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ARTICLE

Averted lung cancer deaths due to reductions in cigarette smoking in the United States, 1970–2022

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Abstract

Lung cancer mortality rates in the United States have declined steeply in recent decades, largely because of substantial reductions in smoking prevalence, as approximately 85% of lung cancer deaths are attributable to cigarette smoking. In this study, the authors estimate the number of averted lung cancer deaths and corresponding person-years of life gained during 1970–2022 as a measure of progress in cancer prevention through tobacco control. By using the 1970–2022 National Center for Health Statistics mortality data (with national coverage), the authors calculated the expected number of deaths for each year, age, sex, race, and age group based on the expected lung cancer death rate multiplied by the population at risk in that group. The number of averted lung cancer deaths were calculated by subtracting the observed number of deaths from the expected number in each group. Person-years of life gained were estimated as a measure of avoided premature mortality based on the average additional years a person would have lived if they had not died from lung cancer. The authors estimated that 3,856,240 lung cancer deaths (2,246,610 in men, 1,609,630 in women) were averted, and 76,275,550 person-years of life (40,277,690 in men, 35,997,860 in women) were gained during 1970–2022, with an average of 19.8 person-years of life gained (17.9 in men, 22.4 in women) per averted death. The number of averted lung cancer deaths accounted for 51.4% of the estimated declines in overall cancer deaths and was substantially greater in men (60.1%) than in women (42.7%). By race, this proportion was 53.6% in the White population (62.8% in men, 44.6% in women) and 40.0% in the Black population (44.4% in men, 34.7% in women). The substantial estimated numbers of averted lung cancer deaths and person-years of life gained highlight the remarkable effect of progress against smoking on reducing premature mortality from lung cancer.

KEYWORDS
lung cancer, cigarette smoking, mortality, prevention, risk factor

INTRODUCTION

Lung cancer mortality rates in the United States have declined in recent decades, by 61% from the peak in men in 1990 and by 38% from the peak in women in 2002.[1] This decline in mortality largely reflects substantial reductions in smoking prevalence[2] because approximately 85% of lung cancer deaths are attributable to cigarette smoking.[3] In the United States, current smoking prevalence in men peaked in the 1950s and remained relatively stable through the early 1960s, whereas the prevalence in women peaked in the early 1960s.[4] After the US Surgeon General's report on smoking and health in 1964,[5] current smoking prevalence in both sexes saw a sustained decline,[4,6,7] from 51.2% in 1965 to 13.2% in 2022 among men, and from 33.7% to 10.0%, respectively, among women.[2,8]

Because most lung cancer deaths are attributable to cigarette smoking,[3] a few studies have estimated the number of averted lung cancer deaths after declines in smoking and lung cancer mortality rates as markers of progress against smoking in the United States. By using national mortality data, for example, a previous study estimated that about 146,000 lung cancer deaths in men during 1991–2003 were averted because of the decline in the lung cancer death rate.[9] That study compared the observed number of lung cancer deaths with expected numbers had the age-specific 1991 lung cancer mortality rates in men remained unchanged through 2003 instead of declining. By constructing simulated smoking histories for individuals born between 1890 and 1970, a modeling study estimated that about 796,000 lung cancer deaths were averted during 1975–2000 because of changes in smoking behavior.[10] Based on the same approach, the number of lung cancer deaths averted during 1975–2020 because of tobacco control was later estimated as 3.45 million.[11] Previous studies, however, did not provide information on person-years of life (PYL) gained, another measure of the toll of avoided premature lung cancer mortality, based on the average additional years a person would have lived if they had not died from lung cancer. PYL gained complement deaths averted as an important indicator of population health.[12] Those studies also did not provide estimates on what proportions of averted all-cancer deaths—because of declines in mortality rates for all cancers combined in recent decades[1]—are attributable to the averted lung cancer burden.

By using national cancer mortality data, we estimate the number of averted lung cancer deaths and corresponding PYL gained during 1970–2022 because of declines in lung cancer mortality rates as a measure of progress in cancer prevention through tobacco control. We also estimate the proportions of averted all-cancer deaths during this period and corresponding PYL gained that are attributable to the averted lung cancer burden.

