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Finding "Bright Spots": Using Multiple Measures to Examine Local-Area Racial Equity in Cancer Mortality Outcomes

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Abstract

In this article, we present a variety of measures that quantify equity in cancer mortality outcomes, demonstrate how the measures perform with various cancer types, and identify counties, or "bright spots," that meet the criteria of those measures. Using county-level age-adjusted mortality rates for 2007–2016 from the National Center for Health Statistics, we identified counties that had both equitable and optimal outcomes for Black and White death rates across 5 types of cancer: cancers of the lung/bronchus, prostate, female breast, colorectum, and liver. The number of counties that met the criteria ranged from 0 to 442, depending on cancer type and measure used. Prostate cancer and male liver cancer consistently had the lowest number of "bright spots," with a maximum of 3 counties meeting the most lenient criteria. This paper presents several ways to examine equity, using rate ratios and standard error measures, in cancer mortality outcomes. It highlights areas with positive progress toward equity and areas with a potential need for equity-focused cancer-control planning. Examining local areas of positive deviance can inform cancer-control programming and planning around health equity.

Keywords

cancer; health disparities; health inequities; medical geography; mortality; population-based studies

While the rate of cancer death in the United States continues to decline (1), racial/ethnic disparities persist. Much of the drop in the cancer mortality rate has been attributed to reductions in cigarette smoking and improvements in early detection and cancer treatment (1). This progress has been driven by rapid declines in mortality for the 4 most common types of cancer: cancers of the lung and bronchus, colorectum, female breast, and prostate (1). Cancer death rates are considered to be a stable measure of progress in cancer control, since they are less affected than other measures by detection practices (1). From 2012 to 2016, death rates for all cancers combined were consistently higher among Black populations than among White populations, particularly for Black men (1, 2). Achieving

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equity in cancer mortality by race/ethnicity can serve as a marker for progress toward health equity in cancer outcomes (2).

Cancer of the lung and bronchus is the most common cause of cancer death among both males and females in the United States, accounting for 26% and 24% of cancer deaths in 2016 (3), respectively. From 2012 to 2016, lung and bronchial cancer death rates were 20% higher in Black men and 9% lower in Black women than in their White counterparts (3). Colorectal cancer (CRC) is the third most common cause of cancer mortality among both males and females, accounting for 9% of cancer deaths in males and females (3). From 2012 to 2016, CRC death rates were 44% higher in Black men and 32% higher in Black women than in their White counterparts (3). Prostate (10%) and breast (15%) cancer are the second most common causes of cancer death among males and females, respectively (3). Prostate cancer death rates were 2.2 times higher in Black men than in White men (3). Breast cancer death rates were 40% higher in Black women than in White women, despite similar incidence rates (3). Cancer of the liver and intrahepatic bile duct is one of the few causes of cancer death that showed increases in death rates from 2012 to 2016. During that period, liver cancer death rates were 48% higher in Black men and 27% higher in Black women than in their White counterparts (3).

Our overarching goal in this study was to identify local geographic areas (counties) that demonstrate racial equity, termed “bright spots,” using 2 different measures for quantifying equitable outcomes in cancer mortality by race/ethnicity, and to demonstrate differences in findings when we varied each measure’s inclusion criteria. Most research assesses disparities at an aggregate geographic level, such as the nation or state—an approach that can obscure heterogeneity at lower geographic levels, like counties and census tracts (4). However, this study allowed us to examine equity at a more granular level.

METHODS

We calculated aggregated county-level age-adjusted mortality rates in the Surveillance, Epidemiology, and End Results (SEER) Program’s SEER*Stat 8.3.5 (5) database (6, 7), with Tiwari et al. (8) modified confidence intervals, for 2007–2016. The SEER*Stat rate ratio test (8) was employed, and rate ratios and 95% confidence intervals were extracted for comparison. Counties with fewer than 10 deaths for any subgroup were excluded, per the data-use agreement, to ensure stability of rates and protect confidentiality (2, 6). Deaths were identified using the SEER Cause of Death Recode, which uses *International Classification of Diseases, Tenth Revision*, coding rules for all data collected after 1998 (6, 9). Causes of death included cancers of the lung and bronchus, colon and rectum, female breast, prostate, and liver and intrahepatic bile duct. Both sex-specific and overall rates were calculated. We examined cancer sites with the highest mortality or increasing mortality and sites with demonstrated racial/ethnic disparities between Black and White populations (1, 3), to ensure that we had adequate numbers of cases during the study time period for comparison.

