Available online at www.sciencedirect.com
ScienceDirect
Journal of Health Economics 27 (2008) 943–958
JOURNAL OF HEALTH ECONOMICS
www.elsevier.com/locate/econbase

The mortality cost to smokers

W. Kip Viscusi *, Joni Hersch

Vanderbilt University, 131 21st Avenue South, Nashville TN 37203, USA

Received 29 May 2007; received in revised form 21 December 2007; accepted 14 January 2008
Available online 2 February 2008

Abstract

This article estimates the mortality cost of smoking using the first labor market estimates of the value of statistical life by smoking status. The value of statistical life is $7 million for both smokers and nonsmokers. Using this value in conjunction with the increase in the mortality risk over the life cycle due to smoking, the value of statistical life by age and gender, and information on the number of packs smoked over the life cycle, the private mortality cost of smoking is $222 per pack for men and $94 per pack for women in $2006, based on a 3% discount rate. At discount rates of 15% or more, the cost decreases to under $25 per pack.

JEL classification: I12; I18; J17

Keywords: Smoking; Cigarettes; Mortality cost; Value of statistical life

1. Introduction

Cigarette smoking substantially reduces life expectancy. Although several studies have addressed the financial externalities of smoking, there have been no comparably detailed examinations of the potentially much more substantial value of the mortality cost to smokers.[1] The appropriate valuation of private mortality risks is the value of statistical life (VSL) at the age of death. To provide a basis for this calculation, we develop the first estimates of VSL by smoking status, age, and gender and use these estimates in valuing the mortality risks. These results, which are of independent interest in their own right, are used to calculate the mortality cost of smoking. In addition, our estimates of the mortality cost of smoking take into account the temporal distribution of the increased mortality associated with cigarette smoking, as well as the pattern of smoking over the life cycle.

Previous studies have indicated fairly similar values for the mortality cost per pack with values of $20 by Sloan et al. (2004), $22 by Cutler (2002), and $30 by Gruber and Köszegi (2001). The methodology in the studies assumes that the loss of life due to smoking occurs at the end of smokers' lifetime and that the value of this loss can be based on a value per life year lost of $100,000.[2] This value of statistical life year (VSLY) approach is based on the assumptions that VSL equals the present discounted value of a series of annual values and that each year of life has an identical value.

* Corresponding author. Tel.: +1 615 343 7715; fax: +1 615 322 5953.
E-mail addresses: kip.viscusi@vanderbilt.edu (W.K. Viscusi), joni.hersch@vanderbilt.edu (J. Hersch).

[1] For studies that have assessed the financial externalities of cigarettes, see, among others, Shoven et al. (1989), Manning et al. (1989, 1991), Gravelle and Zimmerman (1994), Viscusi (1995, 2002), Evans et al. (1999), Cutler et al. (2000), and Sloan et al. (2004).

[2] Their estimates use Viscusi's (1993) consensus value of life of $6.4 million based on the average VSL from US labor market studies.

0167-6296/$ – see front matter
doi:10.1016/j.jhealeco.2008.01.001

In Section 2 we provide an overview of our estimating methodology. Specifically the present value of the mortality cost of smoking is the discounted value of the incremental probability of death at different ages for smokers relative to otherwise comparable nonsmokers, multiplied by the pertinent VSL. This section also introduces the hedonic wage equation model used to estimate VSL. In Section 3 we estimate hedonic wage equations by smoking status, allowing for age variation in the VSL. We find that the VSL does not vary substantially by smoking status. Moreover, there is no evidence of a significant decline in VSL for the age range of the working population. This absence of a steady drop in VSL with age implies that VSL estimates calculated specifically by age will be much larger than those in which VSL is constructed based on an assumed constant unit value per year of life. Section 4 estimates the mortality cost based on the VSL estimates derived from the results in Section 3. Our cost calculation is on a year-by-year basis, taking into account the differential mortality risk of smokers in each year and recognizing the specific expected age of death and the appropriate discounting of these losses. Use of the appropriate age-specific VSL levels leads to a substantial increase in the estimated mortality cost of smoking.

The results of the analysis are quite striking. The discounted expected mortality cost per pack in $2006 using a 3% discount rate for male smokers is $222 and for female smokers is $94. While the mortality cost varies with the discount rate, at all reasonable rates of discount the mortality cost remains considerably above previous estimates.

2. Procedure for calculating mortality cost

In this section we provide an overview of the approach that we implement in Sections 3 and 4. Intuitively, the mortality cost of smoking is the expected number of years of life lost due to smoking multiplied by the economic value of these years. The general formulation of the present value of the mortality cost of smoking c used in this paper is given by

$$c = \sum_{t=t_0}^{100} \frac{(x_{\mathrm{st}} - x_{\mathrm{nt}})v(t)}{(1+r)^{t-t_0}}, \tag{1}$$

where t_0 is the age at which the person became a committed smoker, x_{st} is the probability that this smoker dies at age t, x_{nt} is the probability that a comparable nonsmoker would have died at age t, $v(t)$ is the value of death at age t, and r is the rate of discount. The mortality cost per pack is obtained by dividing c by the discounted number of packs smoked, taking into account the life cycle pattern of smoking.

