“Life Expectancy in Developed Countries in the Absence of Smoking-Attributable Deaths”

Brian Rostron
Center for Tobacco Products
Food and Drug Administration
brian.rostron@fda.hhs.gov

ABSTRACT

This study uses a modified version of the recently proposed Preston-Glei-Wilmoth regression method to estimate smoking-attributable mortality and life expectancy in the absence of smoking-attributable deaths in 20 high-income countries. It finds that life expectancy at age 50 would be on average 2.2 years higher for males and 1.1 years higher for females in these countries in the absence of smoking-attributable deaths. Estimates of smoking-attributable mortality from this modified regression-based method are consistent with estimates from a modified version of the Peto-Lopez indirect method.

1. Introduction

Several recent studies have shown a divergence in mortality trends among developed countries, particularly at older ages.(Janssen, Kunst, and Mackenbach 2007; Mesle and Vallin 2006) Cigarette smoking has been shown to be a leading cause of these differences (Janssen, Kunst, and Mackenbach 2007; Staetsky 2009). Numerous methods exist to estimate smoking-attributable mortality in populations (Perez-Rios and Montes 2008). Many of these methods, such as the method used by the Centers for Disease Control and Prevention (CDC) in the U.S (2005), estimate the proportion of mortality attributable to smoking (smoking-attributable fraction of deaths or SAF) based on smoking prevalence data from health surveys and relative mortality risks of smoking for various causes obtained from epidemiological studies. The indirect method presented by Peto et al. (1992) (commonly called the Peto-Lopez method) uses a similar methodology, but uses lung cancer mortality as a proxy for smoking exposure in place of survey data.

Preston, Glei, and Wilmoth (2010b) recently proposed an innovative regression-based approach for estimating smoking-attributable mortality, which is based on the relationship between lung cancer mortality due to smoking and mortality from other causes caused by smoking. They used this method to produce SAF estimates for 20 high-income countries over time. Rostron (2010), however, showed that this method can over-estimate SAF for females in high-smoking countries such as the U.S. and presented a modified version of the method. Preston, Glei, and Wilmoth (2010a) have acknowledged that their original method can over-estimate female smoking-attributable mortality.

In this study, we use a modified version of the method proposed by Preston, Glei, and Wilmoth to estimate smoking-attributable mortality and life expectancy in developed countries in the absence of smoking-attributable deaths. We use the same group of 20 high-income countries that Preston, Glei, and Wilmoth studied and show that smoking-attributable mortality has a significant effect on life expectancy in these countries. We also show that estimates from the modified method are generally consistent with results from a modified version of the Peto-Lopez method. This modified version of the Peto-Lopez method uses more recent and representative study data and more directly estimates smoking-attributable mortality than does the original Peto-Lopez method.

2. Methods

2.1 PGW and PGW-R Methods

This study uses a modified form of the method proposed by Preston, Glei, and Wilmoth (2010b) (hereafter the PGW method), which uses lung cancer mortality as an indicator of the mortality effects of smoking in order to estimate smoking-attributable mortality. (Some of the following material was presented in an earlier study analyzing the PGW method and introducing a modified version of the method (Rostron 2010).) In summary, the PGW method uses a negative binomial regression approach and models death rates at ages 50-54, 55-59, …, 80-84, and 85+ for causes other than lung cancer as a function of lung cancer death rates and other variables. Mortality for males and females is modeled separately. Specifically, the regression equation for the method is:

$$\ln M_O = \beta_a X_a + \beta_t X_t + \beta_c X_c + \beta_{ct}(t \times X_c) + \beta_L M_L + \beta_{Lt}(M_L \times t) + \beta_{La}(M_L \times X_a), \quad [1]$$

where M_O represents the death rate from causes other than lung cancer by age, sex, year, and country, X_a is a set of dummy variables for each age group, X_t is a set of dummy variables for each year, X_c is a set of dummy variables for each country, (t x X_c) is an interaction term between year as a linear variable and country, M_L represents the lung cancer death rate, (M_L x t) is an interaction term between the lung cancer death rate and year as a linear variable, and (M_L x X_a) is an interaction term between the lung cancer death rate and age group. The highest age group used for the last interaction term is 80+.

We use a modified version of the PGW method (hereafter PGW-R method) that has been shown to improve estimates of smoking-attributable mortality compared to the PGW method (Rostron 2010). This method introduces an age group-year interaction term [$\beta_{at}(t \times X_a)$] into the regression equation shown in Equation 1. Year is treated as a linear variable and the age groups from 50-54 to 85+ are used in this interaction term. Inclusion of this interaction term tends to better model mortality change by age over time, and thus improves estimates of the relationship between lung cancer mortality due to smoking and mortality from other causes due to smoking.

Both the PGW and PGW-R methods then calculate the fraction of lung cancer deaths attributable to smoking (A_L) by country-year-sex-age group by comparing observed lung cancer death rates to expected lung cancer death rates for non-smokers, and dividing the excess lung cancer mortality for the population group by the total lung cancer mortality for this group. Expected lung cancer death rates for non-smokers come from the American Cancer Society Cancer Prevention Study II (CPS-II) (Thun et al. 1997). The smoking-attributable fraction of deaths from causes other than lung cancer (A_O) is then found from the coefficient of the relationship between lung cancer mortality

and mortality from other causes, $\beta_L^{/}$, obtained from the regression analysis represented by Equation 1. This coefficient is equal to the sum of the coefficients β_L, β_{Lt}, and β_{La}. Finally, the smoking-attributable fraction of all deaths is found from A_L and A_O and the numbers of deaths from lung cancer and all other causes.