A county was included as a “bright spot” if it met the optimal and equitable criteria over the 10-year study period. The criterion of *optimal* was defined as the Black death rate being less

than or equal to the US death rate for the period (2, 10, 11). Equity can occur at high death rates, but including the optimal criterion ensures that we are looking at lower-than-average death rates (2). Rate ratios were calculated in SAS (SAS Institute, Inc., Cary, North Carolina) as the Black death rate divided by the White death rate. Two measures were used to find *equitable* counties with varying inclusion criteria: 1) a rate ratio that fell within a) 5% of 1.0 (range, 0.95–1.05) or b) 10% of 1.0 (range, 0.90–1.10), regardless of direction of association; and 2) standard-error-of-the-mean (a measure that quantifies uncertainty in the mean estimate (12)) measures for which a) the Black and White death rate standard error intervals overlapped or b) the 95% confidence intervals of the Black and White death rates overlapped (1.96 × standard error). The numbers of counties that met the criteria for each of the equitable measures individually were identified. These results were compared with the numbers of counties identified using 1) the "rate ratio of exactly 1.0" criterion and 2) the rate ratio test employed by SEER*Stat (8), which uses the inverse F distribution to estimate 95% confidence intervals and P values (13, 14).

RESULTS

The US mortality rates for each cancer site were 44.9 (lung and bronchus), 21.4 (female breast), 20.7 (prostate), 15.0 (colon and rectum), and 6.2 (liver and intrahepatic bile duct) deaths per 100,000 population. Summary statistics for the age-adjusted death rates and the calculated rate ratios are presented in Table 1. On average, the Black death rate was higher than the White death rate for all cancers except female lung and bronchial cancer. The range of the rate ratios demonstrates the heterogeneity among the counties in terms of equitable outcomes. For prostate cancer, the disparity was much greater, as the average Black death rate was 2.6 times higher than the average White death rate. For both male CRC and male liver cancer, the Black death rate was 1.6 times the White death rate, on average. Lung and bronchial cancers had rate ratios closest to 1, while the remaining cancers—breast cancer, overall and female CRC, and overall and female liver cancer—had rate ratios of 1.5, on average.

Of the 3,146 counties included in the analysis, 25 counties met the criterion of having a rate ratio equal to 1.0 (with rates rounded to the nearest decimal place for calculations) for at least 1 cancer. For at least 1 cancer, 1,052 counties had a rate ratio greater than1 and 812 counties had a rate ratio less than 1. For all cancers, 47 counties had a rate ratio greater than 1 and no counties had a rate ratio less than 1 for all cancers. Prostate cancer was the only cancer that had no counties with a rate ratio equal to 1.0 (see Web Table 1, available at https://academic.oup.com/aje). Lung and bronchial cancer had the most counties meeting the criterion of a rate ratio equal to 1.0 (n = 8 counties). Five of the 25 counties were located west of the Mississippi River. Twelve counties met the criteria for more than 1 type of cancer. Using the criterion of a rate ratio equal to 1.0, there was no apparent pattern in geographic distribution or correlation in outcomes between counties.

Table 2 shows the number of counties that met the criteria for "equitable" as we expanded the definition beyond a rate ratio equal to 1.0. As the equitable criteria became more lenient, only 1 county met the criteria for a "bright spot" in prostate cancer using the overlapping 95% confidence interval criterion. Male liver cancer had 2 counties that met the overlapping

standard error criterion and 1 additional county that met the 95% confidence interval criterion. All female cancers, compared with male cancers, consistently had the largest number of counties meet the criteria for each measure. Female lung cancer had the most counties meet each criterion of the 2 measures. Compared with the SEER*Stat measure—nonsignificant rate ratio differences determined using the inverse *F* distribution—there were fewer counties that met any criteria for the 2 introduced measures.