MATERIALS AND METHODS

Data on lung cancer and all-cancer mortality (based on death certificates; 1970–2022) and life expectancy (1970–2021) in individuals aged 20 years and older by year, sex, race, and age were obtained from the Centers for Disease Control and Prevention's National Center for Health Statistics, which provides complete coverage of the US population.[13,14] Averted lung cancer deaths were estimated overall and for White and Black populations without stratification by Hispanic origin. Other race groups and the Hispanic population were not considered in this analysis because cancer mortality data for these groups were not available for the entire study period (i.e., they were unavailable before 1990).[15] PYL gained were only estimated for the entire US population without stratification by race because race-specific life-expectancy data throughout 1970–2022 were not available for the Black population.

Data on life expectancy were obtained by single years of age, and data on lung cancer mortality were obtained by both single years of age (from 20 through 84 years, and then 85 years and older combined) and age groups (20–29, 30–34, 35–39, …, and 80–84 years, then 85 years and older combined). For 2022, only data on life expectancy at birth and at age 65 years were available, which, compared with 2021, demonstrated 1.3-year and 0.9-year increases at birth in males and females, respectively, and a 0.5-year increase at age 65 years in both sexes.[16] Because age 65 was closer to the average age of lung cancer deaths, for 2022, we used life-expectancy data from 2021 after a 0.5-year increase in life expectancy to all ages included in this analysis. This study used deidentified, publicly available data; thus institutional review board review and informed consent were not needed.

STATISTICAL ANALYSIS

Cancer mortality rates

Trends in all-cancer and lung cancer mortality rates from 1970 to 2022 were examined using Joinpoint software, version 5.2.0.0 (National Cancer Institute), allowing a maximum of five joinpoints. Because cancer mortality rates showed some year-to-year fluctuations, especially in younger ages due to relatively small numbers of deaths, we used the rates based on joinpoint analysis (e.g., blue lines in Figure 1) as the observed rates to obtain more stable results.

In some, generally younger age groups (e.g., men aged 40–44 years), cancer mortality rates showed declining trends from the first year of our study period (Figure 1; see Table S1). For these groups, we considered the observed rate in 1970 as the expected rate in the following years for both sexes. In all other groups, cancer mortality rates increased after 1970 for some time but later declined. When the decline in rates in men immediately followed the period with the fastest increase in rates (e.g., in men aged 55–59 years), we used the peak observed rate as the expected rate in the following years. In other groups, we predicted the expected cancer mortality rates using linear regression models based on rates in years with the highest annual percent increase in rates (e.g., 1970–1982 for men aged 75–79 years; Figure 1). For men, the peak expected cancer mortality rates were set to the predicted rate for the peak year of the observed rate, assuming that smoking prevalence in the