The regression models for both methods were fit using mortality data by cause from the World Health Organization (WHO) Mortality Database (World Health Organization 2010) and all-cause mortality data and exposure data from the Human Mortality Database (HMD) (University of California - Berkeley and Max Planck Institute for Demographic Research 2010). Preston, Glei, and Wilmoth (2010b) analyzed data from 20 high-income countries that were members of the Organization of Economic Co-operation and Development and had data in the HMD from 1955 onward. An updated version of their dataset, which was provided by the authors, was used in the analyses. Confidence intervals for SAF's from the PGW-R method were constructed using the delta method employed by Preston, Glei, and Wilmoth. Life expectancy in the absence of smoking-attributable deaths in the 20 countries was also calculated with results from the PGW-R method using HMD data. All analyses were conducted using R Version 2.10.0 (2010).

2.2 Peto-Lopez and Modified Peto-Lopez Methods

Results from the PGW-R method have been shown to be generally consistent with results from a modified version of the Peto-Lopez method, which uses more recent and representative study data and more specifically estimates smoking-attributable mortality (Rostron 2010). In this case, the modified Peto-Lopez method was used to estimate

smoking-attributable mortality by age for the U.S. for purposes of comparison with results from the PGW-R method. The modified Peto-Lopez method follows the methodology of the Peto-Lopez method in estimating smoking prevalence by estimating the proportion of the population by sex-age group that would have to be smokers to produce the observed population lung cancer death rates, assuming that population smokers and non-smokers have the same lung cancer death rates as current and never smokers in a study population. These smoking prevalence estimates are then used with relative mortality risks by cause for smokers, again estimated from data for current and never smokers in a study population, in population attributable risk calculations to estimate smoking-attributable mortality. The modified Peto-Lopez method makes three important changes to the methodology of the Peto-Lopez method. First, the modified method uses U.S. National Health Interview Survey (NHIS) data to estimate lung cancer death rates and relative risks for other causes for current smokers and never smokers in place of the original method's American Cancer Society Cancer Prevention Study II (CPS-II) data. The NHIS data are more recent (coming from survey participants from 1997-2003 followed for mortality through the end of 2006) than the CPS-II data (which were collected from years 3-6 of the CPS-II, from 1984-1988). The NHIS data are also more representative of the U.S. population, given that the NHIS is a probability-based survey of the U.S. household population (Pleis and Lethbridge-Cejku 2006). CPS-II participants, in contrast, were recruited by American Cancer Society volunteers and tended to be more likely to be white, middle class, and college-educated and have lower mortality than the U.S. population of the time ((Thun et al. 1997). The second difference between the methods is that the modified Peto-Lopez directly controls for possible

confounding risk factors in the estimation of relative risks, whereas the Peto-Lopez method only assigns half of the excess relative risk for smokers to smoking to control for confounding factors. The NHIS relative risks for smokers used in the modified Peto-Lopez method were estimated by hazard ratios calculated with a Cox proportional hazards model. Educational attainment, family income, race, Hispanic origin, marital status, alcohol consumption, and body mass index were included as control variables in the Cox model. Finally, the modified Peto-Lopez method directly estimates the smoking-attributable fractions of deaths by cause for those aged 80 and over, whereas the Peto-Lopez method uses the same SAF's by cause estimated for persons aged 75-79 for persons aged 80 and over. The modified Peto-Lopez method used here consistently estimates relative risks for current smokers compared to non-smokers at these advanced ages, using the same procedure used at younger ages. The modified Peto-Lopez method tends to produce lower estimates of smoking-attributable mortality for females than does the Peto-Lopez method and similar estimates for males. In the U.S. in 2000 for example, the modified Peto-Lopez method estimates that there were 210,000 smoking-attributable deaths among females and 237,000 deaths among males. The Peto-Lopez method estimates that there were 243,000 deaths among females and 269,000 deaths among males. The difference in estimates from the two methods is greatest for women aged 70 and over; estimates from the Peto-Lopez method are 40% higher than estimates from the modified method for this group. The overall 15% increase in estimates from the Peto-Lopez method compared to the estimates from the modified method is consistent with previous research. Michael Thun, one of the developers of the Peto-Lopez method, and collaborators (Thun, Apicella, and Henley 2000) published estimates of smoking-

attributable deaths in the U.S. in 1990 using CPS-II data and a full set of control variables that were also approximately 15% lower for males and females than the published estimates from the Peto-Lopez method for the U.S. in that year (Peto et al. 2006).

The modified Peto-Lopez method was used to estimate smoking-attributable mortality by age for the U.S. using mortality and population data from the WHO Mortality Database (2010) and the UN (2006). These are the same data sources used by Peto et al. (2006) to calculate their estimates.

The consistency of the NHIS relative risks was evaluated by calculating the relative risks with follow-up limited through the end of the following two calendar years for each study cohort. This analysis was performed to see if the relative risks changed appreciably with longer follow-up time due to factors such as smoking cessation. The relative risks from the shorter follow-up period were almost exactly the same as those from the longer follow-up time, indicating that the relative risks were generally consistent during the follow-up period.