The geographic distributions of the rate ratios are presented in Figures 1 and 2. The red and blue counties represent rate ratios with greater distance from the value 1 (low equity), while yellow counties represent more equitable rate ratios (within 5% of 1). Lung and bronchial cancers had more counties that were blue (rate ratios < 0.90)—areas where the White death rate was higher than the Black death rate (Figure 2). Counties that are red had the highest rate ratios (rate ratios < 1.10) and were counties where the Black death rate was higher than the White death rate. For both female breast cancer and prostate cancer (Figure 1), there is concentration of these counties in the southern and southeastern United States, along the East Coast, and in several large counties in Southern California and Arizona. CRC followed a similar geographic pattern as female breast and prostate cancer (Figure 2). Liver and intrahepatic bile duct cancer had far fewer counties included on the maps; however, the majority of those counties were red. The counties were geographically dispersed, with no distinct geospatial pattern (Figure 2). Lung and bronchial cancers differed from the other cancers in this study (Figure 2). While male lung and bronchial cancer followed a distribution similar to those of the other cancers, with more diversity in rate ratios, female and overall lung and bronchial cancers appeared to show the opposite of previously seen patterns. While occupying the same geographic space, the disparities were reversed (the White death rate was higher than the Black death rate), as most counties were blue rather than red.

DISCUSSION

This study identified local areas of equity using 2 measures (the rate ratio measure and the standard error measure) for defining equity in mortality outcomes at the county level for 5 different types of cancers. Each of the 5 cancers had at least 1 county meet at least 1 of the criteria. Bright spots were considered counties that fitted both the optimal definition— the Black county mortality rate being equal to or less than the national average—and the equitable definition (using either the rate ratio measure or the standard error measure). The number of “bright spots” ranged from 0 to 442, depending on the type of cancer and the measure used. Lung and bronchial cancer among females consistently had the most “bright spots,” indicating that there has been the most progress toward equity for this cancer relative to the other 4 cancers in the study. In terms of geographic distribution, most counties on the map had not reached equity. Ideally, we would like to see mostly yellow counties on the map; however, for most cancers included in this analysis, the majority of counties with adequate data were red. The exception to this was lung and bronchial cancer, where counties were mostly blue for female and overall rates. There are still cancers that need significant improvement in equity. An example of this is the comparison of male cancers with female cancers. All male cancers in the study demonstrated greater disparities than the female cancer or cancers affecting both sexes. Additionally, prostate cancer had the largest average

mortality rate ratio (rate ratio = 2.6), and only 1 county met any “bright spot” criteria. Given the literature, we did not expect equity in prostate cancer mortality outcomes, but it was included to further show potential results of the varying methods used to evaluate equity. It is one of the most common cancers—the fourth leading cause of cancer death—and has demonstrated a decline in mortality overall. Five percent of all cancer deaths were caused by prostate cancer; and among males, lung/bronchial cancer, CRC, and prostate cancer were the most common causes of cancer death in 2017 (15). When we examined the relationship between incidence and mortality, 6 of the top 10 types of new cancers in 2016 were also among the top 10 causes of cancer death in the same year, with female breast cancer, prostate cancer, lung/bronchial cancer, and CRC being in the top 4 for both incidence and mortality (3). Each of these cancers has varying Black-White differences in both incidence and mortality, so there is no definitive trend. With cancers that have large differences in mortality by race/ethnicity, we can continue to monitor the temporal trend of mortality in the group with the worst outcomes, with the expectation that rates in the group with the lowest rate will remain low and rates in the group with higher rates will decrease over time through improvements in screening, detection, policy, and program planning. The focus of this specific study was on evaluating various ways to examine equity and aid in hypothesis-generation rather than exploring the driving forces behind the equitable or nonequitable outcomes. This study not only elucidated areas of equity but also demonstrated that there are cancers for which improved control and planning is needed to achieve equity.