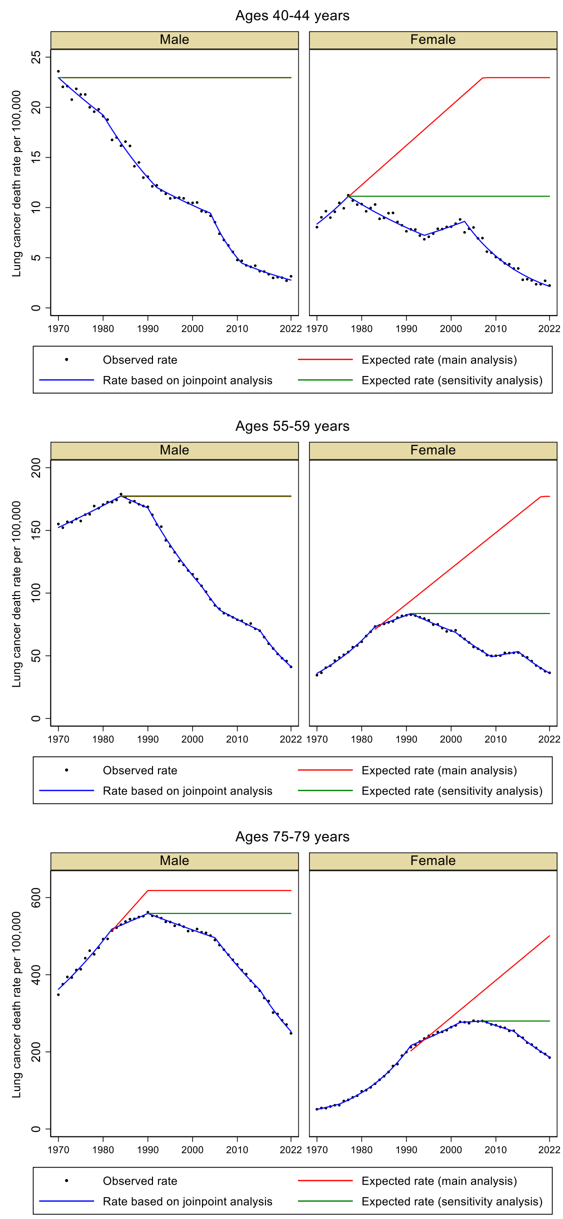

FIGURE 1 Observed and expected lung cancer mortality rates in select age groups by sex, United States, 1970–2022. In some groups (e.g., men aged 40–44 years), cancer mortality rates showed declining trends from 1970, indicating that the peak rate in the corresponding sex, race, and age group occurred in 1970 or earlier. In all other groups, cancer mortality rates increased after 1970 for some time but later declined. In a few groups (e.g., men aged 55–59 years), the decline followed a sharp increase. In many other groups (e.g., men and women aged 75–79 years), the earlier increase in rates slowed down before the decline, likely reflecting declines in smoking prevalence in the first years after tobacco control.

corresponding birth cohort had reached to its peak before 1965; thus, even in the absence of tobacco control, smoking-related cancer death rates would not have increased after the peak year. For women, we assumed the expected cancer mortality rates could increase up to the expected rate in men or until 2022, whichever came first. Although the male–female gap in smoking prevalence in the United States narrowed in more recent decades because of a steeper decline in smoking prevalence in men, the historical peak smoking prevalence in women was considerably lower than in men (see Figure S1) because the tobacco epidemic started later in women.[4,17] Had smoking prevalence in women further increased and approached the peak prevalence in men in the absence of tobacco control, lung cancer mortality rates in women would have been much greater than the observed rates.

Expected lung cancer deaths averted and PYL gained

To calculate the expected lung cancer deaths in each year, sex, race, and age group, we used the expected lung cancer mortality rate multiplied by the population at risk in that year, sex, race, and age group. To calculate 95% confidence intervals, we applied a simulation method in which 1000 repeated draws were generated for log-transformed, expected lung cancer mortality rates for each year, sex, race, and age group. We estimated the number of expected and averted lung cancer deaths in each year, sex, race, and age group in each of 1000 draws using the following equations based on the expected lung cancer mortality rate, the number of observed lung cancer deaths, and population size in the corresponding year, sex, race, and age group.

$$Expected\ N\ of\ lung\ cancer\ deaths = Expected\ rate \times Population$$

$$Averted\ N\ of\ lung\ cancer\ deaths = Expected\ N - Observed\ N$$

The number of PYL gained was calculated as the difference between the expected and observed PYL lost because of premature lung cancer mortality in each year, which were calculated, respectively, by multiplying the expected and observed number of cancer deaths in each sex and single age from 20 to 84 years by corresponding sex-specific and single age–specific residual life expectancy in that year. For the group aged 85 years and older, we used residual life expectancy for age 90 years in the corresponding sex and year (e.g., 3.9 years in men and 4.6 years in women in 2021).[14] Based on 2021 life tables, slightly more than one half of individuals (55%) who were alive at age 85 years were expected to be alive at age 90 years.[14] The numbers of averted lung cancer deaths and related PYL gained were summed over all age groups to obtain total averted deaths and PYL gained by sex. The lower and upper bounds of 95% confidence intervals were the 25th and 975th ordered values from 1000 replications, respectively.

