.

Figure 2.
Racial Differences in Cancer Mortality by Age at Diagnosis and Amenability Levels
Data are provided as hazard ratios adjusted for gender, registry site, county-level poverty concentration and stage at diagnosis.

Percent Distribution of Sociodemographic Characteristics, Disease Stage, SEER Registry sites and Vital Status by Amenability Level in Patients Aged 20–99 years, diagnosed in 1995–1999.

Table 1

	All	Cancer Amenability Level						
		Least-amenable ^a		Part-amenable ^b		Most-amenable ^c		
		N	%	N	%	N	%	
All	516939		122505		160162		234272	
Race								
African American	51670	10.0	14491	11.8	14770	9.2	22409	9.6
Hispanic	41368	8.0	8852	7.2	14110	8.8	18406	7.9
Asian/Pacific Islander	26503	5.1	7463	6.1	8684	5.4	10356	4.4
White	397398	76.9	91699	74.9	122598	76.5	183101	78.2
Age at diagnosis								
20–34	19285	3.7	1661	1.4	7798	4.9	9826	4.2
35–49	72312	14.0	10371	8.5	23486	14.7	38455	16.4
50–64	149492	28.9	35237	28.8	41308	25.8	72947	31.1
65–79	205814	39.8	58242	47.5	59552	37.2	88020	37.6
80–99	70036	13.5	16994	13.9	28018	17.5	25024	10.7
Stage								
Localized	250700	48.5	17821	14.5	58703	36.7	174176	74.3
Regional	108699	21.0	29478	24.1	41378	25.8	37843	16.2
Distant	98068	19.0	58511	47.8	26170	16.3	13387	5.7
Unstaged	59472	11.5	16695	13.6	33911	21.2	8866	3.8
Gender								
Male	254634	49.3	69572	56.8	79698	49.8	105364	45.0
Female	262305	50.7	52933	43.2	80464	50.2	128908	55.0
Poverty								
<10%	330203	63.9	76460	62.4	102175	63.8	151568	64.7
10–19.9%	183428	35.5	45309	37.0	56967	35.6	81152	34.6

	Cancer Amenability Level							
	All		Least-amenable ^a		Part-amenable ^b		Most-amenable ^c	
	N	%	N	%	N	%	N	%
>=20%	3308	0.6	736	0.6	1020	0.6	1552	0.7
Registry								
San Francisco-Oakland SMSA (1973)	59072	11.4	13823	11.3	18432	11.5	26817	11.4
Connecticut (1973)	59288	11.5	14499	11.8	18935	11.8	25854	11.0
Metropolitan Detroit (1973)	67920	13.1	17871	14.6	20189	12.6	29860	12.7
Iowa (1973)	48563	9.4	11588	9.5	16181	10.1	20794	8.9
New Mexico (1973)	21548	4.2	4586	3.7	6584	4.1	10378	4.4
Seattle (Puget Sound) (1974)	57102	11.0	13594	11.1	16893	10.5	26615	11.4
Utah (1973)	20926	4.0	3363	2.7	6330	4.0	11233	4.8
Metropolitan Atlanta (1975)	32746	6.3	7453	6.1	9565	6.0	15728	6.7
San Jose-Monterey	29883	5.8	6753	5.5	9158	5.7	13972	6.0
Los Angeles	118119	22.8	28474	23.2	37318	23.3	52327	22.3
Rural Georgia	1772	0.3	501	0.4	577	0.4	694	0.3
Vital Status								
Deceased - Cancer cause of death	208057	40.2	100490	82.0	64912	40.5	42655	18.2
Deceased - Non-Cancer cause of death	109233	21.1	14815	12.1	40175	25.1	54243	23.2
Alive	199649	38.6	7200	5.9	55075	34.4	137374	58.6

^aLeast amenable cancer sites: esophagus, stomach, liver and intrahepatic bile duct, pancreas, lung and bronchus, brain, myeloma

^bpartly amenable cancer sites: Oral cavity and pharynx, small intestine, colon, rectum, anus, anal canal and anorectum, larynx, soft tissue including heart, cervix uteri, ovary, urinary bladder, kidney and renal pelvis, cranial nerves and other nervous system, Hodgkin and non-Hodgkin lymphoma

^cmostly amenable cancer sites: melanoma and other non-epithelial skin, breast, corpus uteri and uterus otherwise not specified, vulva, prostate, testis, thyroid

Adjusted Hazards Ratios and 95% Confidence Intervals (CI) of Cancer Mortality for Racial Minority Groups Relative to Non-Hispanic Whites by Age at diagnosis^a

Table 2

Model 1. Further adjusted for gender and registry						
	20–34 Years	35–49 Years	50–64 Years	65–79 Years	80–99 Years	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	
African American	2.37 (2.16, 2.60)	1.88 (1.81, 1.95)	1.39 (1.36, 1.42)	1.19 (1.16, 1.21)	1.21 (1.62, 1.26)	
Asian-Pacific Islander	1.64 (1.45, 1.86)	1.17 (1.11, 1.23)	1.07 (1.03, 1.11)	1.04 (1.01, 1.08)	1.18 (1.12, 1.24)	
Hispanic	1.41 (1.29, 1.54)	1.16 (1.12, 1.22)	1.12 (1.08, 1.15)	1.00 (0.98, 1.03)	1.15 (1.09, 1.20)	
Model 2. Further adjusted for gender, registry, county level poverty concentration and stage at diagnosis						
	20–34 Years	35–49 Years	50–64 Years	65–79 Years	80–99 Years	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	
African American	1.85 (1.69, 2.03)	1.46 (1.41, 1.52)	1.19 (1.16, 1.22)	1.03 (1.01, 1.06)	1.02 (0.97, 1.06)	
Asian-Pacific Islander	1.36 (1.20, 1.54)	1.00 (0.95, 1.05)	0.85 (0.82, 0.88)	0.80 (0.78, 0.83)	0.83 (0.79, 0.87)	
Hispanic	1.13 (1.03, 1.23)	1.03 (0.99, 1.07)	1.00 (0.97, 1.03)	0.95 (0.93, 0.98)	0.96 (0.92, 1.01)	

