Lung Cancer Mortality among Nonsmokers in the United States: Estimating Smoking-Attributable Mortality with Nationally-Representative Data

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Abstract

Although 80–90% of lung cancer deaths occur among smokers, many nonsmokers die from lung cancer. Insights into lung cancer mortality among nonsmokers are critical because indirect approaches for estimating smoking-attributable mortality use the difference between observed lung cancer death rates and expected lung cancer death rates among nonsmokers to measure smoking burden. Our study compares lung cancer mortality among nonsmokers from the nationally-representative 1985–2011 National Health Interview Survey Linked Mortality Files (NHIS-LMF) with the non-representative Cancer Prevention Study II (CPS-II). We find that lung cancer death rates among nonsmokers are higher in the NHIS-LMF than in the CPS-II. Second, we find that smoking-attributable fractions, based on the Preston-Glei-Wilmoth indirect method, are slightly lower with NHIS-LMF rates than with CPS-II rates. Despite much lower lung cancer mortality rates among nonsmokers in CPS-II than NHIS-LMF, smoking-attributable fractions based on non-representative CPS-II data do not appear to be biased.

Keywords: smoking; mortality; lung cancer; United States; National Health Interview Survey; Cancer Prevention Study II

Introduction

Lung cancer is the leading cause of cancer death in the United States, accounting for about 25% of cancer deaths (Murphy et al. 2017). Although cigarette smoking is responsible for the majority (80–90%) of lung cancer deaths (Ezzati and Lopez 2003; Thun et al. 1997), a considerable number of lung cancer deaths occur among lifetime never-smokers. For example, if lung cancer among nonsmokers is treated as its own disease category, it still ranks among the 10 most common causes of cancer death, comparable in mortality burden to cervical cancer and leukemia among women and kidney and liver cancer among men (Samet et al. 2009; Thun et al. 2006; Wakelee et al. 2007). Thus, lung cancer mortality has an important impact on population health beyond the contribution of smoking.

Because smoking is the main source of variation in lung cancer mortality, researchers often examine only nonsmokers to identify risk factors for lung cancer death other than smoking, which include secondhand smoke exposure, radon, occupational exposure, indoor/outdoor air pollution, and previous lung disease (Diver et al. 2018; Mayne et al. 1999; Samet et al. 2009; U.S. Department of Health and Human Services 2006). Moreover, indirect approaches for estimating smoking-attributable mortality, such as the Peto-Lopez method (Peto et al. 1992, 1994) and Preston-Glei-Wilmoth (PGW) method (Preston et al. 2010a, 2010b), subtract expected lung cancer death rates among nonsmokers from observed lung cancer deaths rates as a proxy indicator for a population’s cumulative smoking burden. This excess lung cancer mortality serves as a reliable marker of smoking-related damage to then identify smoking-attributable mortality from other causes of death.

Lung cancer death is relatively rare among nonsmokers, so large datasets are necessary to estimate reliable age- and sex-specific rates. Most applications of the indirect approaches for estimating smoking-attributable mortality import lung cancer death rates among nonsmokers from the Cancer Prevention Study II (CPS-II), a sample that consists of over 1.2 million respondents recruited by American Cancer Society volunteers with mortality follow-up from 1982 to 1988 (Thun et al. 1997). However, the CPS-II is not nationally-representative of the U.S. population, and the respondents are disproportionately non-Hispanic white and college-educated (Garfinkel 1985; Peto et al. 1992). Lung cancer death rates among nonsmokers in this advantaged group may be lower than for the overall US population. The lower mortality rates in CPS-II could overestimate smoking-attributable mortality.