We use t_0 equal to age 24 as the demographic reference point. By that age, short-term smoking experimentation has been completed. This focus on 24 year old committed smokers parallels the assumption embodied in the tables by Sloan et al. (2004) in which life expectancy is based on continued smoking behavior excluding quitters. Our focus on continuing smokers ensures a comparable matchup of smoking-related mortality risks and patterns of cigarette consumption over the life cycle. The scientific estimates for mortality risks of smoking over the life cycle are much more reliable for committed smokers than for quitters at different ages.

To calculate the incremental mortality risk from smoking, $(x_{\mathrm{st}} - x_{\mathrm{nt}})$, we use the ‘nonsmoking smoker’ as the reference point, as in Manning et al. (1989, 1991). This approach uses as the baseline the risk profile of a nonsmoker who otherwise has the demographic and risk profile of a smoker and thereby correctly reflects the increased smoking-related mortality risk that will be experienced by smokers specifically due to their smoking behavior. Because our estimates adjust for smokers’ demographic risk profiles, the life expectancy loss estimates are lower than those used in some other studies. If we had not used the nonsmoking smoker reference point, our cost estimates would be even higher.

The most critical component of the calculation is the unit mortality value parameter $v(t)$. Following the standard economic approach, the ideal measure of $v(t)$ is the VSL at age t. For smokers age 65 or over, we do not have a VSL based on labor market tradeoffs so instead will construct this value using the VSLY levels for workers age 55–64.

The relation between VSL and VSLY is based on the quantity-adjusted value of life analysis introduced by Moore and Viscusi (1988). If people lived forever and had a constant value per year of life, the VSL would equal VSLY/r, where r is the rate of discount. To account for a finite lifespan, denote the remaining life expectancy by L. The VSL equals

$$\mathrm{VSL} = \frac{\mathrm{VSLY}}{r} - \frac{1}{(1+r)^{\mathrm{L}}}\left[\frac{\mathrm{VSLY}}{r}\right]. \tag{2}$$

Solving for VSLY, and using the subscript s to indicate that the estimates are conditional on being a smoker,

$$\mathrm{VSLY_s} = \frac{r(\mathrm{VSL_s})}{[1-(1+r)^{-\mathrm{L}}]}. \tag{3}$$

2.1. The hedonic model

Our estimates employ a variant of the canonical hedonic wage equation to derive estimates of $v(t)$, allowing $v(t)$ to vary by smoking status, age, and gender. Our paper makes use of the state-of-the art approach to estimating VSL. We advance the literature by utilizing more refined fatality risk measures by industry-age-gender than in any previous study and by presenting the first wage-fatality risk premiums by smoking status in the literature.

Specifically, the canonical hedonic wage equation is of the form

$$\ln(w_i) = \alpha + G_i'\Psi + \theta_1 p_i + \theta_2 q_i + \theta_3 q_i b_i + \varepsilon_i, \tag{4}$$

where w_i = the worker's hourly wage rate, G_i = a vector of personal characteristics and control variables for worker i, p_i = the fatality risk for worker i's industry-age-gender cell, q_i = the nonfatal injury risk for worker i's industry-age cell, b_i = the state legal maximum workers' compensation replacement rate for temporary total disability in the worker's state, ε_i = the random error term, and α, θ_1, θ_2, and θ_3 are scalar coefficients, while Ψ is a coefficient vector.[3]

Using the coefficient on fatality risk from the wage equations, and assuming 2,000 h worked per year, the general formulation for the VSL is

$$\hat{\mathrm{VSL}} = \hat{\theta}_1 * \bar{w} * 2{,}000 * 1{,}00{,}000. \tag{5}$$

We will compute this value for different age-gender-smoking status groups. This formulation ensures that the VSL estimates will have a time frame comparable to the annual fatality risk variable. If, for example, smokers worked less than 2,000 h per year, their annual fatality risk would decline proportionally as well, so that Eq. (5) would still be the appropriate formula for generalizing the hourly wage-fatality risk tradeoff to calculate the pertinent VSL estimate.

The hedonic labor market equilibrium reflects the joint influence of market opportunities and preferences, and these factors may differ for smokers and nonsmokers. Viscusi and Hersch (2001) find that smokers face a wage-nonfatal risk offer curve that has a lower intercept and a flatter slope than that available to nonsmokers, and that on average, smokers have a lower implicit value of nonfatal injury risk. Whether wage-fatality risk tradeoffs differ for smokers and nonsmokers is an open empirical question. We estimate separate wage equations for smokers and nonsmokers so that the market offer curve and worker preferences toward risk can vary by smoking status. Additionally, we allow for differences by age.

3. The value of statistical life by smoking status, age, and gender

3.1. Data description and empirical framework

To estimate Eq. (4), we use information from the monthly Current Population Survey (CPS) and the CPS Tobacco Use Supplements on individual wage rates, labor market characteristics, and smoking status, matched with industry-age-gender fatality rates calculated from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI), industry-age nonfatal injury rates calculated from the BLS survey of occupational injuries and illnesses, and state-level workers' compensation replacement rates.