This study expanded upon previously published research that examined progress toward racial/ethnic equity in breast cancer and CRC death rates using measures of positive deviance(2,10).The “optimal” definition was derived from those studies, while we expanded on the “equitable” definition (2, 10). We expanded the criteria of each equitable measure to include a range of data that fitted the rate-ratio criterion, beyond the point where the rate ratio for age-adjusted rates, rounded to 1 decimal place, was exactly equal to 1.0, yet more narrowly than the SEER*Stat measure, which uses the F distribution to determine differences between Black and White death rates and calculates rate ratios to the billionths. In an effort to define equity without much loss of statistical precision, we expanded the rate ratio definition and examined whether the rate ratio was within 5% of 1 or within 10% of 1. The number of counties that fitted the criteria increased for each cancer type except prostate cancer and male liver cancer, as compared with a rate ratio equal to 1.0. We also used a second measure involving standard errors. The standard error is a measure of uncertainty, and we hypothesized that if the Black death rate uncertainty intervals were to overlap with those of the White death rate, we would fail to reject the null hypothesis that the death rates were not different. We used both a 1–standard error interval and a 95% confidence interval, as this provided a wider interval for inclusion but not as wide as the formal testing of the rate ratio in SEER*Stat. This analysis built upon the SEER*Stat Health Disparities Calculator but allowed us to compare disparities at a more granular geographic level, since the Health Disparities Calculator either displays aggregate measures for counties or analyzes each county individually (16). The positive deviance approach involves identifying individuals or groups with better outcomes than their peers and examining behaviors and practices that allow for these positive outcomes (17, 18). Counties that met the criteria of a rate ratio between 0.90 and 1.10 and the Black death rate falling within the 95% confidence interval of

the White death rate could serve as a starting point for case studies of what is contributing to the positive deviance in those areas. Examining areas with positive outcomes, rather than just those with disparate outcomes, allows us to evaluate the context and contributors to these positive outcomes and to further explore whether the application of these same conditions could work in areas that have not yet reached equity.

There were several limitations to this study. One limitation was its temporal and spatial scale. The study aggregated death rates over a 10-year period to include as many counties as possible. Deriving assumptions of equity over a long period can introduce bias, as different inferences can potentially be drawn by choosing different specifications for temporal aggregation (19). Ideally, we would evaluate 3- to 5-year periods; however, this would substantially diminish the number of counties that could be used in comparison. A major concern is capturing enough cases to ensure reliable rates for comparison. In order to adequately evaluate these methods, we did not examine any racial/ethnic groups other than Blacks and Whites, as there were far fewer deaths among other racial groups. The normally distributed 95% confidence interval was used, instead of the Tiwari et al. confidence intervals, which are more efficient in analytical samples with small counts (8). When comparing results for the 2 types of intervals, we did not find substantial differences in efficiency in our study. However, the overlapping interval method is considered a conservative and low-power test, particularly when true standard errors are equal (20, 21). The power of this method increases as the standard error ratio increases (20). Our study examined death rates alone and did not evaluate context or risk factors. Another limitation is that we used no formal test to assess statistical significance for the new measures, although the information provided still has practical significance.

Overall, this study identified counties (“bright spots”) that have reached Black-White equity in cancer death rates for 5 different cancers, comparing several ways to examine that equity. We sought to define as many counties as possible that could fit both the optimal and equitable definitions without losing precision in estimate comparisons. Consistently, the “rate ratio within 5% of 1 (range, 0.95–1.05)” measure identified the fewest counties, while the 95% confidence interval measure identified the most. Researchers can decide what may be the best measure for their outcome, as there is consensus on the importance of this choice, but less on which is more meaningful (22). The use of both absolute and relative measures provides important perspectives when evaluating disparity, since differing measures may provide differing results (23, 24). Absolute measures may be useful in the assessment of progress toward a reduction in disparity, while relative measures may be useful in determining whether the disparity has been eliminated (25). Thus, researchers can be liberal in their choice of measure when examining local equity in their outcomes. It is recommended that at least 2 be chosen and differences evaluated for each outcome.

