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Lung Cancer Mortality in the United States between 1999 and 2019: An Observational Analysis of Disparities by Sex and Race

Lung cancer (LC) is the second most common cancer in the United States and the leading cause of cancer deaths in men and women (1). Previous studies have shown disparities in LC mortality between sexes and races (2–5). Our primary aim was to assess changing disparities in LC mortality in the United States over the past 2 decades.

We extracted LC mortality data (International Classification of Diseases-Tenth Revision, C34) from 1999 to 2019 from the CDC WONDER (Centers for Disease Control and Prevention’s Wide-ranging ONline Data for Epidemiologic Research) database, a comprehensive online public health information system developed and owned by the CDC and its collaborating partners to serve public health practice and research (6). Age-standardized mortality rates (ASMRs) were reported yearly on the basis of race and sex per 100,000 population. Research ethics approval was unnecessary as the data used in this analysis is publicly available. We assessed and compared the four groups’ absolute and relative

changes in LC mortality and used Joinpoint regression analysis to assess trends in LC mortality (Command Line Version 4.5.0.1) (7). Joinpoint regression tests for changes in the model with the sequential addition of Joinpoints in which there is a significant change in the slope of the line and computes an estimated annual percentage change (EAPC) for each trend by fitting a regression line to the natural logarithm of the mortality rates.

Over 20 years, 3,244,746 LC deaths were reported. For White patients, ASMR data were available for all 50 states from 1999 to 2019, plus Washington, DC from 2015. For Black patients, ASMR data were available for 38 states for men and 37 states for women, with varying start and end years. Nationally, ASMR for women decreased from 40.2 (95% confidence interval [CI], 39.9–40.5) to 28.2 (95% CI, 28.0–28.4) (PC, –29.9%), for men from 76.8 (95% CI, 76.3–77.3) to 40.1 (95% CI, 39.8–40.3) (–47.8%), for White population from 55.4 (95% CI, 55.1–55.7) to 34.2 (95% CI, 34.0–34.4) (–38.3%), and Black population from 64.7 (95% CI, 63.7–65.8) to 34.5 (95% CI, 34.0–35.1) (–46.7%). Even though the rate of decline from 1999 to 2019 was steeper in the Black population as compared with the White population, with the steepest for Black men (–54.2%) by 2019, the order of mortality burden was unchanged, with the highest ASMR being in Black men (47.1), followed by White men (40.3), White women (29.4), and Black women (25.9). This indicates even though disparities have decreased with curves almost meeting each other, the disparities certainly still exist. At the same time, at the state level, ASMR decreased in all states except South Dakota (+13.0%) for White women, Kansas (+22.5%) for Black women, and Nebraska (+14.4%) for Black men.

Joinpoint regression demonstrated significant changes in trends over the study period. ASMR for men including both races decreased throughout the study period, whereas women from both races had an initial increase followed by a later decline (Figures 1 and 2 and Table 1), indicating a delay in the peak of