The CPS Tobacco Use Supplement has been administered as a supplement to the CPS about every three years beginning in 1992, with three surveys conducted in each wave. We use data on smoking status and packs smoked per

[3] Although the equations will subsequently be estimated by smoking status, for simplicity we suppress these subscripts.

day from the supplements conducted in 1995–1996, 1998–1999, and 2001–2002.[4] A smoker is defined as someone who has smoked at least 100 cigarettes in his/her lifetime and reports currently smoking either every day or some days. Nonsmokers include never-smokers as well as former smokers.

The monthly CPS provides the remaining information on individual worker characteristics. The dependent variable is the log of the real hourly wage rate (in $2000).[5] In addition to the risk variables defined shortly, we control in the wage equation for potential experience (defined as age – years of education – 5), potential experience squared, years of education,[6] part-time employment, union membership or coverage, government employment, metropolitan residence, race (black, Native American, Asian), whether Hispanic, sex, and marital status.

The CPS surveys each household for four consecutive months and surveys the same household one year later for four more months. Earnings information is provided only in the fourth and eighth months that the household is surveyed (MIS 4 and MIS 8, where MIS is the 'month in sample'). The survey month that the CPS Tobacco Use Supplement is administered will only correspond to the survey month that earnings information is reported at most one-fourth of the time.[7] To increase the sample with both earnings and smoking information, we match individuals' Tobacco Use Supplement responses to their earnings information across CPS months. For example, individuals with MIS 3 when they answered the CPS Tobacco Use Supplement questions in January 1996 are linked to their earnings information in the February 1996 CPS when their MIS is 4.[8]

To calculate fatality rates, we use data from the CFOI for the years 1996–2001. The CFOI reports the number of work-related fatalities by two-digit SIC industry, age group (eight age groups), and gender. To construct fatality rates, we use as the numerators the number of fatalities in each two-digit SIC industry by age group and gender.[9] The denominators are the hours-weighted levels of industry employment by age group and gender for 1996–2001 from the CPS for those with MIS 4 or MIS 8. Because the fatality risk measure includes an hours worked adjustment, unlike published fatality risk measures or fatality risk variables constructed for other studies, it explicitly accounts for differences in hours worked over the life cycle. We use the average fatality rate per 100,000 full-time workers over the six-year time period in order to give a more stable estimate of the risk workers face in industries for which fatalities are relatively rare events. We exclude fatalities for those in the under 16 and 16–19 age groups and for those over age 64. The fatality rate is thus a gender-specific fatality risk measure by two-digit industry groups in five age groups: 20–24 years, 25–34 years, 35–44 years, 45–54 years, and 55–64 years.

A longstanding issue in the hedonic wage literature has been the potential influence of measurement error with respect to the fatality risk variable.[10] Our construction of the risk variable mitigates some of the concerns in the early literature. First, the CFOI dataset is a comprehensive census of all work-related fatalities rather than a sample. Second, by constructing the fatality risk variable by industry, age, and gender, it is pertinent to the individual worker.

The nonfatal injury rates are constructed in a similar manner using data on the number of nonfatal injuries from the BLS Survey of Occupational Injuries and Illnesses, except we do not calculate gender-specific rates for injury risk. We use the total number of occupational injuries and illnesses involving at least one lost workday by industry within

[4] The CPS Tobacco Use Supplements were administered in September, January, and May for the 1995–1996 and 1998–1999 waves, and in June, November, and February for the 2001–2002 wave.

[5] Hourly wage is defined as weekly earnings divided by usual hours per week and adjusted for price level changes using the monthly Bureau of Labor Statistics CPI-U-RS, Consumer Price Index Research Series Using Current Methods. Weekly earnings flagged by the CPS as topcoded are multiplied by 1.5 before the hourly wage is calculated.

[6] Years of education are imputed from categorical information on highest grade or degree completed and duration of graduate degree program.

[7] Respondents in their outgoing rotation of the February 2002 CPS did not participate in the Tobacco Use Supplement, reducing even more the sample with both smoking and earnings information in the same survey month.

[8] Respondents are matched using household identification number, person's line number, and MIS. To mitigate incorrect matching, matches are rejected if the person's sex or race was different across the two months, or if the person's reported ages in the two survey months are more than one year apart. Not all respondents to the Tobacco Use Supplement can be matched to a different month of the CPS because the CPS does not follow households or individuals if they move.

[9] Job-related fatalities are not available by smoking status, so it is not feasible to construct a fatality risk variable specific to smokers and nonsmokers. Previous gender-specific job risk measures used in compensating differential studies are those for nonfatal injuries in Hersch (1998) and fatalities in Leeth and Ruser (2003). Aldy and Viscusi (2007) and Viscusi and Aldy (2007) use fatality measures by age and industry.

[10] Black and Kniesner (2003) and Viscusi and Aldy (2003) review the measurement error issues and the different fatality risk measures used in the literature.