The National Health Interview Survey Linked Mortality Files (NHIS-LMF) present a nationally-representative alternative to CPS-II for estimating the contribution of smoking to adult mortality risk (Lariscy et al. 2018; Malarcher et al. 2000; Rogers et al. 2005; Sterling et al. 1993). By pooling annual cross-sectional surveys and linking them to the National Death Index (NDI), the NHIS-LMF is now large enough to estimate stable lung cancer death rates among nonsmokers, with the added advantage of being generalizable to the U.S. adult population. Previous studies questioned the generalizability of the CPS-II and explored whether nationally-representative data may better reflect smoking-attributable mortality than the CPS-II. Sterling et al. (1993) used 1987 National Health Interview Survey (NHIS) combined with the 1986 National Mortality Followback Survey (NMFS) to estimate smoker-nonsmoker risk ratios with the Peto-Lopez indirect method to estimate absolute and relative mortality risk from selected smoking-related causes. They found that the NHIS/NMFS lung cancer death rates among nonsmokers are higher than CPS-II rates among men ages 60+. The resulting mortality risk ratios were higher with CPS-II data than NHIS/NMFS data for nearly every cause of death they examined. Malarcher et al. (2000) also used NHIS/NMFS data to examine mortality relative risk from four broad cause-of-death categories that are associated with smoking. They found that smoking-attributable mortality based on CPS-II data was 19% higher compared with the NHIS/NMFS data. However, they limited the sample to white adults only, which reduced the generalizability of their results. More recent studies have used 1997–2006 NHIS Sample Adult Files (i.e., a subset of NHIS respondents) linked to NDI to examine the contribution of smoking to the United States' poor life expectancy relative to other high-income countries (Rostron 2010; Rostron and Wilmoth 2011). These prior studies used data that is now dated or only used a few years of NHIS data. Since lung cancer deaths among nonsmokers are rare, it is necessary to pool several years of data together to estimate stable rates. A need exists for estimates that pool as many years of NHIS-LMF possible and run through a contemporary time period.

An extensive literature has also estimated the annual number of lung cancer deaths that occur among lifetime never smokers. However, results have been far from conclusive, with estimates ranging from 16,000 to 24,000 deaths (Samet et al. 2009). The proportion of nonsmokers among US adults has grown in recent cohorts as the US has reached a mature stage of the tobacco epidemic (Thun et al. 2012). In 1965, a year after the U.S. Surgeon General report concluded a causal link between smoking and lung cancer, 52% of US men and 34% on US women smoked (Cummings and Proctor 2014). In 2016, the proportion of smokers has fallen to 17.5% and 13.5% among men and women, respectively (Jamal et al. 2018). Thus, contemporary estimates of the number of lung cancer deaths among nonsmokers are needed.

In this study, we estimate lung cancer mortality rates among nonsmokers using nationally-representative, contemporary NHIS-LMF data and compare these estimates to non-representative CPS-II rates. Next, we use the NHIS-LMF rates to estimate the annual number of lung cancer deaths among nonsmokers for the U.S. adult population using the 2010 US population. Finally, we import rates from both the NHIS-LMF and CPS-II into the PGW indirect method to determine whether smoking-attributable fractions (SAFs) differ.

Methods

Data

We use a special-request file of the 1985–2011 NHIS-LMF to estimate lung cancer mortality rates among lifetime never-smokers. The NHIS is an annual, in-person survey that is nationally-representative of the noninstitutionalized US population, conducted by the National Center for Health Statistics (NCHS). About 670,000 respondents reported smoking behavior in supplements to the core questionnaire (1985, 1987, and 1990–1995) and in Sample Adult Files (1997–2009). Lung cancer death is relatively uncommon among nonsmokers, so we pooled 21 years of NHIS cross-sections together to have enough lung cancer deaths among nonsmokers to calculate stable rates. Pooling data over more than two decades should not bias estimates, because prior research has found no trend in lung cancer mortality among nonsmokers (Thun et al. 2008). Vital status of NHIS respondents is ascertained through 2011 by probabilistic linkage to the NDI. Details of the NHIS-LMF have been previously reported (Lochner et al. 2008; NCHS 2013). Analyses included 1,593,633 person-years contributed by nonsmokers, 625 of whom died from lung cancer during the follow-up period. We apply sample weights that are adjusted for NDI linkage eligibility.