To estimate the proportion of the averted all-cancer burden that is attributable to the averted lung cancer burden, the number of averted lung cancer deaths and PYL gained was divided by the number of averted all-cancer deaths and PYL gained, respectively. We estimated the expected number of all-cancer deaths based on overall cancer mortality rates for each year, sex, race, and age group during 1970–2022 using a method similar to that described above; by using these estimates, the numbers of averted all-cancer deaths and PYL gained were estimated.

In a sensitivity analysis, we repeated the analysis described above but used the peak observed rate as the expected mortality rates in the following years for all sex, race, and age groups, as indicated by the green lines in Figure 1. All analyses were conducted using Stata statistical software, version 15.1 (StataCorp). The numbers of averted cancer deaths and PYL gained by sex may not sum to the totals because all numbers were rounded to the nearest 10.

RESULTS

Lung cancer mortality rates showed declining trends from 1970, the first year of our study, in younger men (age groups younger than 45 years) and women (age groups younger than 40 years; see Table S1). In other age groups, the decline usually started earlier in men than in women, e.g., from 1978 and 1990 for men and women aged 50–54 years, respectively. A similar pattern was observed in White and Black populations. These patterns were consistent with the earlier start of steeper reductions in smoking prevalence in men and younger age groups (see Figure S1 and Table S2).[2]

The total estimated numbers of lung cancer deaths averted and PYL gained during 1970–022 were 3,856,240 and 76,275,550, respectively, with an average of 19.8 PYL gained per averted death (Table 1, Figure 2). These numbers were higher in men (2,246,610 averted deaths, 40,277,690 PYL gained) than in women (1,609,630 averted deaths, 35,997,860 PYL gained), but PYL gained per averted death were higher in women (22.4 years) than men (17.9 years). The number of averted lung cancer deaths during 1970–2022 accounted for 51.4% of an estimated 7,504,040 all-cancer deaths that were averted because of declines in overall cancer mortality rates (Table 1; see Figure S2). This percentage was substantially greater in men (60.1% of 3,738,520 averted all-cancer deaths) than in women (42.7% of 3,765,510 averted all-cancer deaths). A similar pattern existed for the proportion of lung cancer-related PYL gained to all-cancer-related PYL gained in total (53.1% of 143,621,360 all-cancer PYL gained), in men (59.9% of 67,241,060 all-cancer PYL gained), and in women (47.1% of 76,380,310 all-cancer PYL gained).

By race, the estimated number of lung cancer deaths averted during 1970–2022 was 3,182,430 in the White population and 527,360 in the Black population, accounting for 53.6% and 40.0% of all averted cancer deaths during that period in these groups, respectively (Table 2; see Figure S3). In both race groups, the number of averted lung cancer deaths and the proportion of averted lung cancer deaths to averted all-cancer deaths were higher in men than in women.

In the sensitivity analysis using the peak observed cancer death rates as the expected rates for all sex, race, and age groups (see Table S3), the estimated numbers of lung cancer deaths averted (2,168,690) and PYL gained (43,881,500) were lower than the estimates described above. Results of the sensitivity analysis showed larger differences by sex, e.g., about a 3.6-times higher number of averted lung cancer deaths in men (1,696,510) than in women (472,190). The overall averted deaths accounted for 39.0% of averted all-cancer deaths. For the White population, this proportion was substantially lower than the results described above (39.6% vs. 53.6%), but the estimates were more comparable for the Black population (37.3% vs. 40.0%). This difference was largely because of a disproportionally smaller number of averted lung cancer deaths in the White population in the sensitivity analysis than in the main analysis (1,722,350 vs. 3,182,430; ratio = 0.54) compared with the Black population (360,670 vs. 527,360; ratio = 0.68); the corresponding ratios for averted all-cancer deaths in sensitivity and main analyses were the same in White and Black populations (ratio = 0.73).

DISCUSSION

We estimated that, during 1970–2022, approximately 3.9 million lung cancer deaths were averted because of declines in lung cancer mortality rates in the United States, consistent with the estimate from a recent modeling study (3.5 million in 1975–2020).[10] We also estimated that 76 million PYL were gained because of this progress. Moreover, the number of averted lung cancer deaths accounted for approximately one half of the estimated all-cancer deaths that were averted because of declines in overall cancer mortality in recent decades. The estimated numbers of averted lung cancer deaths and PYL gained were still substantial (2.2 million deaths, 44 million PYL gained) after using a more conservative approach, assuming no further increases in lung cancer mortality rates over the observed peak rates in the absence of tobacco control.