^a All models include race, age at diagnosis, two-way interaction terms between age and race and additional variables as listed for each model

Adjusted Hazards Ratios and 95% Confidence Intervals (CI) of Cancer Mortality for Racial Minority Groups Relative to Non-Hispanic Whites by Age at diagnosis and Cancer Amenability Levels^a

Table 3

Model 1. Adjusted for gender and registry						
	20–34 Years	35–49 Years	50–64 Years	65–79 Years	80–99 Years	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	
African American						
Least- amenable	1.46 (1.18, 1.79)	1.34 (1.27, 1.42)	1.13 (1.09, 1.17)	1.02 (0.99, 1.05)	0.97 (0.91, 1.03)	
Part-amenable	1.96 (1.71, 2.25)	1.62 (1.52, 1.72)	1.40 (1.34, 1.47)	1.30 (1.24, 1.36)	1.28 (1.19, 1.38)	
Most-amenable	3.61 (3.06, 4.24)	2.08 (1.95, 2.23)	1.58 (1.50, 1.66)	1.41 (1.34, 1.47)	1.35 (1.24, 1.47)	
Asian-Pacific Islander						
Least- amenable	1.59 (1.29, 1.95)	0.95 (0.88, 1.04)	0.81 (0.77, 0.85)	0.78 (0.75, 0.81)	0.81 (0.76, 0.87)	
Part-amenable	1.42 (1.17, 1.72)	1.06 (0.96, 1.16)	0.86 (0.81, 0.93)	0.86 (0.81, 0.91)	0.99 (0.91, 1.08)	
Most-amenable	1.20 (0.92, 1.58)	1.09 (0.98, 1.20)	1.06 (0.97, 1.17)	0.88 (0.81, 0.95)	0.90 (0.77, 1.04)	
Hispanic						
Least- amenable	0.99 (0.83, 1.17)	0.92 (0.85, 0.99)	1.00 (0.96, 1.05)	0.97 (0.94, 1.01)	0.94 (0.88, 1.01)	
Part-amenable	1.18 (1.03, 1.36)	1.07 (0.99, 1.14)	1.09 (1.03, 1.14)	1.03 (0.99, 1.08)	1.10 (1.02, 1.19)	
Most-amenable	1.66 (1.42, 1.94)	1.30 (1.20, 1.40)	1.30 (1.22, 1.39)	1.09 (1.03, 1.16)	1.03 (0.93, 1.15)	
Model 2. Adjusted for gender, registry, county level poverty concentration and stage at diagnosis						
	20–34 Years	35–49 Years	50–64 Years	65–79 Years	80–99 Years	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	
African American						
Least- amenable	1.25 (1.02, 1.54)	1.21 (1.15, 1.29)	1.02 (0.99, 1.05)	0.91 (0.88, 0.93)	0.90 (0.85, 0.96)	
Part-amenable	1.82 (1.59, 2.09)	1.57 (1.47, 1.67)	1.35 (1.29, 1.41)	1.25 (1.19, 1.30)	1.19 (1.11, 1.28)	
Most-amenable	3.05 (2.59, 3.59)	1.85 (1.73, 1.98)	1.51 (1.43, 1.59)	1.22 (1.16, 1.28)	1.08 (0.99, 1.18)	
Asian-Pacific Islander						
Least- amenable	1.50 (1.22, 1.84)	0.98 (0.90, 1.06)	0.82 (0.77, 0.86)	0.78 (0.75, 0.81)	0.83 (0.77, 0.89)	

Model 1. Adjusted for gender and registry					
	20–34 Years	35–49 Years	50–64 Years	65–79 Years	80–99 Years
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Part-amenable	1.47 (1.21, 1.78)	1.02 (0.93, 1.12)	0.84 (0.79, 0.90)	0.84 (0.79, 0.89)	0.91 (0.84, 1.00)
Most-amenable	1.04 (0.80, 1.37)	1.01 (0.91, 1.12)	0.91 (0.83, 1.00)	0.81 (0.74, 0.88)	0.71 (0.61, 0.83)
Hispanic					
Least- amenable	0.89 (0.75, 1.05)	0.90 (0.84, 0.97)	0.92 (0.88, 0.97)	0.92 (0.88, 0.95)	0.95 (0.88, 1.01)
Part-amenable	1.23 (1.07, 1.41)	1.10 (1.03, 1.18)	1.03 (0.98, 1.09)	0.98 (0.93, 1.02)	1.04 (0.97, 1.13)
Most-amenable	1.28 (1.10, 1.21) 1.23)	1.12 (1.04,	1.15 (1.08, 1.08)	1.02 (0.96, 0.98)	0.88 (0.79,

^a All models include race, age at diagnosis, amenability level, three-way interaction between age, race and amenability levels and lower order terms and additional variables as listed for each model