Table 1
Mean occupational fatality rates by gender, age group, and smoking status[a]

	Nonsmokers	Smokers
Males		
All	5.48	6.46
Age 20–24	4.63	5.26
Age 25–34	4.79	5.76
Age 35–44	5.11	6.20
Age 45–54	5.96	7.21
Age 55–64	7.78	9.09
N	102,205	35,970
Females		
All	0.67	0.80
Age 20–24	0.47	0.51
Age 25–34	0.62	0.74
Age 35–44	0.70	0.85
Age 45–54	0.71	0.90
Age 55–64	0.83	0.91
N	109,862	30,874

[a] Fatalities per 100,000 full-time workers. Fatality rates constructed by the authors using fatality data from the Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 1996–2001, and Current Population Survey employment data, 1996–2001.

the same five age groups used to calculate the fatality risk measure, divided by hours-weighted total employment by industry and age group calculated from CPS data. The BLS does not report the number of injuries in several industries in which fatality data are reported. We drop from the sample all workers in these industries in the wage equation estimation.[11]

As a final risk-related measure, we control for the expected workers' compensation replacement rate, denoted as $q_i b_i$ in Eq. (4). This variable is the interaction between the age-group-specific nonfatal lost workday injury risk and the state legal maximum workers' compensation replacement rate for temporary total disability in the worker's state.[12] This interactive formulation is appropriate since the value that workers attach to workers' compensation benefits increases with their likelihood of injury.

The sample used to estimate the hedonic wage equation is comprised of wage and salary workers 20–64 years old who earn between \$2 and \$100 per hour and whose smoking status is reported.[13] The final sample consists of 278,911 observations, with 212,067 nonsmokers and 66,844 smokers. Our wage equations are estimated separately by smoking status. Means by smoking status for all variables used in the analyses are reported in Appendix A.

Table 1 summarizes the average fatality risk per 100,000 full-time workers by smoking status, sex, and age group. Because fatality rates are imputed to individual workers by industry, age, and gender, these averages are implicitly weighted by the frequency of workers in each industry-age-gender category. Women face a substantially lower fatality risk than do men in every age group, and smokers incur significantly greater risks than nonsmokers of the same gender. Also note that fatality risk rises with age.[14]

[11] These industries are US Postal Service (SIC 43), private household services (SIC 88), miscellaneous services (SIC 89), and all industries in public administration (SIC 91–97 and 99). Injuries in the industry 'pipelines, except natural gas' (SIC 46) were not reported by age group or by gender, so workers in this industry are also dropped.

[12] The workers' compensation rates were gathered from two sources: Alliance of American Insurers, *Survey of Workers' Compensation Laws* (various years) and the US Chamber of Commerce, *Analysis of Workers' Compensation Laws* (various years). For states in which the worker's compensation base is the after-tax or spendable wage, the replacement rate is multiplied by one minus the average tax rate for the state including state and federal average rates. The source of tax rates is the NBER and its TAXSIM model available at http://www.nber.org/∼taxsim. See Feenberg and Coutts (1993).

[13] In addition to workers in industries excluded because nonfatal injury data is not available, we also exclude workers in agriculture, fishing, or forestry industries or occupations.

[14] Viscusi and Aldy (2007) examine the age variations in fatality risk for specific occupations and industries and find the same age pattern as is exhibited here. Although worker injury rates decline with age, the severity increases with age, producing the positive age-fatality risk relationship. For a survey of labor market estimates of age variations in VSL, see Aldy and Viscusi (2007).

Table 2
ln(Wage) regression estimates[a]

	(1) Nonsmokers	(2) Smokers	(3) *p*-Values[b]
Panel A: no age variation in risk coefficients			
Fatality rate	0.0022	0.0026	
	(0.0003)**	(0.0004)**	0.41
	[0.0010]*	[0.0012]*	0.64
VSL–average	7.39	7.32	
Males	8.51	8.14	
Females	6.35	6.37	
Panel B: age variation in risk coefficients			
Fatality rate (age 20–34)	6.59 E-6	0.0020	
	(0.0005)	(0.0006)**	0.01
	[0.0020]	[0.0017]	0.03
Fatality rate (age 35–44)	0.0042	0.0041	
	(0.0005)**	(0.0007)**	0.93
	[0.0025]+	[0.0024]+	0.97
Fatality rate (age 45–54)	0.0034	0.0027	
	(0.0005)**	(0.0007)**	0.39
	[0.0024]	[0.0022]	0.53
Fatality rate (age 55–64)	0.0025	0.0031	
	(0.0005)**	(0.0008)**	0.57
	[0.0020]	[0.0021]	0.58

[a] Robust standard errors given in parentheses; robust standard errors accounting for clustering by industry-age groups given in brackets. * Significant at 5%; ** significant at 1%. Additional variables in each regression are a constant, potential experience, potential experience squared, years of education, and indicator variables for part-time employment, union coverage or membership, government employer, metropolitan residence, race (black, Native American, Asian), whether Hispanic, female, and married. In addition, indicators are included for eight survey months, three regions, and 10 occupation groups. The complete regression results for Panel A are provided in Appendix B.