3. Results and Discussion

The age distribution of smoking-attributable deaths estimated by the PGW-R method was first evaluated through comparison with results from the modified Peto-Lopez method. Figure 1 presents results for the U.S. in 2000 for ages 50 and over from both methods. Estimates from the two methods are generally similar with 221,000 deaths for males and 163,000 for females from the PGW-R method and 215,000 deaths for males and 195,000 deaths for females from the modified Peto-Lopez method. Both sets of estimates are also generally consistent with the CDC's estimate of 259,000 annual

deaths for males and 178,000 annual deaths for females at all ages in the U.S. during the period (2005). The estimated age distribution of deaths from both methods is also similar, although there are some differences. The PGW-R method tends to estimate fewer deaths for males aged 50-64 and 70-79 than does the Peto-Lopez method and more deaths for males aged 80 and over. The PGW-R method also tends to estimate fewer deaths for females aged 50-59 and 75 and over and more deaths for females aged 60-74. The principal difference in the estimates from the two methods occurs for females at ages 80 and over. To some extent, the PGW-R method may under-estimate female smoking-attributable mortality at these advanced ages. This under-estimation could be caused by imprecision in estimates of the β_L^l coefficient for these ages, which may be due to limited female smoking-attributable mortality at these ages during most of the period for many of the countries in the dataset. Some of the difference may also be caused by imprecision in the estimates of NHIS relative risks at these advanced ages.

Even with these differences, the estimates of smoking-attributable deaths obtained from the two methods produce similar estimates of life expectancy in the absence of smoking-attributable deaths for both males and females. The PGW-R method estimates that life expectancy at age, e_{50}, in the U.S. in 2000 would have been 30.77 years for males and 34.19 years for females in the absence of smoking-attributable mortality. The modified Peto-Lopez method estimates that e_{50} in the absence of smoking-attributable mortality would have been 30.72 years for males and 34.40 years for females in the U.S. in this year.

The PGW-R method was then used to produce estimates of smoking-attributable fractions of deaths and life expectancy in the absence of smoking-attributable deaths for

high-income countries over time. Table 1 presents the smoking-attributable fractions of all deaths for males and females aged 50 and over in 20 high-income countries in 1955, 1970, and 1985, and 2003 (the last year for which WHO mortality data (2010) was available for all of the countries). The table shows that male smoking-attributable mortality in many of these countries tended to increase appreciably from 1955 to 1970 or 1985. These mortality levels then tended to remain at about the same levels through 2003 in some of the countries such as the Canada and the U.S. and decreased in countries such as Finland and the U.K. Most of the countries that had continuing increases in male smoking-attributable mortality through 2003, such as Japan, Portugal, and Spain, had very low levels of male smoking-attributable mortality in 1955, suggesting that widespread cigarette use among men began at a later time in these countries than in many of the other developed countries and that these countries were essentially "catching up" in terms of smoking prevalence. The one exception to this trend is Hungary, which had fairly typical male smoking mortality levels in 1955 for this group of countries, but saw its male smoking mortality continue to increase until it was the highest of the group in 2003. Hungary is the only Eastern European nation in the group of countries, and it has been well documented that smoking-attributable mortality continued to rise among men in this region, even as it declined in much of the rest of Europe, due to continued high smoking prevalence (Borras et al. 2003).

Table 1 also shows that female smoking-attributable mortality increased from very low or negligible levels in most of the countries in 1955 to higher levels in most of the countries by 1985 and 2003. Some of the first countries to see increases in female smoking-attributable mortality by 1970 were Denmark, the U.K., and the U.S., which

were also some of the same countries specifically identified as having slowdowns in female mortality in older ages in subsequent decades (Janssen, Kunst, and Mackenbach 2007; Mesle and Vallin 2006). Smoking-attributable mortality among women continued to increase in these countries over time, although by 2003 it was common for there to be appreciable levels of smoking-attributable mortality among women in most of the countries.

Table 2 presents comparable estimates from the modified Peto-Lopez method for males and females. Estimates of smoking-attributable mortality from the two methods tend to differ somewhat for males in earlier periods. Some of the difference may due to under-estimation of smoking-attributable mortality for males with the PGW-R method in earlier years. One of the components of the β_L^l coefficient in the PGW-R method is an interaction term between lung cancer mortality and time, which is positive for males. The PGW-R method therefore estimates that the magnitude of the relationship between lung cancer mortality due to smoking for males and smoking-attributable mortality from other causes tends to increase over time, other things being equal. Some of this increase may due to actual mortality trends, but some of the increase may due to imprecise estimation of the relationship between lung cancer mortality and time for males. This imprecision may lead to under-estimates of male smoking-attributable mortality with the PGW-R method for earlier periods, although the method has been shown to produce reasonable estimates of male smoking-attributable mortality for recent years.

Figure 2 presents estimates of e_{50} for males and females in France, Japan, and the U.S. in five-year intervals from 1950 to 2005, calculated with and without smoking-attributable deaths using the PGW-R method. In general, the figure shows the increase in

the effect of smoking mortality life expectancy over time in these countries for both males and females. The figure also graphically illustrates the effect of smoking mortality on slowdowns in gains in life expectancy for males and females in different periods. Figure 2a shows that observed e_{50} for U.S. males was essentially flat from 1955 to 1970, rising only 23.13 years to 23.15 years. Similar very small gains or even declines in male expectancy at this age were observed in countries such as Australia, Belgium, Denmark, the Netherlands, and New Zealand ((University of California - Berkeley and Max Planck Institute for Demographic Research 2010), which, as Table 2a indicates, were generally the same countries with the largest increases in male smoking-attributable mortality during the period. Figure 2a also shows, however, that in the absence of smoking deaths U.S. male e_{50} would have increased from 24.40 years to 25.69 years during the period, for a more robust gain of 1.19 years. Similar gains are also estimated for the other countries with slowdowns in increases in male life expectancy during the period. Australia, for example, actually experienced a decrease in observed male e_{50} of 0.44 years from 1955 to 1970; the estimated increase in the absence of smoking-attributable deaths would have been 0.76 years, for a gain of 1.20 years.