In addition to the NHIS-LMF, we use data from three other sources. First, we compare our NHIS-LMF estimates of lung cancer death rates among nonsmokers to those produced with the CPS-II (Thun et al. 1997). Second, we use US-specific coefficients from the PGW formula for estimating smoking-attributable mortality, which were produced by Fenelon and Preston

(2012) with 1996–2004 U.S. vital statistics data. Third, we use the number of deaths from lung cancer and other causes of death from the U.S. National Vital Statistics System. We use the number of deaths from lung cancer, causes other than lung cancer, and all causes combined in 2004 (the last year of data used by Fenelon and Preston) to estimate SAFs. We also draw on the number of lung cancer deaths in 2010 (the end of the NHIS-LMF follow-up period in our data) to estimate the number of lung cancer deaths among nonsmokers.

Measures

Nonsmokers report smoking fewer than 100 cigarettes in their lifetime. We exclude current smokers, former smokers, and respondents missing on smoking status from analyses. Note though that we include current and former smokers to estimate the proportion of NHIS-LMF respondents who are nonsmokers. We limit age to 50+ years since lung cancer deaths are relatively rare at younger ages. About 97% of all cancer deaths occur at ages 50+ (US DHHS 2018). We categorize age into five-year groups (50-54, 55-59,…, 85+). We stratify analyses by sex throughout because of sex differences in smoking prevalence and mortality risk (Pampel 2002; Preston and Wang 2006).

The outcome of interest is death from lung cancer, coded as 162 in the International Classification of Diseases, Ninth Edition (ICD-9) and C33–C34 in ICD-10. In ICD-9, 162.0 indicates malignant neoplasm of the trachea, 162.2 indicates malignant neoplasm of the bronchus, and 162.3–162.9 indicate malignant neoplasm of the bronchus and lung. In ICD-10, C33 is malignant neoplasm of the trachea, and C34 is malignant neoplasm of bronchus and lung. Thus, the results present detail on cancers of the trachea, bronchus, and lung, not solely lung cancer. Respondents are censored if they survive through December 31, 2011 or die from a cause of death other than lung cancer. We analyzed a special-request file that includes complete ICD-9 and ICD-10 codes in a Federal Statistical Research Data Center since lung cancer deaths are combined with all cancer deaths for years 2007 and later in public-use NHIS-LMF data.

Analytic Approach

We estimated weighted age- and sex-specific mortality rates from lung cancer (per 1,000 person-years) among never smokers by dividing the number of lung cancer deaths among nonsmokers by a count of person-years contributed by nonsmokers during the follow-up period. We compare our nationally-representative NHIS-LMF rates to CPS-II rates.

We estimate the annual number of lung cancer deaths among never smokers ($D_{x,L,n}$) with the following formula:

$$D_{x,L,n} = \sum_{x=50-54}^{85+} [(p_{x,n} \times N_x) \times (m_{x,L,n})], \quad (1)$$

where $p_{x,n}$ is the proportion of never smokers in 5-year age group x, N_x is the age-specific population, and $m_{x,L,n}$ is the death rate from lung cancer among never smokers in age group x. The proportion of nonsmokers and lung cancer death rates among never smokers come from our NHIS-LMF data, and population counts come from 2010 Census data (Howden and Meyer 2011).

We use the PGW indirect method to compare the influence of using lung cancer mortality rates among nonsmokers from NHIS-LMF versus CPS-II to estimate smoking-attributable mortality among U.S. adults (Fenelon and Preston 2012; Preston et al. 2010a, 2010b). The PGW method produces similar results as the older Peto-Lopez method but makes fewer assumptions. Whereas the Peto-Lopez method imports relative risks for a few causes of death other than lung cancer from CPS-II and halves them to account for possible confounding, the PGW method relies on the macro-level association between lung cancer mortality and mortality from other causes of death combined to assess smoking-attributable causes. The PGW method relies on lung cancer death rates among nonsmokers to estimate SAFs from lung cancer, causes of death other than lung cancer, and all causes. We estimate each value with both NHIS-LMF and CPS-II rates and then compare SAFs.