Up to 15% of lung cancer deaths in the United States are attributable to factors other than smoking, including environmental (other than smoking) and occupational risk factors.[3] Although data from Canada indicate an increase in exposure to residential radon,[18] which is the second leading risk factor for lung cancer,[19] few data are available on trends in exposure to radon in the United States. In contrast, exposure to some other risk factors, such as asbestos, have substantially declined over the past several decades.[20–22] However, the decline in these exposures, as well as any changes in the prevalence of potentially predisposing inherited genetic variations,[23,24] are unlikely to explain a significant fraction of the 61% and 38% declines in lung cancer mortality rates in men (since 1991) and women (since 2002) in the United States, respectively.[1] Moreover, although there have been important advances in nonsmall cell lung cancer treatment, including targeted therapies and immunotherapies, these treatments were only approved by the US Food and Drug Administration in 2015 or later; currently, they are beneficial to a relatively small fraction of individuals whose tumors have specific mutations.[25,26] As such, although the contribution of continuing advances in treatment is expected to increase in the future, the overall contribution of recent advances to declines in lung cancer mortality rates from 1970 to 2022 is likely modest. For example, previous studies estimated the number of averted lung cancer deaths in the United States because of advances in treatment as 10,000 deaths during 2014–2016[27] and 60,000 deaths

TABLE 1 Estimated number of averted lung cancer and all-cancer deaths and related person-years of life gained because of declines in lung and overall cancer mortality rates in individuals aged 20 years and older by sex: United States, 1970–2022.[a]

Cancer mortality averted	Total	Sex: Male	Sex: Female
Lung cancer mortality averted			
Averted lung cancer deaths	3,856,240 (3,842,110–3,870,210)	2,246,610 (2,243,480–2,249,680)	1,609,630 (1,595,910–1,623,510)
PYL gained	76,275,550 (76,010,010–76,532,560)	40,277,690 (40,230,840–40,324,110)	35,997,860 (35,752,790–36,246,610)
Average PYL gained per averted death	19.78 (19.75–19.80)	17.93 (17.91–17.94)	22.36 (22.30–22.43)
All-cancer mortality averted: All cancers combined			
Averted all-cancer deaths	7,504,040 (7,499,370–7,509,050)	3,738,520 (3,736,390–3,740,850)	3,765,510 (3,761,370–3,770,150)
PYL gained	143,621,360 (143,468,740–143,790,850)	67,241,060 (67,159,370–67,323,890)	76,380,310 (76,249,210–76,521,150)
Average PYL gained per averted death	19.14 (19.13–19.15)	17.99 (17.97–18.00)	20.28 (20.27–20.30)
Lung cancer mortality averted vs. all-cancer mortality averted, %			
Proportion of lung cancer deaths averted to all-cancer deaths averted	51.4	60.1	42.7
Proportion of PYL gained for lung cancer to PYL gained for all cancers combined	53.1	59.9	47.1

Abbreviation: PYL, person-years of life.

[a]Numbers in parantheses indicate 95% confidence intervals. The numbers of averted cancer deaths and PYL gained by sex may not sum to the totals because all numbers were rounded to the nearest 10.