Figure 2b shows a similar, although less pronounced, slowdown in gains in life expectancy for U.S. females in a later period. Between 1980 and 1995, for example, U.S. female e_{50} increased by 1.1 years from 30.56 to 31.66 years. The figure shows that the increase would have been 1.96 years from 32.06 to 34.02 years. Similar trends are observed for other countries with significant levels of female smoking-attributable mortality, although the timing of the slowdowns may differ. The United Kingdom, for example, was one of the first developed countries to have large numbers of young female

smokers (Forey et al. 2002). Observed female e_{50} in the U.K. only increased by 1.09 years between 1965 and 1980 (University of California - Berkeley and Max Planck Institute for Demographic Research 2010); the PGW-R method estimates that female e_{50} in the U.K. would have increased by 1.77 years during this period in the absence of smoking-attributable deaths.

Figure 2 also shows that e_{50} for males and females in France and the U.S. in 2005 would have been quite similar in the absence of smoking-attributable deaths, although life expectancy in these countries would have still been below life expectancy in Japan in the absence of smoking deaths.

Finally, Table 3 presents values for e_{50} for the 20 high-income countries in 2003, calculated with and without smoking-attributable mortality. The results demonstrate that smoking accounts for a large proportion of the observed differences in life expectancy among developed countries. The table also shows the larger effect of smoking-attributable mortality for males than for females in developed countries, given that smoking deaths lowered e_{50} by an average of 2.2 years for males and 1.1 years for females in these countries.

4. Conclusion

This analysis has used the PGW-R method to produce reliable estimates of smoking-attributable mortality and life expectancy in the absence of smoking-attributable mortality. The results have shown the increasing effect of smoking on life expectancy trends in developed countries during the second half of the twentieth century, first for males and then for females. The results also show that smoking is an important cause of

observed mortality differences among these countries at the present time. For example, as shown in Table 3, the U.S. ranked toward the bottom of the 20 countries in observed e_{50} in 2003, at 14th for males and 17th for females. The PGW-R method estimates that the U.S. would have ranked much closer to the middle among these countries, at 10th for males and 12th for females (although close to tying four other countries), in the absence of smoking-attributable deaths. Similar improvements in life expectancy would occur in a country such as Canada, which would improve from 6th place in observed e_{50} for males and 7th place for females to 2nd place for both males and females in the absence of smoking-attributable mortality. The consistency of these estimates of life expectancy in the absence of smoking deaths for males and females in these countries once again supports the validity of the PGW-R method and its estimates.

References

Borras J., Fernandez E., Gonzalez J., Negri E., Lucchini F., La Vecchia C., Levi F. (2003). Lung Cancer Mortality in European Regions (1955-1997). *Annals of Oncology* 14(1):159-61.

Centers for Disease Control and Prevention. (2005). Smoking-attributable mortality, years of potential life lost, and productivity losses--United States, 1997-2001. *Morbidity anad Mortality Weekly Report* 54(25):625-8.

Forey B., Hamling J., Lee P., Wald N. *International Smoking Statistics*. London: Oxford University Press; 2002.

Janssen F., Kunst A., Mackenbach J. (2007). Variations in the pace of old-age mortality decline in seven European countries, 1950–1999: the role of smoking and other factors earlier in life *European Journal of Population* 23(2):171-88.

Mesle F., Vallin J. (2006). Diverging trends in female old-age mortality: the United States and the Netherlands versus France and Japan. *Population and Development Review* 32(1):123-45.

Perez-Rios M., Montes A. (2008). Methodologies used to estimate tobacco-attributable mortality: a review. *BMC Public Health* 8(22).

Peto R., Lopez A.D., Boreham J., Thun M. *Mortality from smoking in developed countries 1950-2000*. http://www.ctsu.ox.ac.uk/~tobacco/SMK_All_PAGES.pdf (7 April, 2010, date last accessed).

Peto R., Lopez A.D., Boreham J., Thun M., Heath C. (1992). Mortality from tobacco in developed countries: indirect estimation from national vital statistics. *Lancet* 339(8804):1268-78.

Pleis J.R., Lethbridge-Cejku M. (2006). Summary health statistics for U.S. adults: National Health Interview Survey, 2005. *Vital and Health Statistics* 10(232):1-163.

Preston S.H., Glei D.A., Wilmoth J.R. (2010a). Contribution of smoking to international differences in life expectancy. In: Crimmins E.M., Preston S.H., Cohen B. (eds). *International Differences in Mortality at Older Ages: Dimensions and Sources*. Washington, DC: National Academies Press:105-31.

Preston S.H., Glei D.A., Wilmoth J.R. (2010b). A new method for estimating smoking-attributable mortality in high-income countries. *International Journal of Epidemiology* 39(2):430-8.

R Development Core Team. R: A Language and Environment for Statistical Computing, Version 2.10.0. Vienna, Austria: R Development Core Team; 2010.

Rostron B.L. (2010). A modified new method for estimating smoking-attributable mortality in high-income countries. *Demographic Research* 23(14):399-420.