[b] The *p*-values correspond to the test of equality of the coefficients by smoking status based on the standard errors reported in the corresponding row of the table.

3.2. Regression estimates

Table 2, Panel A reports the coefficient estimates on the fatality risk variable in Eq. (4), with robust standard errors in parentheses and standard errors corrected for clustering by industry and age group in brackets. The full equations appear in Appendix B.[15] Results for nonsmokers are in column 1, and those for smokers are in column 2.[16] The coefficients on fatality risk, which are used to calculate the VSLs, are statistically significant at the 95% level or better.[17]

The last row of Panel A in Table 2 reports the VSL levels by smoking status and gender. The average estimated VSL is $7.39 million for nonsmokers and $7.32 million for smokers. Wage rates for men and women differ, leading to different VSL levels by gender within the same smoking status. For males, the average VSL is $8.51 million for nonsmokers and $8.14 million for smokers. The average VSL for females is $6.35 million for nonsmokers and $6.37 million for smokers. Despite the similarity in the fatality risk valuations for nonsmokers and smokers, the effect of nonfatal lost workday risk follows the pattern found in Viscusi and Hersch (2001).[18]

[15] Appendix B reports only the clustered standard errors to save space.

[16] The null hypothesis that the vector of coefficients in the nonsmoker and smoker equations is equal is rejected at the 1% level.

[17] As the results in Appendix B indicate, the coefficients on the nonfatal job risk variable and the workers' compensation variable also are statistically significant and have the expected signs, as workers receive a premium for nonfatal injury risk and incur a wage offset for expected workers' compensation benefit.

[18] The full effect of the lost workday injury rate variable must take into account the interaction of the injury rate with the state level workers' compensation replacement rates in constructing the expected workers' compensation replacement rate variable. Based on the results in Appendix B and evaluated at the mean workers' compensation replacement rates of 0.681 for nonsmokers and 0.682 for smokers, the marginal effects of the lost workday injury rate variable on log wages is 0.0096 for nonsmokers and −0.0026 for smokers.

3.3. Age variation in VSL

To take into account the age distribution of smoking-related mortality, we examine whether there is age variation in VSL. In the Shepard and Zeckhauser (1984) analysis, individuals' VSL will decline steadily with age in an idealized world in which there are perfect annuities with respect to life expectancy and perfect capital markets, where it is possible to borrow at birth on one's future lifetime earnings.[19] For more restrictive models in which there is no saving, consumption in any given year will equal earnings, which follow the life-cycle earnings profile that rises with age and subsequently declines. For this more restrictive model, Shepard and Zeckhauser (1984) show that VSL is proportional to discount future consumption and that for reasonable parameter values VSL rises over the life cycle and subsequently declines. Using the exact hazard rate rather than the approximation of reductions in the hazard rate, as in Shepard and Zeckhauser (1984), Johansson (2002) shows that even with actuarially fair life annuities, VSL may not decline substantially with age if the individual's marginal rate of time preference is approximately equal to the market rate of interest plus the hazard rate.[20]

The principal consequence of the ambiguous theoretical predictions and the absence of empirical evidence indicating a steady decline of VSL with age is that VSLY is not a constant value. It is important to estimate how VSL and VSLY vary with age in order to assess accurately the mortality cost of smoking. To explore possible age differences, we let the coefficients on the risk variables in Eq. (4) vary with age.[21] The four age groups, which are indexed by k, have separate risk variable coefficients θ_{1k}, θ_{2k}, $\theta_{3k,}$ and θ_{4k}. Eq. (4) is augmented to become

$$\ln(w_i) = \alpha_0 + G_i \Psi_k + \sum_{k=1}^{4} \theta_{1k}\,\text{age}_k\, p_i + \sum_{k=1}^{4} \theta_{2k}\,\text{age}_k\, q_i + \sum_{k=1}^{4} \theta_{3k}\,\text{age}_k\, q_i b_i + \varepsilon_i, \tag{6}$$

where the variables are defined as before, with the indicator variable for age group k denoted by age_k.

Table 2, Panel B reports the age variation in the fatality rate coefficients for the nonsmoker sample and the smoker sample. Based on the clustered standard errors, one cannot reject the hypothesis that the θ_{1k} coefficients are equal for all values of k for both nonsmokers and smokers.[22] As a result, to calculate the variation in the VSL with age, we use age group-gender wage levels coupled with the fatality risk coefficients reported in Panel A of Table 2.

Table 3 reports the VSL_s for the sample overall evaluated at the average sample age and for each age group, with values reported separately for age 24, our base age. For example, consider males at age 24. Their $\text{VSL}_\text{s}(24)$ of \$5.98 million is calculated using Eq. (5), where the fatality rate coefficient is that reported in Table 2, Panel A, and the wage is the average wage for 24 year old males.