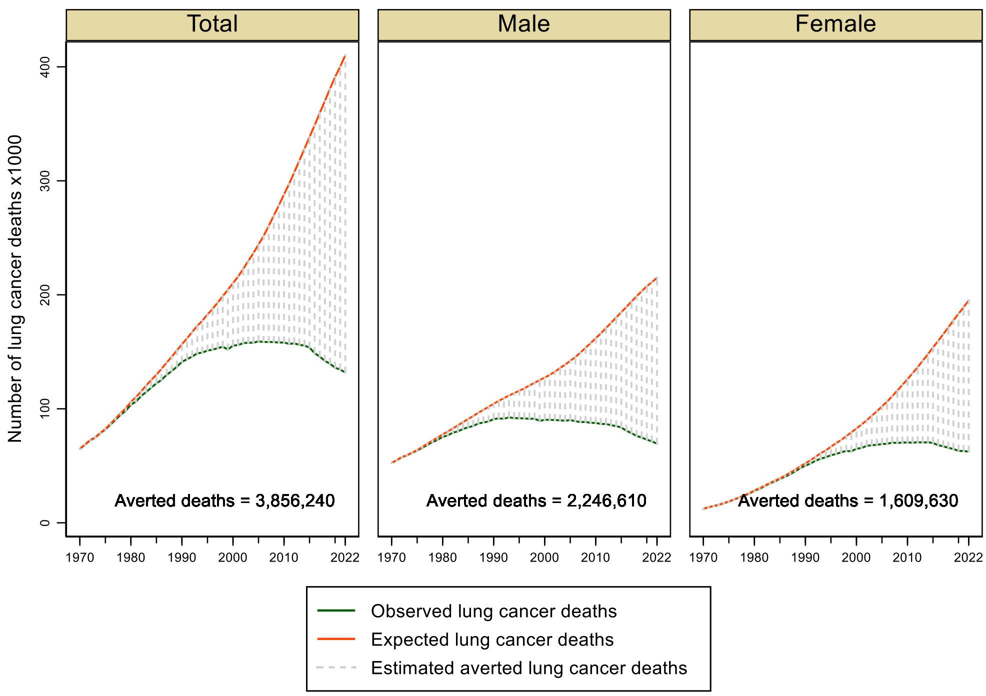

FIGURE 2 Number of observed and expected lung cancer deaths in those aged 20 years and older by sex, United States, 1970–2022.

TABLE 2 Estimated number of averted lung cancer and all-cancer deaths because of declines in lung and overall cancer mortality rates in individuals aged 20 years and older by sex and race: United States, 1970–2022.[a]

Cancer mortality averted by race	Total	Sex: Male	Sex: Female
Lung cancer mortality averted			
White	3,182,430 (3,171,490–3,194,240)	1,835,770 (1,833,070–1,838,270)	1,346,670 (1,335,500–1,358,220)
Black	527,360 (525,550–529,180)	317,120 (316,320–318,020)	210,240 (208,630–211,880)
All-cancer mortality averted: All cancers combined			
White	5,938,650 (5,934,490–5,943,170)	2,922,500 (2,920,570–2,924,440)	3,016,150 (3,012,410–3,020,090)
Black	1,319,320 (1,317,120–1,321,600)	714,040 (712,820–715,160)	605,290 (603,290–607,420)
Proportion of lung cancer deaths averted to all-cancer deaths averted, %			
White	53.6	62.8	44.6
Black	40.0	44.4	34.7

[a]Numbers in parantheses indicate 95% confidence intervals. Numbers of averted cancer deaths by sex may not sum to the totals because all numbers were rounded to the nearest 10. The race groups White and Black include persons of Hispanic and non-Hispanic origin.

during 1970–2020.[11] Before 2013, declines in lung cancer incidence and mortality rates were relatively comparable,[1,27] suggesting that, at the population level, declines in mortality rates were largely driven by declines in incidence rates because of reductions in smoking. Thus the estimated lung cancer deaths averted and PYL gained in our study can largely be attributed to the substantial reduction in cigarette smoking through tobacco control. This also justifies the utilization of our direct method based on lung cancer mortality data rather than making assumptions about changes in smoking prevalence over time and cancer occurrence patterns associated with those projected changes.

Although the estimated numbers of averted lung cancer deaths and related PYL gained in this study are substantial, our findings likely underestimate the averted lung cancer burden because of progress against smoking. We assumed that the expected lung cancer death rates in men would not increase after the peak year for observed rates, suggesting that no increases in smoking prevalence would have occurred after the peak observed prevalence in the corresponding birth cohorts. The expected cancer mortality rates in men were also considered as the maximum expected rates in women. Without tobacco control and subsequent progress against smoking, however, smoking prevalence could have further increased (see Figure S1).[9] It has been estimated that, in the complete absence of tobacco control, per capita cigarette consumption in the United States in 2011 would have been nearly five times higher than the observed consumption.[28] Moreover, declines in lung cancer mortality rates in younger age groups started before 1970,[29] the first year of our study period, suggesting that the actual averted lung cancer deaths and PYL gained are likely to be higher than our estimates.