The first step of the PGW method determines the fraction of lung cancer deaths due to smoking (A_L) with the following formula:

$$A_L = \frac{M_L - \lambda_L^N}{M_L}, \tag{2}$$

where M_L is the observed lung cancer death rate and λ_L^N is the expected lung cancer death rate among nonsmokers. We must also consider deaths due to smoking from causes of death other than lung cancer. Lung cancer accounts for only about a quarter of smoking-attributable deaths (Thun et al. 1997). Other causes of death linked to smoking include other cancers, heart diseases, respiratory diseases, and stroke (Carter et al. 2015; Lariscy et al. 2018; US DHHS 2014). The PGW method estimates the fraction of deaths from causes of death other than lung cancer (A_O):

$$A_O = 1 - e^{-\beta_L'(M_L - \lambda_L^N)}, \tag{3}$$

where the regression coefficient β_L' represents the association between lung cancer death rates and death rates for all other causes of death combined, net of age, year, and state of residence. We derive age-specific coefficients for the association between lung cancer mortality and mortality from all other causes of death for US adults ages 50–84 from Fenelon and Preston (2012). These coefficients are well suited for the current study because they are based on the US population whereas coefficients estimated by Preston et al. (2010a, 2010b) were based on 20 or 21 developed countries that vary in smoking prevalence, smoking-attributable fraction, and stage of the tobacco epidemic. Fenelon and Preston excluded ages 85+ due to concerns about implausibly high levels of smoking-attributable mortality among older US women produced by the PGW method. We also limit this step of our analyses to ages 50–84.

The final formula combines the SAFs and number of deaths from lung cancer and other causes of death to estimate the SAF for all causes:

$$A = \frac{A_L D_L + A_O D_O}{D}, \tag{4}$$

where D_L is the number of lung cancer deaths, D_O is the number of deaths from causes other than lung cancer, and D is the number of deaths from all causes among US adults 50–84 in 2004.

Results

Lung Cancer Death Rates among Never Smokers in NHIS-LMF and CPS-II

We find that NHIS-LMF lung cancer death rates among nonsmokers are higher than CPS-II rates (Table 1 and Figure 1). In both the NHIS-LMF and CPS-II series, lung cancer death rates among nonsmokers increase with age and rates diverge more at older ages than younger ages. Rates are higher among men than women in both series, perhaps due to men's elevated exposure of harmful substances in mining and other occupational settings, such as radon and asbestos.

[Table 1 and Figure 1 about here]

Recall that the PGW indirect method uses excess lung cancer mortality (i.e., the difference between a population's observed lung cancer death rates and expected lung cancer death rates among nonsmokers) as a marker of cumulative smoking burden. If CPS-II underestimates lung cancer death rates among nonsmokers, then this proxy of excess lung cancer mortality may be too large, and the contribution of smoking to mortality may be overstated.

Number of lung cancer deaths among nonsmokers

We use these NHIS-LMF lung cancer death rates among nonsmokers, along with the proportion of nonsmokers in NHIS-LMF and the 2010 US population size, to estimate the number of lung cancer deaths among US nonsmokers in 2010 (Table 2). We find 9,775 female deaths and 6,379 male deaths from lung cancer, or 16,154 total deaths. These numbers represent 14% and 7% of lung cancer deaths among women and men, respectively. Our percentages affirm the estimate of 80–90% of lung cancer deaths occurring among smokers reported in prior research (Ezzati and Lopez 2003; Thun et al. 1997).

[Table 2 about here]

We observe more deaths among women than men. Although men exhibit higher mortality rates from lung cancer, a higher proportion of women than men are nonsmokers. In the absence of smoking, lung cancer mortality would not be completely eradicated, but it would be substantially reduced.

