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Article

Racial/Ethnic Disparities in Lost Earnings From Cancer Deaths in the United States

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Abstract

Background: Little is known about disparities in economic burden due to premature cancer deaths by race or ethnicity in the United States. This study aimed to compare person-years of life lost (PYLLs) and lost earnings due to premature cancer deaths by race/ethnicity. **Methods:** PYLLs were calculated using recent national cancer death and life expectancy data. PYLLs were combined with annual median earnings to generate lost earnings. We compared PYLLs and lost earnings among individuals who died at age 16-84 years due to cancer by racial/ethnic groups (non-Hispanic [NH] White, NH Black, NH Asian or Pacific Islander, and Hispanic). **Results:** In 2015, PYLLs due to all premature cancer deaths were 6 512 810 for NH Whites, 1 196 709 for NH Blacks, 279 721 for NH Asian or Pacific Islanders, and 665 968 for Hispanics, translating to age-standardized lost earning rates (per 100 000 person-years) of $34.9 million, $43.5 million, $22.2 million, and $24.5 million, respectively. NH Blacks had higher age-standardized PYLL and lost earning rates than NH Whites for 13 of 19 selected cancer sites. If age-specific PYLL and lost earning rates for NH Blacks were the same as those of NH Whites, 241 334 PYLLs and $3.2 billion lost earnings (22.6% of the total lost earnings among NH Blacks) would have been avoided. Disparities were also observed for average PYLLs and lost earnings per cancer death for all cancers combined and 18 of 19 cancer sites. **Conclusions:** Improving equal access to effective cancer prevention, screening, and treatment will be important in reducing the disproportional economic burden associated with racial/ethnic disparities.

The burden of cancer varies by race and ethnicity in the United States (1-3). Since the 1960s, Black men and women have had higher cancer mortality rates than their White counterparts (4). Such racial/ethnic disparities in cancer mortality vary by age, with greater disparities in younger populations among whom health-care access disparities are the largest (5). Although overall and age-specific mortality rates are common indicators of disease burden and are used to monitor progress against cancer, these measures do not fully describe the magnitude of life lost. Person-years of life lost (PYLLs) due to premature deaths from cancer incorporate age at death and the number of years a person may have lived in the absence of cancer death (6). By definition, PYLLs are higher for individuals who die at younger ages than older ages and are useful for evaluating racial/ethnic disparities given greater differences in mortality rates in younger age groups, especially comparing Blacks to Whites (7).

A prior analysis of 2011 US mortality data showed that racial/ethnic minorities had higher PYLLs due to premature cancer death compared with Whites (8). However, although premature death also results in substantial economic losses to society, little research has addressed the racial disparities in economic burden associated with PYLLs due to cancer. A common approach to measure this economic burden is to estimate the loss of future earnings due to cancer death (9-12), which translates economic losses of cancer into a monetary value (13). In this study, we used contemporary data to quantify both PYLLs and lost earnings due to premature cancer deaths by race/ethnicity. Our findings can help prioritize strategies to reduce the disproportional burden of cancer when allocating limited resources for cancer prevention, screening, and treatment.

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Methods

Data Sources and Overview

The number of cancer deaths and life expectancy data (Supplementary Table 1, available online) in 2015 by single year of age, sex, and race/ethnicity were provided by the National Center for Health Statistics (14,15). Median earnings and employment rates in 2015 by age group (16-19, 20-24, ... 80-84 years), sex, employment status (part-time, full-time), and race/ethnicity were derived retrospectively from the US Census Bureau's 2016 Current Population Survey's March Annual Social and Economic Supplement (Supplementary Table 2, available online) (16). Consistent with prior studies (11), we used median instead of mean earnings because the distribution of earnings was not normal. To calculate age-standardized PYLL and lost earning rates, the 2015 US population estimates were obtained by age group (16-19, 20-24, ... 80-84 years), sex, and race/ethnicity from the US Census Bureau (15). Race/ethnicity was categorized as non-Hispanic (NH) White, NH Black, NH Asian or Pacific Islander (API), and Hispanic. American Indians and Alaska Natives were excluded because of sparse data. Analyses were restricted to decedents aged 16-84 years because earnings data were available for only this age range.