The columns in Table 3 following VSL_s report the corresponding standard errors for these values, which are calculated taking into account the fact that the VSL is constructed using the product of the fatality risk coefficient and the wage rate for the groups, both of which are random variables.[23] For VSL_s levels for each gender, there are ten possible pairwise tests of equality of the age group VSL. All paired comparisons indicate statistically significant differences at the 1% level, with the exception of the VSL_s levels for males age 45–54 as compared to males age 55–64 ($p = 0.29$) and for females age 35–44 as compared to age 55–64 ($p = 0.02$). Other than these exceptions, VSL_s increases through ages 45–54.

[19] Previous analyses of the mortality cost of smoking have used a constant VSLY based on this formulation.

[20] Previous empirical studies generally indicate a rising VSL with age. This rise is followed by a continued increase in VSL with age, as in the analysis of healthy workers in Smith et al. (2004). Kniesner et al. (2006) find a subsequent flattening of VSL linked to life-cycle consumption patterns, and Viscusi and Aldy (2007) find a slight decline in VSL with age. Reviews of the mixed evidence with respect to VSL-age patterns appear in Viscusi and Aldy (2007) and in Krupnick (2007).

[21] Our approach follows that in Viscusi and Aldy (2007), which in turn is a modification of the Smith et al. (2004) model.

[22] Based on the robust standard errors rather than the clustered standard errors, the joint hypothesis that the θ_{1k} coefficients are equal for all values of k can be rejected at the 1% level for the nonsmoker sample. Test of individual coefficient pairs shows that only the coefficient for the lowest age group differs from the other three age group coefficients.

[23] Our calculations follow Eq. (7) of Goodman (1960) and assume independence of $\hat{\theta}_1$ and $\bar{w}_k$.

Table 3
Value of statistical life (VSL_s) and value of statistical life year ($VSLY_s$) estimates for smokers ($2000)[a]

	Males			Females		
	VSL_s ($ millions)	VSL_s standard error[b]	$VSLY_s$ ($)	VSL_s ($ millions)	VSL_s standard error[b]	$VSLY_s$ ($)
All ages	8.14	0.031	390,321	6.37	0.024	279,776
By age group						
Age 24	5.98	0.109	238,738	5.17	0.086	195,450
Age 25–34	7.32	0.044	311,021	6.04	0.038	240,051
Age 35–44	8.68	0.052	422,960	6.72	0.044	298,741
Age 45–54	9.31	0.066	549,007	7.00	0.053	366,484
Age 55–64	9.17	0.116	707,684	6.52	0.077	429,735

[a] All calculations are based on a discount rate of 3%, the fatality rate coefficients from Panel A of Table 2, the conditional life expectancy of a lifetime smoker at the midpoint of the age group in each gender-age group, and the average wage of the gender-age group.
[b] Standard errors are based on the robust standard errors accounting for clustering by industry-age groups.

3.4. Estimating the value of a statistical life year

The failure of VSL to decline steadily with respect to age implies that VSL is not simply the discounted sum of annual unit values of life. Consequently, for the ages for which we have VSL estimates, it is preferable to use these age-specific values for $v(t)$. However, because most smokers who die prematurely die after age 64, an age range for which we do not have VSL(t) estimates, it is necessary to approximate their $v(t)$ values using the VSLY for the age range of 65 years and over.

For the discussion below we denote the VSL and VSLY for committed lifetime smokers at age t by $VSL_s(t)$ and $VSLY_s(t)$. In the VSLY calculation, we use values for L that are derived from life tables developed by Sloan et al. (2004). Sloan et al. define current smokers as those who either smoked at the time of the survey or had quit smoking less than 5 years earlier. Their study provides survival rates at every age, which we convert into years of remaining life expectancy for each age t by dividing the sum of person years lived from age t to 100 years of age by the number of persons surviving to age t.[24] Our analysis of the cost of smoking by gender incorporates the gender-specific difference in the survival probabilities between smokers and nonsmokers. Based on these calculations, the remaining life expectancy for 24 years old committed smokers is 47.09 years for males and 53.34 years for females. The excess mortality risk from smoking is considerably higher for men than for women, in part because of the greater number of cigarettes smoked by male smokers. For both groups, the mortality risk of smoking escalates once smokers reach their sixties.

Using Eq. (3) in conjunction with the remaining life expectancy L of a 24 year old committed male smoker and a discount rate of 3% leads to an estimated $VSLY_s(24)$ of $238,738. This figure will be the basis for calculating the annual smoking fatality costs $v(t)$ using the VSLY approach.

Table 3 also presents the $VSL_s(t)$ and $VSLY_s(t)$ estimates for the other age groups. The calculations follow an analogous procedure using the average gender-specific wage for the age group and the remaining gender-specific life expectancy for committed lifetime smokers at the midpoint of the age cell. The VSL estimates for these other age groups are used below to calculate the cost of smoking based on the VSL methodology. Note that a shorter remaining life expectancy boosts the VSLY for any given VSL value, which accounts for the large $VSLY_s$ for those 55–64.

It is clear from the age variation in VSLY levels that VSLY is not a constant over the life cycle. Rather, the VSLY varies from youngest to oldest by a factor of three for men and a factor of two for women.