In addition, our findings do not fully represent health benefits of reductions in smoking because we considered only lung cancer mortality, whereas reductions in smoking reduce mortality from multiple other cancer types and noncancer conditions.[30] In 2019, a total of 169,810 cancer deaths in the United States were attributed to cigarette smoking, of which 51,020 (30%) were deaths from cancer types other than lung cancer.[3] A few modeling studies have estimated averted all-cause deaths associated with reductions in smoking. For example, a study compared all-cause mortality based on smoking histories by birth cohorts and a counterfactual scenario under no tobacco control.[31] That study estimated that 8 million premature deaths in 1964–2012 were averted because of tobacco control, resulting in an estimated 157 million PYL gained.[31] By comparing the number of observed deaths with counterfactual scenarios if tobacco-control policies had remained constant since 1965, another modeling study estimated that 2 million all-cause deaths were averted during 1965–2014 because of the implemented policies.[32] A few other studies have estimated the number of all-cause averted deaths and PYL gained in more recent years and projected the averted burden into the future.[33–35] Although previous studies have used different methods and their results may sometimes vary, they all point to the substantial progress against premature mortality that has been achieved or can be achieved in the future by tobacco control. It should be noted, however, that, despite substantial declines in smoking and lung cancer mortality rates, lung cancer is still the leading cause of cancer death in the United States, with 124,730 deaths expected to occur in 2025.[1] As such, our results underscore that continued and equitable implementation of evidence-based tobacco-control policies can substantially augment the progress against premature mortality.

Among tobacco-control policies, increasing the price of cigarettes through excise taxes has shown the strongest effect in the United States.[36] However, the cigarette excise tax remains low in many states, e.g., <$2 per cigarette pack in 27 states and <$5 in all states except New York and Maryland as of June 2024; the tax ranged from $0.17 in Missouri to $5.35 in New York per cigarette pack and often was lower in states in the South and Midwest.[37] There is also wide variation across states in the implementation of other effective measures to reduce smoking, including assistance with smoking cessation, marketing bans, media campaigns, and smoke-free laws.[38] These collectively contribute to substantial variation in state-level cancer mortality attributable to smoking,[39,40] underscoring the need for expanding comprehensive tobacco-control programs across all states.[41] In particular, these programs should be designed to reach groups at higher risk of smoking. For example, declines in smoking have been much slower among people of lower socioeconomic status,[42,43] in part because of tobacco industry targeting.[44] Compared with individuals who have a college degree, for example, individuals with a high school diploma or lower education levels have about five times higher smoking prevalence[45] and lung cancer mortality rates.[46]

The average PYL gained per averted lung death because of tobacco control in our study, i.e., 19.8 years (1970–2022), is comparable to a previous estimate of 19.6 years for all causes of death (1964–2012),[31] but higher than some other estimates, including 17.4 years (2019)[47] and 14.2–16.5 years (2000–2004)[48] for lung cancer and 11–12 years shorter survival in individuals who currently smoked than in those who never smoked (1997–2004).[49] These differences may be caused in part by differences in study periods, outcomes (lung cancer, all causes of death), and methods. The latter study, for example, estimated the survival probability, which, in addition to age, was adjusted for educational level, alcohol consumption, and body mass index.[49]

In our sensitivity analysis based on peak observed cancer mortality rates, the proportions of the averted all-cancer deaths attributable to the averted lung cancer deaths analysis were comparable in Black and White populations; however, in the main analysis using expected rates based on linear regression models, this proportion was substantially higher in the White population. This difference was because of disproportionally higher expected lung cancer death rates in the White population than in the Black population. This pattern may largely reflect a faster decline in smoking prevalence in younger Black persons from 1965 through the 1980s,[2] in part because of targeted campaigns,[50] consequently resulting in a faster decline in lung cancer mortality rates and lower numbers of expected lung cancer deaths in the following decades. For example, smoking prevalence in individuals aged 18–44 years declined from 66.3% in 1965 to 25.5% in 2000 among Black men, whereas the corresponding decline among White men was from 57.1% to 30.2%.[2] The overall smoking prevalence, however, remains slightly higher in Black men than in White men.[2] Because the prevalence of menthol-flavored cigarette smoking among Black adults who currently smoke is high (83.7% in 2022),[8] expanding the ban on flavored cigarettes to menthol cigarettes can further reduce smoking prevalence in this population.[51,52]