The proportion of nonsmokers is higher among women than men in every age group. Among men, the proportion of nonsmokers is higher among younger cohorts. For instance, 42% of men have never smoked at ages 50–54, and 31% of men have never smoked at ages 70–74. In contrast, among women ages 50–74, the percent of nonsmokers is consistently more than half. The proportion of nonsmokers is especially high at ages 75+ due to selective survival at the oldest ages and should be interpreted with caution (Christopoulou et al. 2011).

Smoking-Attributable Mortality

Tables 3 and 4 compares SAFs using both NHIS-LMF data and CPS-II data to estimate lung cancer mortality among nonsmokers. The percentage of deaths attributable to smoking is somewhat lower with lung cancer mortality rates among nonsmokers from NHIS-LMF than CPS-II. SAFs estimated with the PGW indirect method are slightly lower with NHIS-LMF rates (19% of male deaths and 16% of female deaths) than with CPS-II rates (21% of male deaths and 17% of female deaths). The reduced percentage is due to the higher rates in NHIS-LMF, which results in smaller differences between observed lung cancer death rates and expected lung cancer death rates among nonsmokers. In each case, attributable risk from smoking is higher among men than women. Despite much higher lung cancer mortality rates among nonsmokers in the NHIS-LMF compared with the CPS-II, SAFs are similar regardless of which rates are used to assess excess lung cancer mortality. Thus, smoking-attributable fractions based on non-representative CPS-II data do not appear to be biased.

[Tables 3 and 4 about here]

Discussion

Although most lung cancer deaths are due to smoking, a considerable number of nonsmokers die from lung cancer. Additionally, lung cancer death rates among nonsmokers are used by indirect methods to estimate smoking-attributable mortality. Many countries undergoing the tobacco epidemic do not have large population-based studies that measure smoking status and then ascertain vital status through follow-up or linkage to death certificates. For these populations, indirect methods are the only option to measure smoking-related mortality. However, indirect methods can only estimate smoking-attributable mortality if they have an accurate estimate of excess lung cancer mortality (i.e., the difference between a population's observed lung cancer mortality and the expected lung cancer mortality in the absence of smoking).

We estimated lung cancer mortality among nonsmokers using the large, nationally-representative NHIS-LMF and compared our rates to the CPS-II. We found that our NHIS-LMF rates are higher than CPS-II rates among women and men and especially at older ages. Despite much higher lung cancer rates among nonsmokers in NHIS-LMF compared with CPS-II, SAFs with NHIS-LMF rates were only slightly lower than with CPS-II rates: one percentage point lower among women and two percentage points lower among men. Thus, prior studies that used CPS-II rates with indirect methods likely were not biased in their estimates of smoking-attributable mortality.

Because a small proportion of lung cancer deaths occur among nonsmokers, large datasets are necessary. Previous efforts to examine lung cancer mortality among nonsmokers utilized datasets that are not nationally representative or current, samples that are diverse but geographically restricted (e.g., the Multi-Ethnic Cohort data), or case-control studies. Our study is the first to use contemporary, nationally-representative data to examine lung cancer mortality among nonsmoking U.S. adults. Nationally-representative data should be used with national vital statistics data in order to estimate excess mortality from lung cancer and other causes of death. Thus, future applications of the PGW or Peto-Lopez indirect methods should use lung cancer death rates among never smokers derived from NHIS-LMF rather than CPS-II.