Studies of this type are useful in the advancement of cancer control and planning. After identification of counties with equitable outcomes between Blacks and Whites, further studies can be conducted in these counties to determine what is driving this equity. In those counties with equitable and optimal outcomes, in-depth case studies might high light how these positive outcomes are achieved for the Black population living in those counties. Researchers can examine demographic, environmental, and other contextual variables that

characterize the counties classified as “bright spots.” It is important to note that contextual factors may contribute to equity differently by county. Studies of this kind can inform larger intervention programs that target local communities and work to address disparities, like the Centers for Disease Control and Prevention’s Racial and Ethnic Approaches to Community Health (REACH) Program (26) and the National Comprehensive Cancer Control Program (27). Examining disparities at the local level is important to better understanding underlying mechanisms that contribute to those disparities and how we can better work toward equity in cancer mortality. More focus on local outcomes can inform our progress toward equity and can aid us in planning and prevention along the cancer-control continuum.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

CRC	colorectal cancer
SEER	Surveillance, Epidemiology, and End Results

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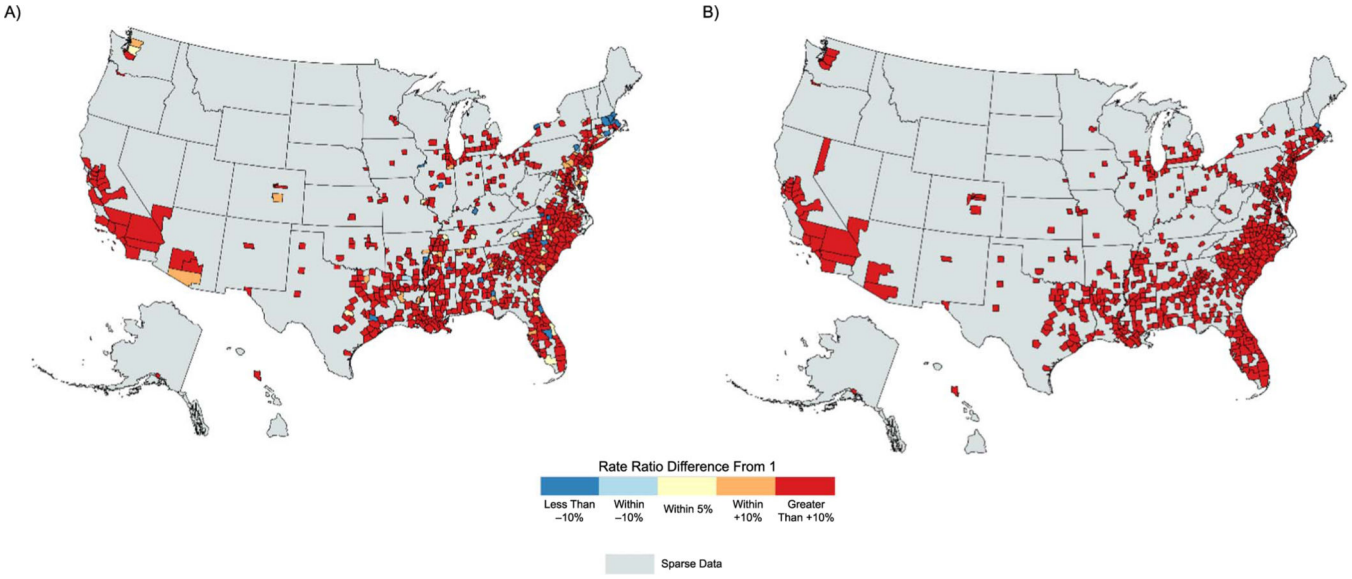

Figure 1.

Geographic distribution of Black/White mortality rate ratios for female breast cancer (A) and prostate cancer (B), United States, 2007–2016. Rate ratios are divided into 5 categories: less than −10%, within 10%, within 5%, within +10%, and greater than 10%.