Staetsky L. (2009). Diverging trends in female old-mortality: a reappraisal. *Demographic Research* 21(885-914.

Thun M.J., Apicella L.V., Henley S.J. (2000). Smoking vs. Other Risk Factor as the Cause of Smoking-Attributable Deaths. *Journal of the American Medical Association* 284(6):706-12.

Thun M.J., Day-Lally C., Myers D.G., Calle E.E., Flanders W.D. (1997). Trends in tobacco smoking and mortality from cigarette use in Cancer Prevention Studies I (1959 through 1965) and II (1982 through 1988). In: Burns D.M., Garfinkel L., Samet J.M. (eds). *Changes in Cigarette-Related Disease Risks and Their Implications for Prevention and Control*. Smoking and Tobacco Control, Monograph No. 8. Bethesda, MD: National Cancer Institute:305-82.

UN Department of Economic and Social Affairs. *World Population Prospects; the 2004 Revision; Volume 2: Sex and Age Distribution of the World Population.* . New York City: UN Publications; 2006.

University of California - Berkeley and Max Planck Institute for Demographic Research. *Human Mortality Database*. http://www.mortality.org/ (15 June, 2010, date last accessed).

World Health Organization. *WHO Mortality Database*. <http://www.who.int/whosis/mort/download/en/index.html> (5 January, 2010, date last accessed).

Table 1. Estimated smoking-attributable fraction (SAF) of deaths for ages 50+ from the PGW-R method; by country, sex, and year

a) Males

Country	1955		1970		1985		2003	
	SAF	CI	SAF	CI	SAF	CI	SAF	CI
Australia	0.06	(0.049, 0.064)	0.14	(0.124, 0.149)	0.19	(0.181, 0.207)	0.16	(0.147, 0.176)
Austria	0.12	(0.109, 0.137)	0.16	(0.145, 0.175)	0.18	(0.162, 0.190)	0.17	(0.156, 0.185)
Belgium	0.07	(0.066, 0.083)	0.18	(0.163, 0.193)	0.29	(0.271, 0.308)	0.26[a]	(0.240, 0.286)
Canada	0.05	(0.048, 0.061)	0.13	(0.117, 0.138)	0.22	(0.206, 0.232)	0.23	(0.210, 0.248)
Denmark	0.06	(0.052, 0.067)	0.13	(0.117, 0.141)	0.21	(0.195, 0.226)	0.20	(0.177, 0.214)
Finland	0.15	(0.131, 0.169)	0.23	(0.207, 0.248)	0.23	(0.211, 0.245)	0.17	(0.152, 0.185)
France	0.04	(0.037, 0.047)	0.10	(0.089, 0.104)	0.16	(0.154, 0.175)	0.19	(0.172, 0.199)
Hungary	0.06	(0.054, 0.069)	0.13	(0.120, 0..144)	0.23	(0.213, 0.244)	0.31	(0.293, 0.335)
Iceland	0.03	(0.000, 0.053)	0.04	(0.016, 0.073)	0.10	(0.066, 0.140)	0.15	(0.099, 0.196)
Italy	0.04	(0.033, 0.040)	0.11	(0.102, 0.118)	0.21	(0.201, 0.224)	0.23	(0.208, 0.245)
Japan	0.01	(0.009, 0.012)	0.05	(0.046, 0.055)	0.12	(0.113, 0.130)	0.19	(0.172, 0.205)
The Netherlands	0.08	(0.074, 0.091)	0.20	(0.183, 0.214)	0.29	(0.274, 0.312)	0.25	(0.228, 0.272)
New Zealand	0.07	(0.057, 0.080)	0.14	(0.127, 0.160)	0.18	(0.163, 0.196)	0.16	(0.141, 0.179)
Norway	0.02	(0.013, 0.022)	0.05	(0.048, 0.062)	0.11	(0.095, 0.115)	0.15	(0.133, 0.166)
Portugal	0.01	(0.011, 0.019)	0.03	(0.030, 0.039)	0.08	(0.076, 0.090)	0.12	(0.110, 0.131)
Spain	0.03	(0.027, 0.034)	0.07	(0.064, 0.075)	0.15	(0.142, 0.161)	0.21	(0.193, 0.227)
Sweden	0.02	(0.021, 0.029)	0.06	(0.053, 0.065)	0.09	(0.080, 0.095)	0.09	(0.079, 0.098)
Switzerland	0.08	(0.067, 0.087)	0.13	(0.120, 0.144)	0.19	(0.173, 0.199)	0.15	(0.137, 0.165)
UK	0.13	(0.122, 0.150)	0.23	(0.213, 0.249)	0.26	(0.240, 0.274)	0.19	(0.177, 0.213)
USA	0.07	(0.064, 0.078)	0.15	(0.135, 0.157)	0.22	(0.205, 0.230)	0.22	(0.198, 0.232)