4. Smoking mortality cost over time

4.1. Discounted mortality cost

The calculation of the discounted mortality cost of cigarettes is based on the lifetime incremental mortality risk distribution from smoking, the value of the period of life lost, and the number of packs smoked. The value of the mortality

[24] See http://www.lifeexpectancy.org/lifetable.shtml.

cost from death in any year t is based on the economic loss in that year, which is discounted back to the reference age 24. We consider two sets of estimates, one based on VSL levels over time, and the other based on VSLY levels.

Using the VSL method, mortality cost is valued based on the VSL for the person's age range at the time of death. Thus, if a male smoker dies at age 53, the pertinent VSL loss is $9.31 million based on the male VSL numbers in Table 3. Similarly, female smokers who die are assigned the VSL value for females at the age range at time of death from Table 3. Because the last age range for which we have VSL estimates is for workers 55–64, the valuation of the deaths of smokers at ages beyond 64 requires additional assumptions to impute a mortality cost to this age group. In the absence of any empirical evidence about the pattern of VSLY_s levels for workers older than 64, we assume that the VSLY_s for the 55–64 age group, denoted by $\text{VSLY}_\text{s}(60)$, can be used to estimate the value of the mortality cost for death at any age. Thus, once a smoker reaches age 65, the calculated VSL_s for that smoker is the discounted present value of the VSLY_s levels for the remaining years of the smoker's expected life. This formulation consequently leads to an imputed VSL_s that is steadily declining with age starting at age 65. The procedure consequently takes into account the shorter remaining life expectancy of older smokers, whereas use of VSL_s for a younger age group would not.

In implementing Eq. (1), the mortality cost calculation consists of two components of losses – the losses from ages 24 to 64 for which we have VSL_s estimates and the losses from ages 65 to 100 for which we approximate the losses using the VSLY estimates. The value of discounted expected mortality cost $c(\text{VSL})$ using the VSL approach is given by

$$c(\text{VSL}) = \sum_{t=24}^{64} \frac{(x_{\text{st}} - x_{\text{nt}})\text{VSL}_\text{s}(t)}{(1+r)^{t-24}} + \sum_{t=65}^{100} \frac{(x_{\text{st}} - x_{\text{nt}})\text{VSLY}_\text{s}(60)\left[\sum_{t'=t}^{100}(y_{\text{st}'}/y_{\text{st}})/(1+r)^{t'-t}\right]}{(1+r)^{t-24}}, \quad (7)$$

where x_{nt} is the probability that the 24 year old nonsmoker dies during year t, x_{st} is the probability that the 24 year old smoker dies during year t, and y_{st} is the probability that the 24 year old smoker has survived to year t.[25] The first cost term in Eq. (7) directly parallels Eq. (1). The $\text{VSL}_\text{s}(t)$ values equal $v(t)$, and the incremental probability of death is $(x_{\text{st}} - x_{\text{nt}})$. The specific values of x_{nt} and x_{st} in Eq. (7) are from Sloan et al. (2004).

The second cost term in Eq. (7) is the cost from ages 65 to 100 based on VSLY estimates. The formulation also follows that of Eq. (1) where $v(t)$ is approximated by $\text{VSLY}(60)\left[\sum_{t'=t}^{100}(y_{\text{st}'}/y_{\text{st}})/(1+r)^{t'-t}\right]$. This expression is the present discounted value of the VSLY stream lost due to premature mortality at age t. The ratio $y_{\text{st}'}/y_{\text{st}}$ is the relative probability of survival to age t' for a smoker who has lived to age t. The VSLY loss consequently reflects smokers' additional risk of death at subsequent ages had they not died in year t.

The denominator of the cost per pack calculation is the discounted expected number of packs of cigarettes smoked over the lifetime. The rationale for dividing the present value of the discounted expected mortality cost c by the discounted expected number of packs smoked is that doing so establishes the proper unit mortality cost for a pack of cigarettes. To see this, suppose that smokers were entirely ignorant of the mortality risk of smoking. What unit excise tax on cigarettes will lead smokers to internalize the mortality risk? Taking into account the life-cycle pattern of consumption is necessary because the average number of packs smoked varies over the life cycle. The appropriate value captures not only the effect of risks on lifetime mortality cost, but also the effect on the lifetime number of packs smoked. Discounting costs and risks is also necessary so that the present value of a uniform cost value per pack will just equal the present value of cost given by c.[26]

[25] The values for x_{st} and y_{st} are, of course, related. The age-specific probability of death is equal to the number of deaths between year t and $t+1$ divided by the number who survived to year t. That is, $x_{\text{st}} = (y_{\text{st}} - y_{\text{st+1}})/y_{\text{st}}$.

[26] To see why the appropriate denominator for the mortality cost per pack calculation is the discounted number of packs rather than the undiscounted number of packs, consider the following simple two-period example. Let the present value of cigarette mortality costs $c = 100$, smokers' cigarette consumption be z_1 packs in period 1 and z_2 packs in period 2, and r be the discount rate. What cost of mortality per pack t will have a present value of 100? Dividing the cost by the total lifetime number of packs yields a value of $t = 100/(z_1 + z_2)$, which in turn yields a present value of lifetime costs of $[100z_1/(z_1 + z_2)] + [100z_2/(z_1 + z_2)(1 + r)] < 100$. If, instead, the discounted number of packs denominator is used and the value of t is set equal to $t = 100/[z_1 + z_2/(1 + r)]$, it is straightforward to verify that the present value of lifetime costs based on the per pack cost of t will equal the c value of 100.