We document higher lung cancer death rates among nonsmokers in NHIS-LMF than CPS-II, but our data do not allow us to explain which factors account for differences. The differences are likely due to compositional differences between the two datasets: the NHIS-LMF is nationally-representative of the US population, whereas the CPS-II is not. For instance, the NHIS-LMF includes a larger proportion of racial/ethnic minority respondents than CPS-II. Thun and colleagues (2006) noted that nonsmoker lung cancer mortality was higher among black women than white women. A similar racial comparison could not be made among men because of too few lung cancer deaths among non-smoking black men. Unequal access to treatment could account for racial differences in lung cancer mortality among nonsmokers (Alberg et al. 2013). The CPS-II sample also has disproportionately higher socioeconomic status (SES) than the US population. Smoking is becoming increasingly concentrated among groups with low SES (de Walque 2010; Meara et al. 2008), so low SES nonsmokers may be exposed to more secondhand smoke in their homes and workplaces. They may also encounter lung cancer risk factors other than smoking, such as occupational exposures (e.g., asbestos and radon) and air pollution due to residence in substandard housing or near industrial sites. Although the NHIS-LMF is more recent than the CPS-II data, lung cancer death rates among nonsmokers tend to be consistent over time (Thun et al. 2008). Thus, the higher lung cancer mortality among nonsmokers in the NHIS-LMF compared with CPS-II is likely a result of differences in composition rather than time. More explanatory research is needed to address our descriptive finding of higher rates in NHIS-LMF than CPS-II. Studies are especially needed to address lingering debates on lung cancer risk among nonsmokers regarding gender differences in lung cancer incidence and mortality, estimates among small racial/ethnic minority groups, and trends over time (Samet et al. 2009; Thun et al. 2006).

Limitations

Some limitations must be noted. First, although our NHIS-LMF data are nationally-representative data, sample sizes are not large enough to allow us to stratify by race/ethnicity or socioeconomic status. Future research should explore whether low SES and/or minority groups that are included in the NHIS-LMF data but underrepresented in CPS-II data account for the higher lung cancer death rates among nonsmokers in NHIS-LMF. Second, misclassification of smoking status could lead some very light/intermittent or former smokers to be classified as never smokers. Individuals may be coded as nonsmokers but still consume other tobacco products (including cigars and pipes). However, self-reports of smoking status tend to be valid and are supported by studies that measure serum cotinine levels (Caraballo et al. 2001). Third, lung cancer may be misdiagnosed among nonsmokers, especially among older adults who experience multiple, concurrent chronic conditions (Anderson 2011; Preston et al. 2010a). Relatedly, lung cancer may be listed as a contributing factor but not the underlying cause of death given the belief that lung cancer is very rare among nonsmokers. Finally, although our data cover a 21 year period, we were not able to address the debate regarding whether lung cancer mortality rates among nonsmokers have increased, decreased, or remained stable over time. We pooled deaths across all years to have sufficient numbers of deaths to produce stable rates within sex- and-age-specific subgroups.

Conclusion

Although our study finds non-negligible levels of lung cancer mortality among lifetime nonsmokers, cigarette smoking remains the dominant risk factor for lung cancer mortality. Smoking accounts for one in five deaths in the United States overall and 80–90% of lung cancer deaths. The greatest gains in lung cancer mortality reduction will be wrought by policies that reduce smoking prevalence. Workplace and indoor smoking bans are key interventions to protecting those who decide not to smoke from exposure to the carcinogenic substances in secondhand smoke as well as promoting smoking avoidance and cessation (Farrelly et al. 1999; Pickett et al. 2006).

With declines in smoking prevalence and growth in the number of smoke-free Americans, medical professionals must be mindful of the unique aspects of lung cancer among the nonsmoking population. Cancer is usually defined by stage and grade, and it is likely that, compared with nonsmokers, smokers have cancers that develop faster and that are more likely to metastasize. Compared with current and former smokers, nonsmokers tend to be diagnosed with lung cancer at older ages, exhibit better response to treatments, and have higher survival rates (Wakelee et al. 2007). Continued research on lung cancer mortality among nonsmokers can provide more targeted approaches for improved strategies for the prevention, detection, and treatment of lung cancer among nonsmokers.

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Table 1 Lung cancer death rates (per 1,000) among never smokers, U.S. adults ages 50+

	Female		Male	
Age group	NHIS-LMF	CPS-II	NHIS-LMF	CPS-II
50–54	0.09	0.06	0.12	0.06
55–59	0.15	0.07	0.20	0.05
60–64	0.23	0.12	0.32	0.12
65–69	0.25	0.17	0.44	0.22
70–74	0.36	0.31	0.63	0.35
75–79	0.45	0.33	0.79	0.52
80–84	0.80	0.58	1.05	0.89
85+	0.97	0.61	1.36	0.87

Note: NHIS-LMF rates are estimated for years 1985–2011. CPS-II rates are estimated for years 1982–1988 (Thun et al. 1997).