Statistical Analysis

We used national average life expectancy and earnings data (stratified by age group and sex) instead of race/ethnicity-specific data for our primary analysis. PYLLs and lost earnings were calculated by sex and race/ethnicity for all cancers combined and 15 cancer sites with the highest mortality rates for each sex (19 cancer sites in total). PYLLs for each single age were calculated by multiplying the number of cancer deaths at each age by the corresponding residual life expectancy.

To reflect fringe benefits (eg, health insurance, retirement benefits, paid leave), annual earnings were adjusted upwards by 22.4% for full-time workers and 10.3% for part-time workers (10). Age-, sex-, and race/ethnicity-specific lost earnings were calculated by multiplying PYLLs by the corresponding median earnings in 2015 US dollars. A 3% annual inflation rate was applied to discount future dollars to their present value (17), and an upward adjustment of 1.6% was used to account for annual median wage increase (18), which resulted in a total annual downward adjustment of 1.4% for future lost earnings. PYLLs and lost earnings were summed over age to generate sex- and race/ethnicity-specific total PYLLs and lost earnings for each cancer site. We also generated age-standardized PYLL and lost earning rates and average PYLLs and lost earnings per death by race/ethnicity. Age-standardized rate ratios (RR) of PYLLs and lost earnings were calculated using NH White as the reference group. To further quantify the economic burden of cancer mortality, we calculated the total lost earnings as a percentage of annual income for each race/ethnicity group and additionally compared the age-standardized lost earning rate with the age-standardized earning rate for each race/ethnicity. We calculated average age at cancer death and the distribution of age at cancer death by race/ethnicity to further characterize the disparities. To account for the uncertainty in median earnings and employment rates, 95% confidence intervals (CIs) for lost earnings estimates were generated using a simulation method, with 1000 replications for each age group, sex, and race/ethnicity (19).

Race/ethnicity-specific life expectancies were not used in the primary analysis because they incorporate existing mortality disparities into PYLL estimates (8,20). For example, the remaining life expectancy for a 50-year-old NH Black man was 2.9 years less than the national average for all 50-year-old men (Supplementary Table 1, available online). This method is also consistent with methods used in earlier studies (8,9,11,20,21). However, a disadvantage of using national average life expectancies, as in our primary analysis, is that cancer-attributable PYLLs may be over- or underestimated for populations with lower or higher than average life expectancy, respectively. To address this concern, we conducted a sensitivity analysis using race/ethnicity-specific life expectancies to calculate PYLLs and lost earnings, excluding APIs, for whom race/ethnicity-specific life expectancy data were unavailable. A second sensitivity analysis was conducted using race/ethnicity-specific earnings and employment data to reflect different income status across race/ethnicities. Among men aged 50-54 years, for example, national full-time employment rate (76.7%) and median earnings ($58 204) in Whites were higher than in Blacks (64% and $45 002, respectively; Supplementary Table 2, available online). RStudio-1.1.419 and SAS 9.4 were used for all analyses. Detailed methods are presented elsewhere (11).

Results

All Cancers Combined

In 2015, 379 728 NH Whites, 60 829 NH Blacks, 14 558 APIs, and 32 549 Hispanics aged 16-84 years died of cancer, translating to total PYLLs of 6 512 810, 1 196 709, 279 721, and 665 968, respectively, largely reflecting population size (Table 1). Similarly, NH Whites had the highest total lost earnings for all cancers combined ($66.7 billion), followed by NH Blacks ($14.2 billion), Hispanics ($8.8 billion), and APIs ($3.3 billion). Compared with NH Whites ($34.9 million), age-standardized lost earning rates for all cancers combined were higher among NH Blacks ($43.5 million) but lower among APIs ($22.2 million) and Hispanics ($24.5 million).