b) Females

Country	1955		1970		1985		2003	
	SAF	CI	SAF	CI	SAF	CI	SAF	CI
Australia	0.00	(0.000, 0.003)	0.03	(0.020, 0.031)	0.06	(0.051, 0.065)	0.07	(0.057, 0.090)
Austria	0.01	(0.008, 0.019)	0.02	(0.014, 0.024)	0.03	(0.022, 0.036)	0.04	(0.033, 0.050)
Belgium	0.00	(0.001, 0.008)	0.01	(0.003, 0.009)	0.02	(0.017, 0.025)	0.04[a]	(0.037, 0.052)
Canada	0.01	(0.003, 0.011)	0.02	(0.017, 0.025)	0.10	(0.092, 0.113)	0.14	(0.116, 0.169)
Denmark	0.01	(0.005, 0.017)	0.04	(0.031, 0.049)	0.10	(0.086, 0.109)	0.14	(0.117, 0.160)
Finland	0.01	(0.006, 0.018)	0.01	(0.000, 0.010)	0.03	(0.019, 0.031)	0.03	(0.026, 0.042)
France	0.00	(0.002, 0.004)	0.00	(0.000, 0.002)	0.01	(0.005, 0.007)	0.02	(0.019, 0.024)
Hungary	0.02	(0.013, 0.025)	0.03	(0.027, 0.040)	0.05	(0.046, 0.062)	0.11	(0.092, 0.129)
Iceland	0.00	(0.000, 0.000)	0.02	(0.000, 0.050)	0.08	(0.038, 0.119)	0.14	(0.095, 0.184)
Italy	0.00	(0.001, 0.004)	0.01	(0.007, 0.011)	0.02	(0.020, 0.026)	0.03	(0.023, 0.038)
Japan	0.00	(0.000, 0.000)	0.02	(0.015, 0.020)	0.04	(0.032, 0.045)	0.04	(0.026, 0.060)
The Netherlands	0.00	(0.000, 0.004)	0.00	(0.000, 0.006)	0.03	(0.021, 0.030)	0.08	(0.068, 0.091)
New Zealand	0.00	(0.000, 0.008)	0.04	(0.029, 0.054)	0.08	(0.068, 0.095)	0.10	(0.081, 0.118)
Norway	0.00	(0.000, 0.006)	0.00	(0.000, 0.006)	0.03	(0.023, 0.035)	0.07	(0.055, 0.076)
Portugal	0.00	(0.000, 0.000)	0.00	(0.000, 0.004)	0.00	(0.001, 0.006)	0.01	(0.004, 0.009)
Spain	0.00	(0.000, 0.001)	0.01	(0.004, 0.008)	0.00	(0.001, 0.003)	0.00	(0.003, 0.005)
Sweden	0.00	(0.000, 0.006)	0.01	(0.005, 0.013)	0.02	(0.020, 0.029)	0.05	(0.043, 0.062)
Switzerland	0.00	(0.000, 0.006)	0.00	(0.001, 0.008)	0.02	(0.012, 0.021)	0.04	(0.031, 0.044)
UK	0.02	(0.019, 0.026)	0.06	(0.053, 0.067)	0.11	(0.094, 0.119)	0.10	(0.079, 0.130)
USA	0.01	(0.005, 0.008)	0.04	(0.035, 0.044)	0.12	(0.108, 0.130)	0.14	(0.116, 0.174)

SAF = smoking-attributable fraction of deaths, CI = 95% confidence interval.

[a] Estimates for Belgium are for 2004, due to the unavailability of 2003 data in the WHO Mortality Database.

Table 2. Estimated smoking-attributable fraction (SAF) of deaths for ages 50+ from the modified Peto-Lopez method; by country, sex, and year

Country	Males				Females			
	1955	1970	1985	2000	1955	1970	1985	2000
Australia	0.09	0.22	0.25	0.16	0.01	0.03	0.06	0.09
Austria	0.17	0.22	0.21	0.17	0.01	0.01	0.03	0.04
Belgium	0.13	0.26	0.35	0.23[a]	0.01	0.01	0.02	0.03
Canada	0.08	0.19	0.27	0.20	0.02	0.03	0.11	0.15
Denmark	0.07	0.18	0.24	0.20	0.01	0.04	0.09	0.16
Finland	0.23	0.30	0.25	0.14	0.02	0.01	0.01	0.02
France	0.06	0.13	0.20	0.17	0.01	0.00	0.00	0.02
Hungary	0.10	0.18	0.29	0.28	0.03	0.03	0.06	0.11
Iceland	0.01	0.07	0.12	0.12	0.00	0.03	0.08	0.16
Italy	0.07	0.17	0.27	0.25	0.02	0.01	0.01	0.03
Japan	0.01	0.05	0.13	0.16	0.01	0.02	0.04	0.05
The Netherlands	0.13	0.27	0.36	0.25	0.01	0.01	0.02	0.07
New Zealand	0.11	0.23	0.24	0.16	0.02	0.05	0.08	0.12
Norway	0.02	0.07	0.12	0.12	0.01	0.01	0.02	0.06
Portugal	0.02	0.05	0.10	0.11	0.01	0.01	0.01	0.01
Spain	0.04	0.11	0.20	0.21	0.02	0.01	0.00	0.01
Sweden	0.02	0.07	0.09	0.06	0.01	0.01	0.02	0.04
Switzerland	0.11	0.18	0.20	0.15	0.00	0.00	0.02	0.03
UK	0.24	0.35	0.33	0.20	0.03	0.07	0.11	0.13
USA	0.12	0.22	0.27	0.21	0.02	0.06	0.12	0.18

[a] Estimates for Belgium are for 1999, due to the unavailability of 2000 data in the WHO Mortality Database.