Lung cancer screening as recommended by guidelines can help detect lung cancer at earlier stages, when treatment is more beneficial.[53–55] In 2014–2020, the relative 5-year survival rate was 64% for localized stage lung cancer (confined to the lung) and only 9% for distant stage (metastatic) lung cancer.[1] In 2013, both the US Preventive Services Task Force and the American Cancer Society recommended lung cancer screening with low-dose computed tomography for adults aged 55–80 years who had a 30 pack-year smoking history and currently smoked or had quit within the past 15 years.[53] In 2021, the US Preventive Services Task Force expanded the eligibility by age to 50–80 years and by smoking history to 20 pack-years.[53] In 2023, the American Cancer Society adopted the same age and pack-year recommendation but removed the number of years since quitting smoking as a factor in eligibility for lung cancer screening.[54] Increased utilization of chest computed tomography in clinical practice in the past 2 decades resulted in increased incidental diagnosis of lung cancers, many with smaller tumor sizes.[56] However, increased incidental diagnoses of lung cancers did not coincide with a substantial change in the proportion of localized stage lung cancers at the population level through the first one half of the 2010s; this proportion rose only slightly from 15% in 1999–2005[57] to 16% in 2009–2015[58] and to 17% in 2010–2016.[59] Coinciding with recommendations for lung cancer screening, the proportion later increased more substantially to 27% in 2017–2021.[1] Nevertheless, early detection because of screening is unlikely to have substantially affected the number of averted lung cancer deaths during the time period of our study because screening and the relatively slight increase in the proportion of localized stage lung cancers occurred recently. Receipt of the recommended lung cancer screening among individuals eligible for the screening was very low nationally through 2021 (7% in 2019 and 2021),[60] and it increased only to 18.1% in 2022,[61] which was the last year of our study period. Lung cancer screening prevalence varies substantially across states, from 10% to 31% in 2022, with lower prevalence in southern states, where lung cancer mortality rates generally are the highest.[61]

This study has limitations. First, we only considered lung cancer in this study because most lung cancers are attributable to smoking.[3] In contrast, for many other major conditions that are associated with smoking, a significant proportion of deaths can be attributed to other risk factors, some of which have shown considerable changes in prevalence in the past decades, such as obesity[62] and low-density lipoprotein cholesterol.[63] Moreover, some causes of deaths have seen substantial progress in treatment.[64] As such, it can be challenging to estimate with great certainty the effects of progress against smoking on mortality from many other causes of death. In any case, however, the contribution of tobacco control to reductions in overall mortality is far greater than the contributions to lung cancer alone. Second, we did not examine any effects of advances in treatment or increases in early detection on trends in lung cancer mortality rates. Finally, we were not able to conduct analyses for specific race groups other than White and Black or by ethnicity because of inadequate data, including for the American Indian/Alaska Native population, which has the highest smoking prevalence of all race groups.[8,65]

We estimated that approximately 3.9 million lung cancer deaths were averted and 76 million PYL were gained because of declines in lung cancer mortality rates in the United States, largely reflecting the remarkable progress against smoking. Our results also indicate that about one half of averted all-cancer deaths in recent decades can be attributed to declines in lung cancer mortality rates. Nevertheless, smoking-attributable morbidity and mortality from cancer or other conditions remain high, and mortality from lung cancer remains the leading cause of cancer death in the United States. Stronger commitment to tobacco control at the local, state, and federal levels would additionally reduce smoking and the associated health burden. Needed interventions include substantially increasing the price of cigarettes through excise taxes and enhancing support for smoking cessation.

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CONFLICT OF INTEREST STATEMENT

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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