If age-specific PYLL and lost earning rates for NH Blacks were the same as those of NH Whites, 241 334 PYLLs and $3.2 billion lost earnings (22.6% of the total lost earnings in NH Blacks) would have been avoided in 2015. Average PYLLs and lost earnings per death were higher among NH Blacks (19.7 years and $232 600), APIs (19.2 years and $229 800), and Hispanics (20.5 years and $270 800) compared with NH Whites (17.2 years and $175 600), with the largest disparity observed among Hispanics. If average lost earnings per cancer death were the same as those of NH Whites, $1.8 billion (12.6%), $0.3 billion (10.4%), and $1.4 billion (16.1%) in lost earnings would have been avoided for NH Blacks, APIs, and Hispanics, respectively. The discrepancies in avoidable lost earnings calculated with same age-specific lost earning rates vs same average lost earning per death reflected racial/ethnic disparities in age-specific death rates and age at death.

Specific Cancer Sites

NH Blacks had higher age-standardized PYLL and lost earning rates compared with NH Whites for 13 of 19 cancer sites, with lost earning rates more than double for cancers of the prostate (RR = 2.69, 95% CI = 2.66 to 2.72), stomach (RR = 2.37, 95% CI = 2.37 to 2.37), and multiple myeloma (RR = 2.23, 95% CI = 2.21 to 2.25) (Table 2). Conversely, APIs and Hispanics had lower PYLL

Table 1. Numbers of deaths, person-years of life lost, and lost earnings from all cancers combined in both sexes by race/ethnicity, aged 16-84 years, United States, 2015

Measure[a]	NHW	NHB	API	Hispanic
Cancer deaths, n	379 728	60 829	14 558	32 549
Total PYLL, year	6 512 810	1 196 709	279 721	665 968
Age-std PYLL rate, year per 10^5 persons[b]	3151 (3149-3153)	3878 (3873-3883)	1959 (1953-1964)	2173 (2169-2177)
Average PYLL, year per death	17.2	19.7	19.2	20.5
Total lost earnings, million $	66 716 (64 492-69 102)	14 153 (13 784-14 554)	3346 (3262-3438)	8816 (8617-9026)
Total lost earnings as a percentage of annual income, %	1.74 (1.69-1.81)	1.89 (1.84-1.94)	0.90 (0.87-0.92)	0.90 (0.88-0.92)
Age-std lost earning rate, million $ per 10^5 persons[b]	34.9 (34.0-36.0)	43.5 (42.4-44.8)	22.2 (21.6-22.8)	24.5 (23.9-25.3)
Age-std lost earning rate to age-std earning rate	0.0142 (0.0137-0.0146)	0.0182 (0.0172-0.0182)	0.0090 (0.0088-0.0093)	0.0099 (0.0097-0.0103)
Average lost earnings, $1000 per death	175.6 (169.7-182.2)	232.6 (226.2-239.1)	229.8 (223.7-235.9)	270.8 (264.4-277.2)

[a]Age-std = age-standardized; API = non-Hispanic Asian and Pacific Islander; NHB = non-Hispanic black; NHW = non-Hispanic white; PYLL = person-years of life lost.
[b]Age standardized to the 2000 US standard population, with ages younger than 16 years or older than 84 years excluded.

Table 2. Age-standardized lost earning rate ratios compared with non-Hispanic white in individuals aged 16-84 years for both sexes combined, United States, 2015