Table 3. Observed life expectancy at age 50 (e_{50}) and e_{50} without smoking-attributable deaths as estimated by the PGW-R method, by country and sex: 2003

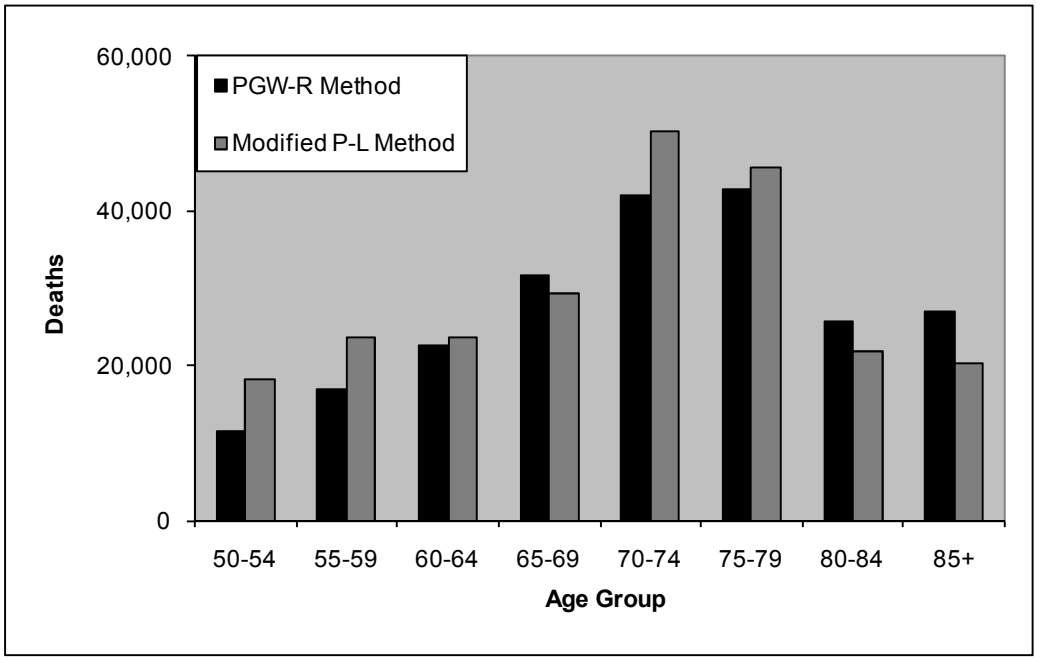
Country	Males		Females	
	Observed e_{50}[a]	e_{50} without Smoking Deaths	Observed e_{50}	e_{50} without Smoking Deaths
Australia	30.63	32.51	34.59	35.79
Austria	28.47	30.31	33.11	33.61
Belgium[b]	28.06	31.44	33.40	33.97
Canada	29.82	32.59	33.85	36.00
Denmark	27.77	29.99	31.66	33.84
Finland	27.98	29.80	33.25	33.79
France	28.83	30.99	34.59	34.70
Hungary	22.55	26.92	29.15	30.68
Iceland	30.95	32.48	33.61	35.45
Italy	29.46	31.92	34.19	34.56
Japan	30.47	32.85	36.66	38.04
The Netherlands	28.34	31.01	32.55	33.72
New Zealand	29.80	31.65	33.26	34.81
Norway	29.40	31.09	33.39	34.58
Portugal	27.69	29.12	32.44	32.55
Spain	29.00	31.51	34.44	34.61
Sweden	29.83	30.84	33.66	34.56
Switzerland	30.14	31.86	34.48	35.09
UK	28.62	30.77	32.21	33.60
USA	28.46	31.30	32.26	34.55
Mean	28.81	31.05	33.34	34.43

[a] Observed life expectancy values are from the Human Mortality Database (HMD) (2010). Life expectancy values in the absence of smoking-attributable deaths are estimated using HMD and WHO data and results from the PGW-R method, as described in this study.

[b] Life expectancy values for Belgium are for 2004, due to the unavailability of 2003 data in the WHO Mortality Database.

Figure 1. Smoking-attributable deaths by sex and age as estimated by the PGW-R and modified Peto-Lopez methods: U.S., 2000