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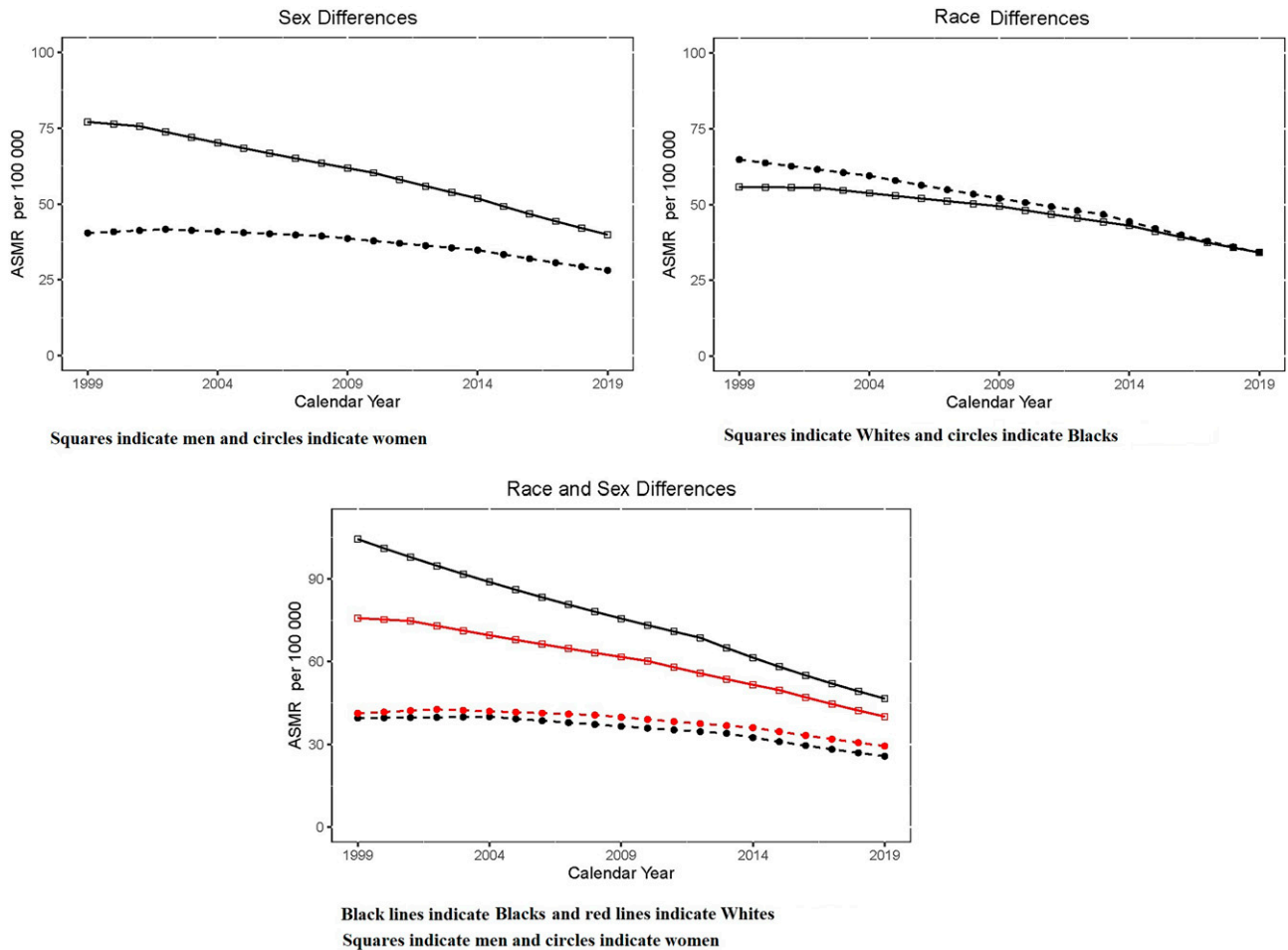


Figure 1. Trends in lung cancer mortality stratified by (A) sex (squares indicate men and circles indicate women), (B) race (squares indicate White patients and circles indicate Black patients), and (C) both sex and race (black lines indicate Black individuals and red lines indicate White individuals; squares indicate men and circles indicate women). ASMR = age-standardized mortality rates.