Measure[a]	NHW[b] Reference group	NHB Rate ratio (95% CI)	API Rate ratio (95% CI)	Hispanic Rate ratio (95% CI)
All cancers	1.00	1.25 (1.24 to 1.25)	0.64 (0.63 to 0.64)	0.70 (0.70 to 0.70)
Lung and bronchus	1.00	1.12 (1.12 to 1.12)	0.51 (0.51 to 0.52)	0.37 (0.36 to 0.37)
Colorectum	1.00	1.43 (1.43 to 1.44)	0.70 (0.70 to 0.70)	0.78 (0.78 to 0.78)
Pancreas	1.00	1.30 (1.29 to 1.30)	0.54 (0.53 to 0.54)	0.72 (0.72 to 0.72)
Breast (female)	1.00	1.74 (1.74 to 1.75)	0.70 (0.70 to 0.70)	0.75 (0.75 to 0.75)
Brain and other nervous system	1.00	0.53 (0.53 to 0.53)	0.47 (0.47 to 0.47)	0.54 (0.54 to 0.54)
Liver and intrahepatic bile duct	1.00	1.66 (1.66 to 1.67)	1.63 (1.63 to 1.64)	1.39 (1.39 to 1.40)
Esophagus	1.00	0.71 (0.70 to 0.71)	0.28 (0.28 to 0.28)	0.41 (0.41 to 0.41)
Leukemia	1.00	1.12 (1.11 to 1.13)	0.73 (0.72 to 0.74)	1.06 (1.05 to 1.08)
Head and neck	1.00	1.26 (1.25 to 1.26)	0.86 (0.85 to 0.86)	0.54 (0.54 to 0.54)
Lymphoma	1.00	1.31 (1.29 to 1.33)	0.61 (0.61 to 0.61)	0.91 (0.90 to 0.91)
Kidney and renal pelvis	1.00	1.29 (1.28 to 1.31)	0.48 (0.47 to 0.48)	0.92 (0.92 to 0.93)
Melanoma (skin)	1.00	0.10 (0.10 to 0.10)	0.11 (0.11 to 0.11)	0.18 (0.18 to 0.19)
Prostate	1.00	2.69 (2.66 to 2.72)	0.47 (0.47 to 0.47)	0.97 (0.97 to 0.97)
Urinary bladder	1.00	0.82 (0.81 to 0.83)	0.31 (0.31 to 0.31)	0.39 (0.38 to 0.39)
Ovary	1.00	0.86 (0.86 to 0.86)	0.89 (0.89 to 0.90)	0.80 (0.80 to 0.80)
Stomach	1.00	2.37 (2.37 to 2.37)	2.04 (2.03 to 2.05)	2.56 (2.54 to 2.58)
Myeloma	1.00	2.23 (2.21 to 2.25)	0.68 (0.68 to 0.69)	0.96 (0.96 to 0.96)
Cervix	1.00	1.26 (1.26 to 1.27)	0.61 (0.61 to 0.61)	1.11 (1.10 to 1.11)
Uterine corpus[c]	1.00	1.98 (1.98 to 1.99)	0.95 (0.94 to 0.95)	1.09 (1.09 to 1.10)

[a]API = non-Hispanic Asian and Pacific Islander; CI = confidence interval; NHB = non-Hispanic black; NHW = non-Hispanic white.
[b]Reference group is NHW. Rate ratios are based on unrounded rates age-standardized to the 2000 US standard population.
[c]Population estimate were not adjusted for hysterectomy for cancer of uterine corpus.

and lost earning rates than NH Whites for most cancers except those related to infectious agents, including cancers of the cervix (Hispanics only), liver and intrahepatic bile duct, and stomach. In particular, lost earning rates for stomach cancer were more than double those in NH Whites among both APIs (RR = 2.04, 95% CI = 2.03 to 2.05) and Hispanics (RR = 2.56, 95% CI = 2.54 to 2.58). Similar patterns of PYLLs and lost earnings by sex were also observed for most cancer types, with the exception of lung and bronchus, for which rates in NH Blacks compared with NH Whites were higher in male (RR = 1.27, 95% CI = 1.26 to 1.27) but lower in female (RR = 0.91, 95% CI = 0.91 to 0.91).

Average PYLLs per death were higher in all racial/ethnic minority groups than in NH Whites for 18 of 19 cancer sites (Figure 1); for example, PYLLs for leukemia were higher by 5.0 years among NH Blacks, 4.8 years among APIs, and 9.6 years among Hispanics than in NH Whites. The exception was cervical cancer, for which average PYLLs were 0.6 and 0.5 years lower in NH Blacks and APIs, respectively, than in NH Whites. Similarly, the average lost earnings per death for all studied cancer sites was higher in minority groups than in NH Whites except for cervical cancer among NH Blacks and APIs (Figure 2). Racial/ethnic minorities were more likely to die from cancer at younger ages than NH Whites. This difference was substantially greater for some cancer sites such as female breast cancer, brain and other nervous system cancer, leukemia, and lymphoma, resulting in greater racial/ethnic disparities in average PYLLs and lost earnings for those malignancies (Supplementary Table 3, Supplementary Figure 1, available online). Detailed