Table 2 Number of lung cancer deaths among never smokers in 2010, U.S. adults ages 50+ years

	Lung cancer rates among nonsmokers (per 1,000)[a]	Proportion of never smokers[a]	2010 US population[b]	Estimated number of lung cancer deaths among never smokers in 2010
Women				*9,775*
50–54	0.09	0.53	11,364,851	525
55–59	0.15	0.53	10,141,157	778
60–64	0.23	0.52	8,740,424	1,045
65–69	0.25	0.52	6,582,716	843
70–74	0.36	0.55	5,034,194	991
75–79	0.45	0.60	4,135,407	1,112
80–84	0.80	0.65	3,448,953	1,802
85+	0.97	0.74	3,703,754	2,680
Men				*6,379*
50–54	0.12	0.42	10,933,274	552
55–59	0.20	0.38	9,523,648	734
60–64	0.32	0.34	8,077,500	876
65–69	0.44	0.31	5,852,547	805
70–74	0.63	0.31	4,243,972	824
75–79	0.79	0.32	3,182,388	795
80–84	1.05	0.34	2,294,374	812
85+	1.36	0.40	1,789,679	981

[a] Estimated from 1985–2011 NHIS-LMF.

[b] U.S. population counts are drawn from the 2010 U.S. Census (Howden and Meyer 2011).

Table 3 Smoking-attributable fractions with NHIS-LMF in 2004, U.S. adults ages 50+ years

	Lung cancer death rates (per 1,000)[a]	Lung cancer death rates among never smokers[b]	A_L	β'_L	A_O	Lung cancer deaths in 2004 (D_L)	Deaths from causes other than lung cancer in 2004 (D_O)	A
Women								
50–54	0.31	0.09	0.72	0.207	0.045	3,136	34,054	0.10
55–59	0.61	0.15	0.76	0.175	0.078	5,186	42,673	0.15
60–64	1.13	0.23	0.79	0.087	0.075	7,469	51,541	0.17
65–69	1.75	0.25	0.86	0.085	0.120	9,315	64,374	0.21
70–74	2.39	0.36	0.85	0.069	0.131	11,275	92,116	0.21
75–79	2.75	0.45	0.84	0.056	0.121	11,857	138,719	0.18
80–84	2.80	0.80	0.71	0.039	0.075	9,620	190,630	0.11
Weighted average	—	—	—	—	—	—	—	0.16
Men								
50–54	0.31	0.09	0.72	0.297	0.064	58,078	58,078	0.16
55–59	0.61	0.15	0.76	0.186	0.083	65,928	65,928	0.20
60–64	1.13	0.23	0.79	0.111	0.095	74,053	74,053	0.24
65–69	1.75	0.25	0.86	0.073	0.104	85,440	85,440	0.25
70–74	2.39	0.36	0.85	0.046	0.089	109,449	109,449	0.23
75–79	2.75	0.45	0.84	0.027	0.060	144,738	144,738	0.18
80–84	2.80	0.80	0.71	0.016	0.032	162,271	162,271	0.11
Weighted average	—	—	—	—	—	—	—	0.19

[a] Lung cancer mortality rates (per 1,000) are estimated with 2004 U.S. vital statistics data.

[b] Estimated from 1985–2011 NHIS-LMF.

Note: β'L derived from Fenelon and Preston (2012).