a) Males



b) Females

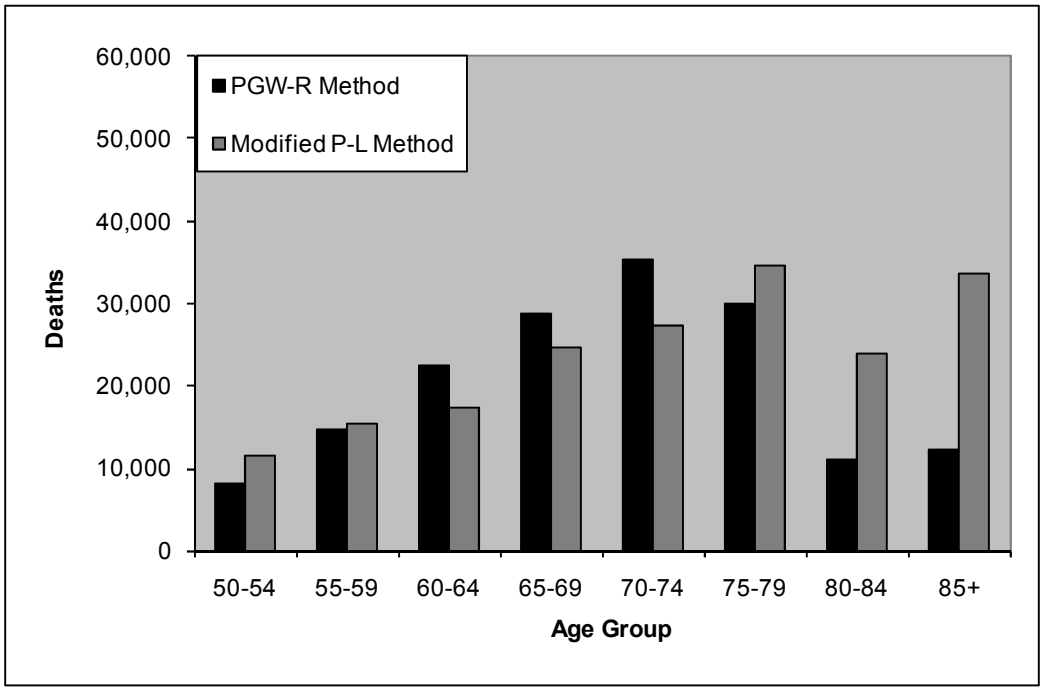
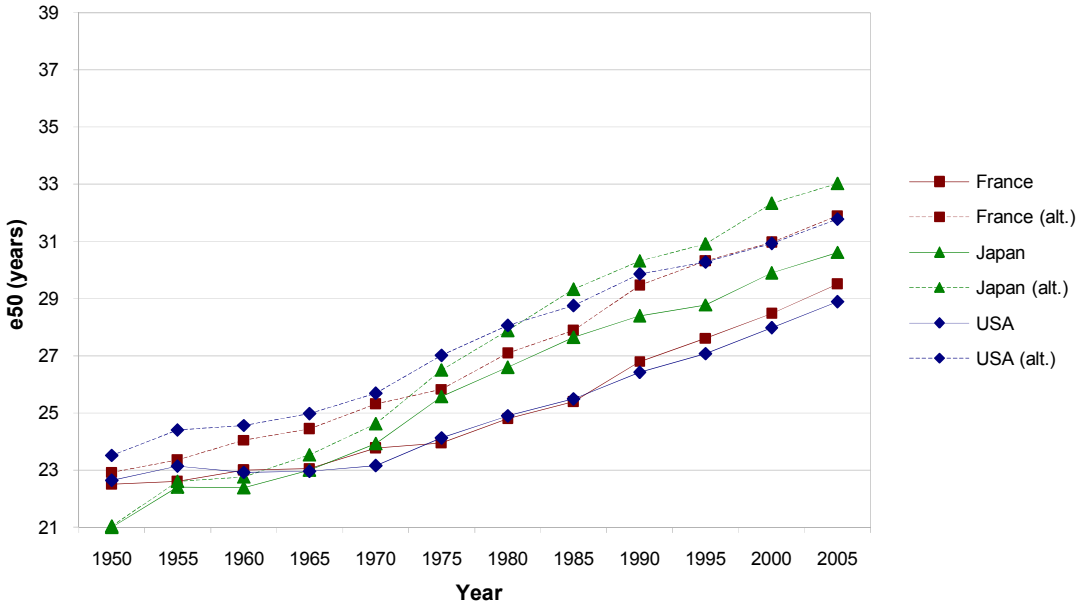
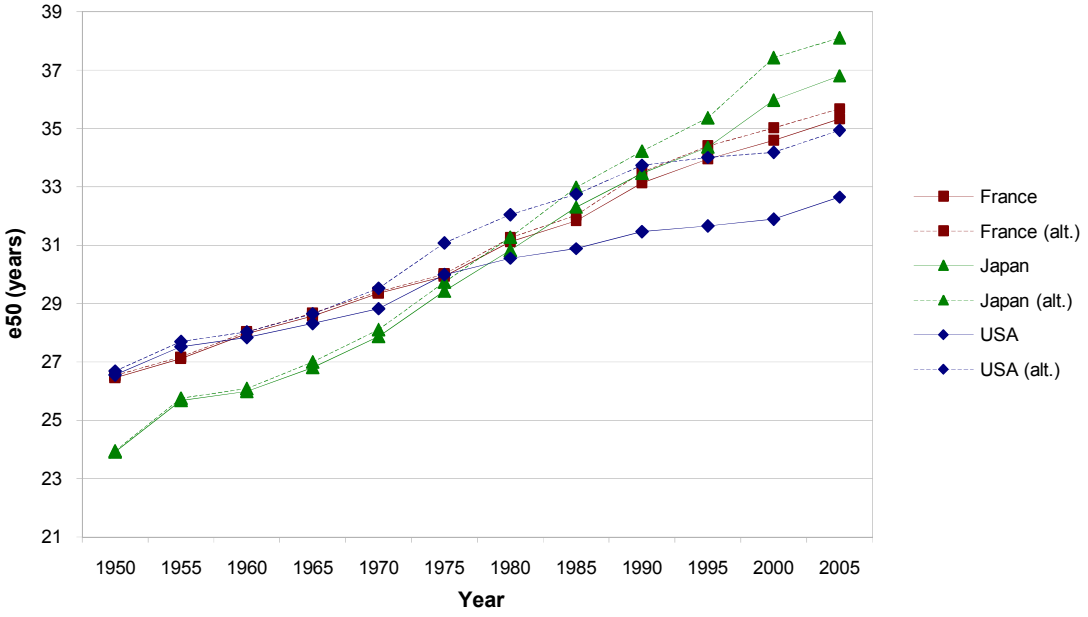


Figure 2. Observed life expectancy at age 50 (e_{50}) and e_{50} without smoking-attributable deaths as estimated by the PGW-R method: France, Japan, and the U.S., 1950-2005

a) Males



b) Females



Note: Dashed lines show e_{50} in the absence of smoking-attributable deaths, as estimated by the PGW-R method.