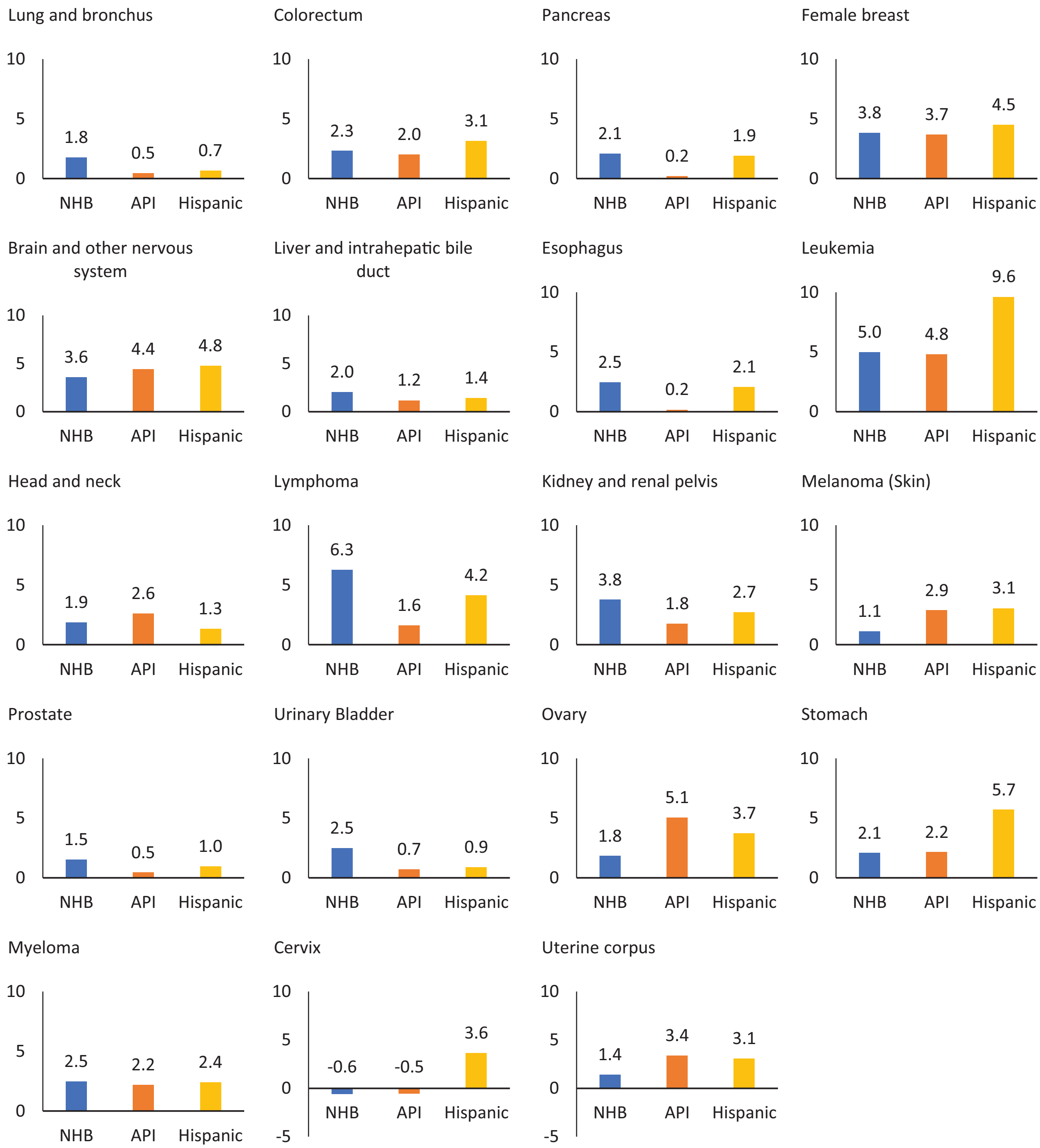

Figure 1. Difference in person-years life lost (PYLLs) per death due to cancers compared with non-Hispanic white in individuals aged 16-84 years for both sexes combined, by race/ethnicity, United States, 2015.