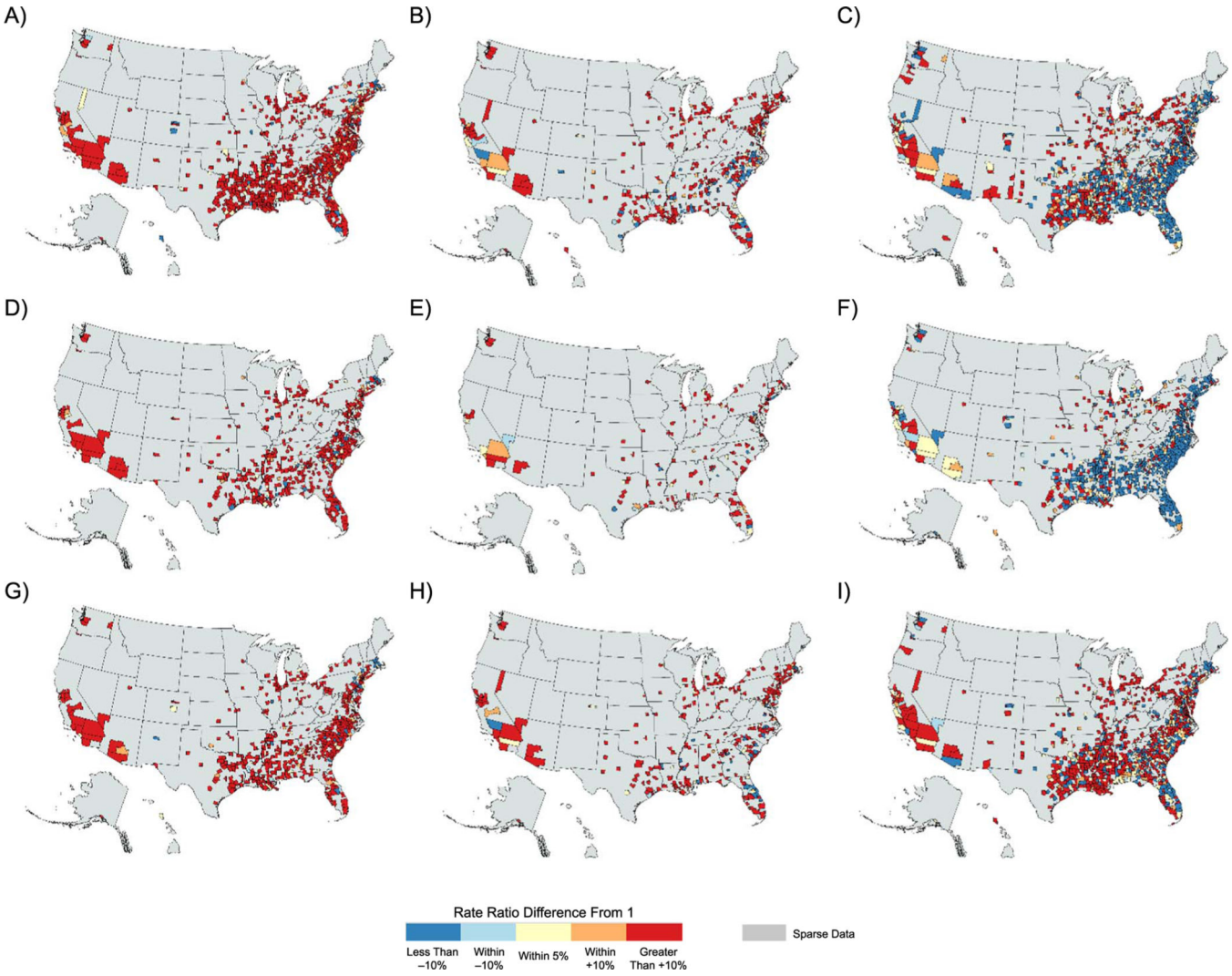

Figure 2.

Geographic distribution of Black/White mortality rate ratios, overall (top row) and by sex (middle and bottom rows), for colorectal cancer (CRC; left column), liver and intrahepatic bile duct (LIBD) cancer (middle column), and lung and bronchial (LB) cancer (right column), United States, 2007–2016. A) Total CRC; B) total LIBD cancer; C) total LB cancer; D) female CRC; E) female LIBD cancer; F) female LB cancer; G) male CRC; H) male LIBD cancer; I) male LB cancer. Rate ratios are divided into 5 categories: less than −10%, within 10%, within 5%, within +10%, and greater than 10%.

Table 1.