Table 4 Smoking-attributable fractions with CPS-II in 2004, U.S. adults ages 50+ years

	Lung cancer death rates (per 1,000)[a]	Lung cancer death rates among never smokers[b]	A_L	β'_L	A_O	Lung cancer deaths in 2004 (D_L)	Deaths from causes other than lung cancer in 2004 (D_O)	A
Women								
50–54	0.31	0.06	0.81	0.207	0.050	3,136	34,054	0.11
55–59	0.61	0.07	0.89	0.175	0.090	5,186	42,673	0.18
60–64	1.13	0.12	0.89	0.087	0.084	7,469	51,541	0.19
65–69	1.75	0.17	0.90	0.085	0.126	9,315	64,374	0.22
70–74	2.39	0.31	0.87	0.069	0.134	11,275	92,116	0.21
75–79	2.75	0.33	0.88	0.056	0.127	11,857	138,719	0.19
80–84	2.80	0.58	0.79	0.039	0.083	9,620	190,630	0.12
Weighted average	—	—	—	—	—	—	—	0.17
Men								
50–54	0.50	0.06	0.88	0.297	0.123	58,078	58,078	0.18
55–59	0.96	0.05	0.95	0.186	0.156	65,928	65,928	0.24
60–64	1.80	0.12	0.93	0.111	0.170	74,053	74,053	0.27
65–69	2.86	0.22	0.92	0.073	0.175	85,440	85,440	0.28
70–74	4.01	0.35	0.91	0.046	0.155	109,449	109,449	0.25
75–79	5.08	0.52	0.90	0.027	0.116	144,738	144,738	0.19
80–84	5.31	0.89	0.83	0.016	0.068	162,271	162,271	0.12
Weighted average	—	—	—	—	—	—	—	0.21

[a] Lung cancer mortality rates (per 1,000) are estimated with 2004 U.S. vital statistics data.

[b] Estimated from CPS-II.

Note: β'L derived from Fenelon and Preston (2012).

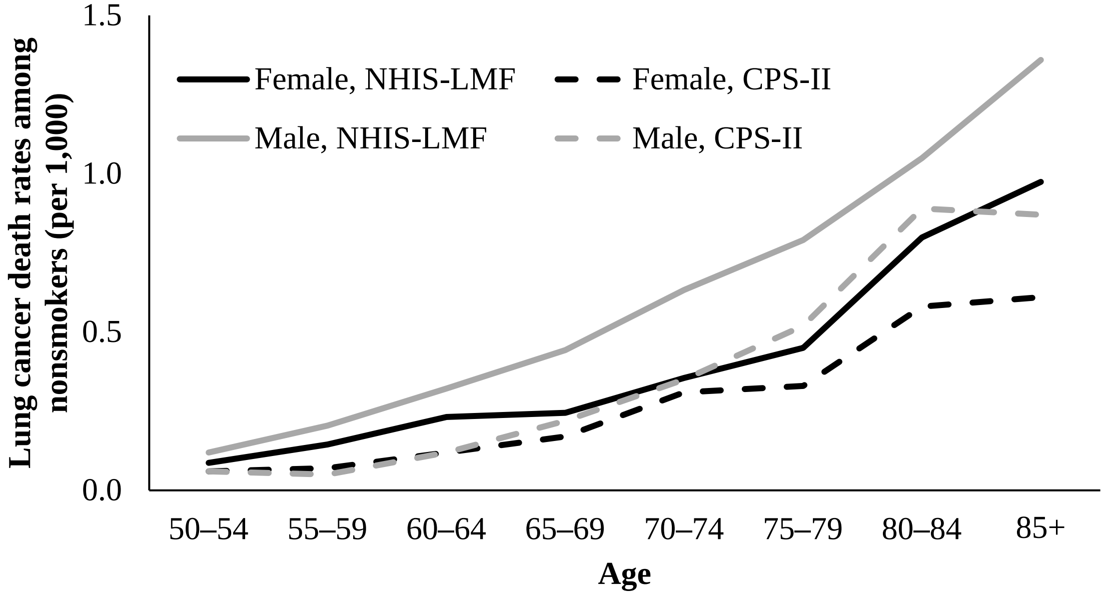

Fig. 1 Lung cancer death rates (per 1,000) among never smokers in NHIS-LMF and CPS-II, U.S. adults ages 50+