Each unit in y-axis represents 1 PYLL. API = non-Hispanic Asian and Pacific Islander; NHB = non-Hispanic black.

information on the number of cancer deaths and estimated PYLLs and lost earnings are presented in Supplementary Tables 4-10 (available online).

Sensitivity Analyses

Compared with analyses using overall average life expectancy, PYLLs and lost earnings based on race/ethnicity-specific life expectancy were lower for NH Blacks, among whom life expectancies were shorter than the national average, and slightly higher for Hispanics, among whom life expectancies were longer. For example, the age-standardized PYLL rate (per 100 000 person-years) for NH Blacks was 3139 based on NH Black life expectancy compared with 3878 based on national average life expectancy. However, disparities in age-standardized PYLL and lost earning rates and average PYLLs and lost earnings per death persisted, with patterns similar to those described above (Supplementary

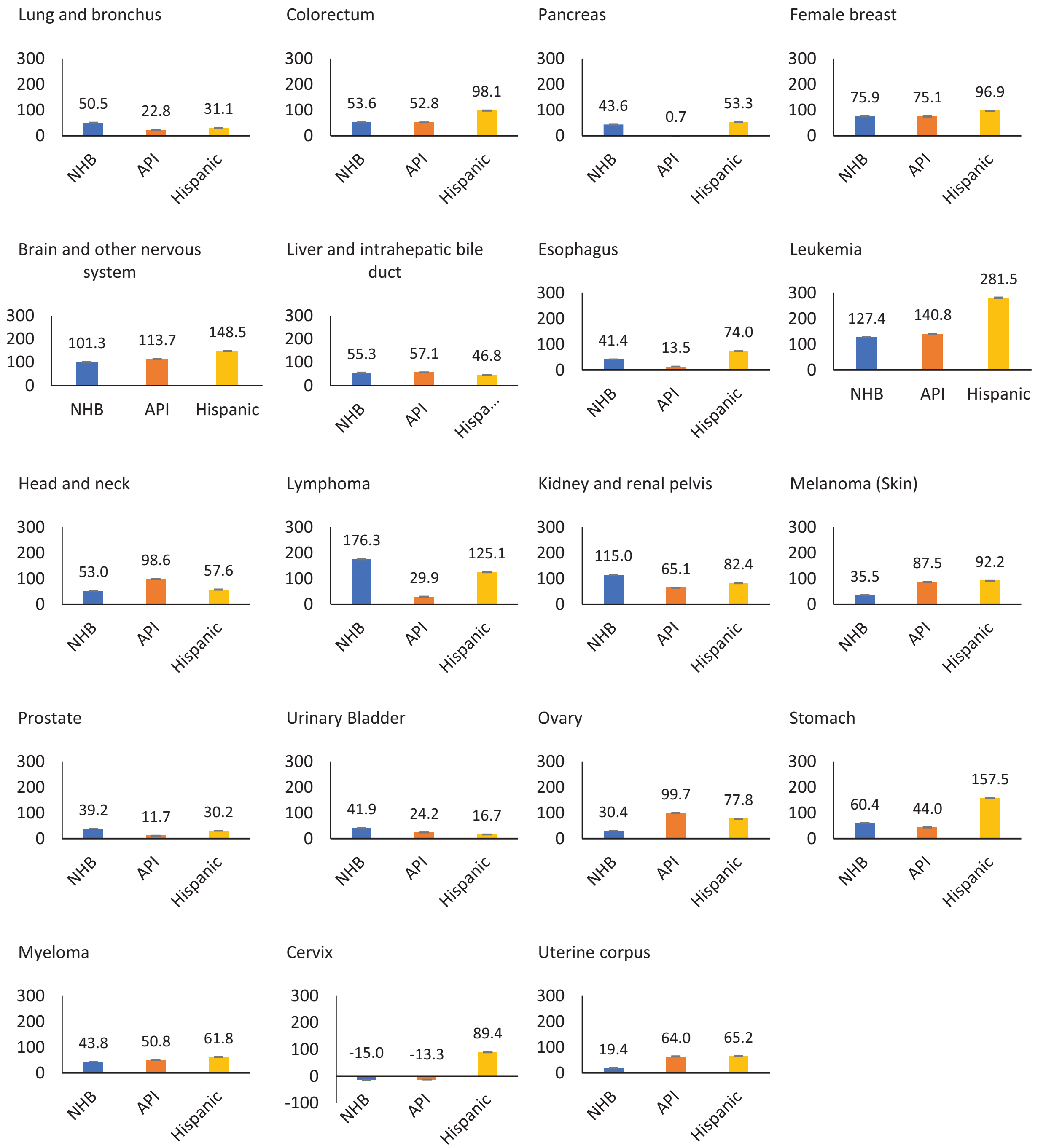

Figure 2. Difference in average lost earnings ($1000) per death due to cancers compared with non-Hispanic white in individuals aged 16-84 years for both sexes combined, by race/ethnicity, United States, 2015.

Each unit in y-axis represents $1000 lost in earnings. API = non-Hispanic Asian and Pacific Islander; NHB = non-Hispanic black.

Tables 11-12; Supplementary Figure 2, A and B, available online). Detailed estimates are presented in Supplementary Tables 13-16.

Lost earning disparities based on race/ethnicity-specific earnings and employment rates were similar to those in the main analysis among women (Supplementary Tables 17-18; Supplementary Figure 3A, available online). However, in contrast to the main analysis, age-standardized lost earning rates among men were lower in NH Blacks than NH Whites for 11 of 15 cancer sites, except for prostate (RR = 1.42, 95% CI = 1.09 to 1.82) and stomach cancers (RR = 1.39, 95% CI = 1.24 to 1.57). In addition, average lost earnings per death among males were lower for NH Blacks and Hispanics than for NH Whites for all cancers combined and most cancer sites (Supplementary Figure 3B, available online). However, compared with NH White men, NH Black men had higher age-standardized lost earnings to earning rate ratio (RR = 0.0188, 95% CI = 0.0165 to 0.0212 vs RR = 0.0154, 95% CI = 0.0147 to 0.0163) (Supplementary Tables 17). Detailed estimates are presented in Supplementary Tables 19-21.