Age-Adjusted Rates of Death From Breast, Prostate, Colorectal, Liver, and Lung and Bronchial Cancers, United States, 2007–2016[a]

Cancer Site, Sex, and Race/Ethnicity	No. of Counties (*n* = 3,146 Counties)	Mortality Rate[b]	
		Mean (SD)	Range
Female breast			
Black	709	31.0 (8.5)	13.4–78.4
White	2,624	21.4 (4.5)	7.5–55.3
Ratio	682	1.5 (0.5)	0.6–5.8
Prostate			
Black	651	49.1 (15.6)	14.9–145.3
White	2,467	20.6 (5)	8.5–52.1
Ratio	606	2.6 (0.9)	0.7–8.6
Colon and rectum			
Total			
Black	830	23.1 (7.1)	7.2–63.4
White	2,833	16.5 (3.8)	6.1–42.3
Ratio	808	1.5 (0.4)	0.5–4.3
Female			
Black	524	19.0 (5.9)	6.4–49.8
White	2,396	14.0 (3.8)	4.5–40.9
Ratio	497	1.5 (0.5)	0.5–3.7
Male			
Black	588	29.6 (10.1)	10.6–82.5
White	2,512	19.9 (5.2)	7.6–48.7
Ratio	559	1.6 (0.5)	0.6–4.9
Liver and intrahepatic bile duct			
Total			
Black	438	8.9 (3.8)	3.3–48.9
White	2,094	6.0 (1.9)	1.7–25.7
Ratio	427	1.5 (0.6)	0.5–5.0

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Cancer Site, Sex, and Race/Ethnicity	No. of Counties (n = 3,146 Counties)	Mortality Rate[b]	
		Mean (SD)	Range
Female			
Black	175	5.1 (1.7)	2.3–10.7
White	1,069	3.8 (1.3)	1.4–13.3
Ratio	168	1.5 (0.5)	0.4–3.3
Male			
Black	334	14.4 (6.6)	4.3–79.7
White	1,735	8.9 (3.1)	3.0–43.0
Ratio	326	1.6 (0.7)	0.4–5.1
Lung and bronchus			
Total			
Black	1,166	54.8 (17.8)	15.2–183.1
White	3,033	51.6 (14)	7.1–137.6
Ratio	1,165	1.0 (0.4)	0.3–5.2
Female			
Black	757	37.0 (13.2)	10.5–118.3
White	2,853	41.4 (10.8)	9.0–97.6
Ratio	745	0.9 (0.3)	0.3–2.9
Male			
Black	990	82.4 (29.7)	20.3–445.3
White	2,968	66.3 (20)	12.8–201.3
Ratio	987	1.2 (0.4)	0.4–8.0

Abbreviation: SD, standard deviation.

[a] Counties with fewer than 10 deaths for any subgroup were excluded from consideration, since a rate ratio could not be computed due to either a missing Black death rate or a missing White death rate

[b] Number of deaths per 100,000 population

Table 2.

Numbers of Counties (n= 3,146 Counties) That Met the Criteria for "Bright Spots," by Measure and Cancer Type, United States, 2007–2016

Cancer Site and Sex	Bright Spots[a]				Comparison Measure	
	RR Measure		SE Measure			
	5% RR	10% RR	Overlapping SE Interval	Overlapping 95% CI	RR = 1.0[b]	SEER*Stat
Female breast	16	22	50	55	2	426
Prostate	0	0	0	1	0	93
Colon and rectum						
Total	20	31	51	64	1	503
Female	24	38	91	119	5	341
Male	5	8	16	20	1	328
Liver						
Total	12	26	76	90	7	277
Female	16	31	84	123	4	194
Male	0	0	2	3	6	115
Lung and bronchus						
Total	34	57	118	222	8	890
Female	63	139	284	442	8	544
Male	7	15	29	47	8	758

Abbreviations: CI, confidence interval; RR, rate ratio; SE, standard error; SEER, Surveillance, Epidemiology, and End Results.

[a]Bright spots were defined as local geographic areas (counties) that demonstrated racial equity in outcomes by meeting "optimal" and "equitable" criteria over the 10-year study period.

[b]The mortality rate ratio (Black death rate/White death rate) was equal to 1.0 when the age-adjusted rates were rounded to 1 decimal place.