ASMR for women. For men, the initial trend seen was between 1999 and 2001 (EAPC, -0.9%), followed by a steeper negative trend between 2001 and 2010 (EAPC, -2.5%), 2010 and 2014 (EAPC, -3.7%), and the last and most noticeable change was seen between 2014 and 2019 (EAPC, -5.1%). At the same time, women had an initial positive trend (EAPC, 1.0% [1999–2002]) followed by declining trends (EAPC, -0.9% [2002–2008] and EAPC, -2.1% [2008–2014]). Like men, the most noticeable change was seen in the fourth trend (2014–2019), with a trend of EAPC -4.2% . At the same time, for racial groups, there was a steady decline for Whites, with the highest decline observed from 2009 to 2014 (EAPC, -4.5%). Similarly, Blacks also observed a similar decline, with the highest decline in the last years of the study between 2013 and 2019 (EAPC, -5.1%). Interestingly, all subgroups showed the highest decline in recent years. White men's most notable change was between 2015 and 2019 (EAPC, -5.2%). For Black men, the most notable change was between 2012 and 2019 (EAPC, -5.4%). Women from both races had an initial positive trend followed by negative trends (White women, EAPC, $+1.1\%$ between 1999 and 2002 and Black women, EAPC,

$+0.2\%$ between 1999 and 2004). The most notable change for White and Black women was EAPC, -4.0% (2014–2019) and EAPC, -4.5% (2013–2019), respectively.

All states showed a decrease in ASMR throughout the study period except New York (EAPC, 1.5% [2008–2011]), Missouri (EAPC, 3.2% [2009–2014]), and Indiana (EAPC, 6.9% [2017–2019]) for Black men, and Illinois for White men (EAPC, 0.0% [1999–2001]). For White women, even though ASMR increased initially in many different states (25/51 [49.0%]), there was a decline in all states in recent years. In contrast, only a few states (6/51 [17.1%]) showed an increase in ASMR during the initial years for Black women, with a decline in recent years except for Kansas (34.0% [2017–2019]). Overall, there was a significant variation in state-by-state ASMR for lung cancer (Figure 2), indicating existing disparities within different states.

Compared with White population, we observed that Black population had higher LC mortality rates for 2 decades, which seems to be multifactorial (5). It is found that Black men and women have a twofold likelihood of developing LC between 40 and 54, with a higher smoking-adjusted risk of developing LC



Figure 2. Lung cancer related age-standardized mortality rates (ASMRs) in Black men, White men, Black women, and White women in different states in the United States (2019). All indices are per 100,000 population.

(8–10). However, over the past 20 years, there has been a greater proportional decrease in tobacco smoking among the Black population compared with the rest of the United States population (11, 12). It is also observed that Black patients are less likely to undergo standard-of-care interventions, including surgery, systemic therapy, and radiation, compared with White patients (13–16). Interestingly, it has been demonstrated that Black and White patients experience no difference in lung cancer survival after controlling for stage and socioeconomic factors (17, 18). Studies have also shown that Black patients have better survival with the recent incorporation of biomarker-driven therapies and checkpoint inhibitors (15, 19, 20). A recent study by Howlader and colleagues showed that the decrease in mortality was associated with a substantial improvement in survival over time, which corresponded to the timing of approval of targeted therapy. Similar to our study, they saw a sharp decline in recent years, and survival after diagnosis has improved significantly (21). A 2-year survival improvement related to non small cell lung cancer was noted among all races and ethnic groups (21). The above findings can be contributed to our observation of improvement in LC mortality with proportional improvement in Black patients.

During the same period, there has been an increasing awareness of lung cancer screening (LCS) (22–24). A recent study showed that non-Hispanic White people and people living in the highest income and educational areas showed a significant shift to

an earlier stage of diagnosis coinciding with the introduction of LCS, highlighting the need for efforts to increase LCS access to non-White patients and in underserved areas (25). Recently, the United States Preventive Services Taskforce guidelines lowered the threshold as the lower pack-year smoking history found among Black individuals with LC resulted in many Black individuals falling behind with the older LCS guidelines (26, 27). There are still concerns that these guidelines might result in many Black individuals falling below the limit of 20 pack-years (28). Future studies like ours showing mortality trends will help us evaluate the effects of the newer guidelines.