Discussion

In this study, we quantified substantial racial/ethnic disparities in rates and average PYLLs and lost earnings per cancer death in the United States in 2015. Compared with NH Whites, NH Blacks had higher age-standardized PYLL and lost earning rates for all cancers combined and for 13 of 19 selected cancer sites. Importantly, if age-specific PYLL and lost earning rates for NH Blacks were equivalent to those in NH Whites, 241 334 PYLLs and $3.2 billion in lost earnings, representing 22% of the total PYLLs and lost earnings among NH Blacks, would have been avoided in 2015. Our estimates highlight the disproportional economic burden of premature cancer deaths by race/ethnicity and reinforce the importance of reducing racial/ethnic disparities for major cancer sites, such as colorectal, female breast, and lung. Furthermore, racial/ethnic minority groups are expected to account for more than one-half of the population by the year 2050 (22), suggesting a growing economic burden of cancer due to disparities based on population changes alone.

Our findings can inform efforts to reduce racial/ethnic disparities in PYLLs and lost earnings due to premature cancer deaths. For example, we found that NH Blacks had higher lost earning rates for many common cancers, including colorectal, female breast, and lung, that are associated with modifiable risk factors and/or for which effective screening is available. Thus, the implementation of programs that increase equitable access to cancer prevention and screening can contribute to reducing the unequal burden. We also measured average losses per cancer death, which reflect economic losses of each decedent and disparities at the individual level. Although age-standardized lost earning rates were lower in Hispanics and APIs than in NH Whites for most cancer sites, average losses were higher. This could be explained by younger median age at cancer death due to the younger age structures and, in Hispanics in particular, shorter age-specific survival for some cancers because they are more likelyto be diagnosed at advanced stages and have limited access to timely and high-quality treatment (23). In addition, we observed higher lost earning rates and average lost earnings per cancer death in Hispanics and APIs than in NH Whites for infectious-related cancers such as liver, stomach, and cervical cancer, suggesting the importance of infection prevention and treatment.

The disparities in PYLLs and lost earnings by race/ethnicity could potentially be explained by inequities in receiving cancer prevention, screening, and treatment (24-28). For example, substantially higher age-standardized lost earning rates for NH Blacks and average lost earnings for all minority groups compared with NH Whites could reflect disparities in receipt of cancer screening (67% in NH Whites received mammography compared with 60%, 60%, and 52% in NH Blacks, English-speaking Hispanics, and Spanish-speaking Hispanics, respectively) (29) and advanced stage at diagnosis compared with NH Whites for most cancer sites (2,3,30). Greater disparities were observed in lost earning rates or average lost earnings for female breast, colorectal, and lung cancers. In addition, minorities were less likely to receive recommended treatments and more likely to experience treatment delays. For example, Black and Hispanic female breast cancer patients had higher risks of 30-, 60-, and 90-day delay to initial treatment compared with White patients and were less likely to receive radiation therapy after breast-conserving surgery (31). Younger age at cancer deaths also led to disparities in average lost earnings, especially for female breast cancer, leukemia, and lymphoma, highlighting the need for improved access to care for young minority cancer patients.

Broad multilevel engagement in eliminating the unequal burden of cancer mortality will be essential given the substantial disparities observed in this study and persistence of higher cancer mortality among Blacks compared with Whites since the 1960s (32). At the point-of-care level, a recent multifaceted intervention with elements of race-specific feedback and patient-centered communication reduced Black–White disparities in access to treatment of early stage lung cancer at 5 cancer centers (33). In 2016, the American Society of Clinical Oncology approved a strategic plan for increasing racial/ethnic diversity in the oncology workforce, which could potentially bring intercultural responsiveness and expand health-care access among minorities (34). Cancer disparities by race/ethnicity vary at the regional level in the United States (24,32), illustrating the importance of state and local policies. A recent study showed that states with expanded Medicaid coverage eligibility had larger increases in health insurance coverage among cancer patients than nonexpansion states, especially for NH Blacks and Hispanics, highlighting the role of Medicaid expansion in reducing racial/ethnic disparities (35).

In this study, we used a human capital approach to estimate the unrealized lifetime earnings among individuals who die from cancer. The human capital approach places lower or no value on individuals not in the workforce and reflects the economic impact of cancer mortality. In addition, this approach can mask different age and sex structures of PYLLs across race/ethnicity. Another common approach to value PYLLs is to calculate the willingness to pay for each additional year of life. However, methods for this approach are less well developed (13).

We estimated PYLLs with national average life expectancies in our main analyses and with race/ethnicity-specific life expectancies in sensitivity analyses. Although both approaches are limited by data availability, the 2 methods generally yielded consistent results. We also conducted sensitivity analyses using race/ethnicity-specific earnings information. In contrast to the main analysis, age-standardized lost earning rates based on race/ethnicity-specific earning information were lower in NH Black men than NH White men for most cancer sites, reflecting the dramatic difference in earnings and employment status by race/ethnicity. In addition, compared with NH White men, NH Black men had higher age-standardized lost earning to earning rate ratios, reflecting higher economic burden from cancer mortality for NH Black men, which was consistent with the main analysis. Results from the sensitivity analysis should be interpreted cautiously as it incorporates existing racial/ethnic economic disparities.

Our study was limited by the validity of race/ethnicity death certificate information, which is known to be more accurate for NH Whites than other races/ethnicities (36). Because cancer deaths in Hispanics and APIs are likely to be underreported, our estimates for these groups may be understated. In addition, we were not able to evaluate the losses from cancer death for those aged younger than 16 years or older than 84 years; however, these populations are less likely to be a part of the work force and would not have any substantial influence on the results and conclusion of this study. Despite these limitations, strengths of our study include the use of comprehensive national mortality data to assess multiple measures of racial/ethnic disparities in the economic burden associated with premature cancer death. We also conducted multiple sensitivity analyses, which provided robust results as well as further insight into racial/ethnic disparities.

In summary, this study highlighted the substantial racial/ethnic disparities in PYLLs and the associated lost earnings due to premature cancer deaths in the United States. The burden of many of these cancers could be reduced through improving access to effective, high-quality, and targeted cancer prevention, screening, and treatment for these vulnerable populations. Broad, equitable application of strategies to address these issues will be essential for reducing the economic burden associated with racial/ethnic cancer disparities.

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