Strengths and Limitations

The strengths of this investigation include using annual mortality data collected from national surveillance statistics from the CDC. These data have made it possible to assess racial and sex disparities in population-level trends over an extended observation period, allowing comparisons in trends rather than absolute annual mortality rates. Using longitudinal data has also helped comment on overall trends within individual states after standardization and reporting these differences between state health systems. There were a few limitations of our study. We could not assess the prevalence or incidence of LC. However, previous reports have suggested an accelerating decrease in lung cancer incidence, with the absolute number of new LC cases in 2022 projected to be higher in females

Table 1. Trends in lung cancer mortality stratified by sex, race, and both sex and race

	Trend 1			Trend 2			Trend 3			Trend 4		
	Years	EAPC (95% CI)	P Value	Years	EAPC (95% CI)	P Value	Years	EAPC (95% CI)	P Value	Years	EAPC (95% CI)	P Value
Sex												
Women	1999-2002	1 (0.1 to 1.9)	0.026	2002-2008	-0.9 (-1.3 to -0.5)	<0.001	2008-2014	-2.1 (-2.4 to -1.7)	<0.001	2014-2019	-4.2 (-4.5 to -3.8)	<0.001
Men	1999-2001	-0.9 (-2.8 to 1)	0.313	2001-2010	-2.5 (-2.7 to -2.3)	<0.001	2010-2014	-3.7 (-4.6 to -2.8)	<0.001	2014-2019	-5.1 (-5.5 to -4.7)	<0.001
Race												
Black	1999-2004	-1.7 (-2.2 to -1.2)	<0.001	2004-2013	-2.6 (-2.9 to -2.4)	<0.001	2013-2019	-5.1 (-5.5 to -4.7)	<0.001	—	—	—
White	1999-2002	-0.1 (-0.9 to 0.6)	0.739	2002-2009	-1.7 (-1.9 to -1.4)	<0.001	2009-2014	-2.7 (-3.2 to -2.3)	<0.001	2014-2019	-4.5 (-4.8 to -4.2)	<0.001
Race and sex combined												
Black women	1999-2004	0.2 (-0.7 to 1.2)	0.575	2004-2013	-1.8 (-2.2 to -1.4)	<0.001	2013-2019	-4.5 (-5.2 to -3.9)	<0.001	—	—	—
Black men	1999-2012	-3.2 (-3.3 to -3)	<0.001	2012-2019	-5.4 (-5.7 to -5)	<0.001	—	—	—	—	—	
White women	1999-2002	1.1 (0.2 to 2.1)	0.027	2002-2008	-0.8 (-1.2 to -0.4)	0.002	2008-2014	-2 (-2.4 to -1.6)	<0.001	2014-2019	-4 (-4.4 to -3.6)	<0.001
White men	1999-2001	-0.7 (-2.5 to 1.1)	0.416	2001-2010	-2.4 (-2.6 to -2.2)	<0.001	2010-2015	-3.8 (-4.3 to -3.2)	<0.001	2015-2019	-5.2 (-5.8 to -4.7)	<0.001

Definition of abbreviations: CI = confidence interval; EAPC = estimated annual percentage change.

than males for the first time in the United States (24). Also, although the risk for mortality can vary on the basis of the stage and grade as well as different pathological subtypes, this data is not available in the CDC WONDER database, and we are unable to further characterize trends on the basis of these factors. Furthermore, ASMR data was available for only 38 and 37 states for Black men and women, respectively. All the missing states had under 6% of Black population, decreasing the chances of bias in national trends (29). Also, as with any observational study, causal statements could not be made.

Conclusions

In the past 20 years, there has been a significant decrease in LC mortality for men and women and White and Black patients. Although there appears to be a decrease in the disparity in LC mortality between sexes and races, significant disparities remain, with Black men having the highest mortality and men consistently having higher mortality than women. Decreasing the disparities in LC screening and smoking rates might have helped reduce the gaps. Future studies are required to evaluate potential causes of racial and sex disparities in LC mortality and help formulate appropriate strategies to eliminate inequalities. ■

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