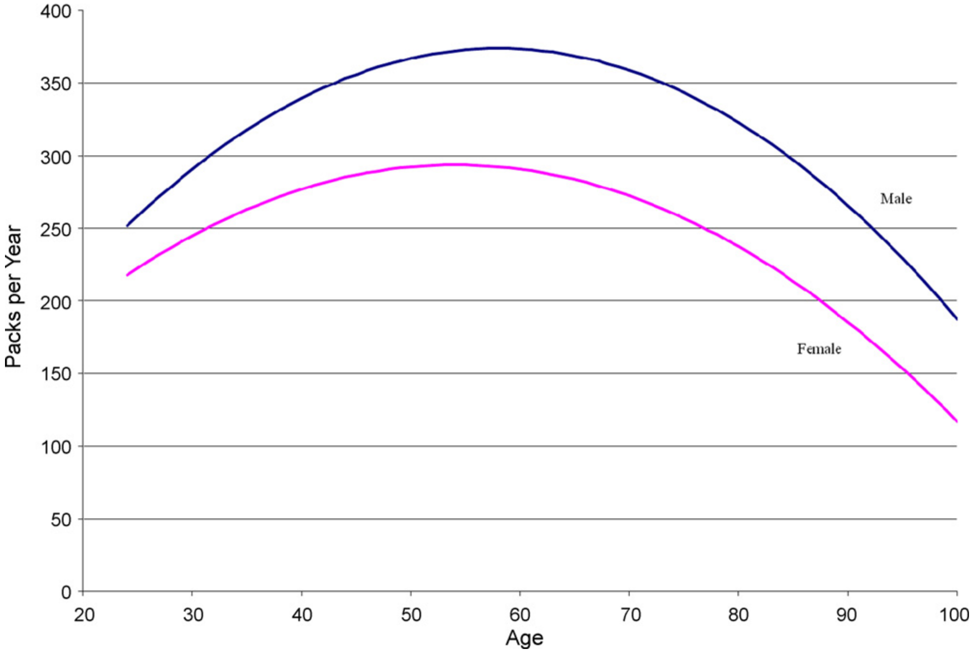

Fig. 1. Cigarette consumption by age.

To calculate the discounted number of packs, let z_{st} be the number of packs smoked in year t for the particular gender-specific smoker who is alive in year t. The present value d of the number of packs at age 24 is given by

$$d = \sum_{t=24}^{100} \frac{y_{st} z_{st}}{(1+r)^{t-24}}. \tag{8}$$

The mortality cost per discounted expected pack smoked based on the VSL approach is $c(\mathrm{VSL})/d$.

To estimate the number of packs of cigarettes smoked per year z_{st}, we use information from the CPS Tobacco Use Supplement.[27] The estimated coefficients (with standard errors in parentheses) from the regression of packs smoked per year on age, gender, and an interaction of age with gender are

$$\begin{aligned} z_{st} = {} & 17.76(11.10) + 12.28(0.59) * \text{age} - 0.11(0.01) * \text{age}^2 + 30.84(14.57) * \text{female} \\ & -3.22(0.77) * \text{female} * \text{age} + 0.02(0.01) * \text{female} * \text{age}^2. \end{aligned} \tag{9}$$

Fig. 1 illustrates the lifetime consumption pattern for male and female smokers. The fitted number of packs at age 24 is 251 for males and 218 for females. The peak levels of smoking are at age 58 for men, at 374 packs, and at age 54 for women, at 294 packs. The lower number of packs smoked by women will reduce the denominator d of the mortality cost per pack calculation, but it will also reduce the risks per pack that affect the numerator.[28]

We also calculate the mortality cost based entirely on the VSLY approach for comparison with the literature. The basis for the calculation is $\mathrm{VSLY_s}(24)$, reported in Table 3. Thus, mortality loss values are based on the discounted expected value of the stream of lost VSLY amounts. This calculation parallels previous assessments of the cost of smoking in that the economic value of the life lost due to smoking declines steadily with age.

[27] We use self-respondents ages 15–90 to estimate the packs per year equation. Only self-respondents were asked how many cigarettes they smoked per day.

[28] Female smokers may also differ in the kinds of cigarettes they smoke, how they smoke, and their dose-response relationships with respect to smoking. For these reasons, it is important to use gender-specific mortality risks as in our study and in Sloan et al. (2004).

Table 4
Mortality costs of smoking ($2000)

	Males	Females
Panel A: total costs		
VSL cost estimate	1538,631	563,299
VSLY cost estimate	561,666	258,792
Panel B: costs per pack		
VSL cost estimate	189.35	80.09
VSLY cost estimate	69.12	36.79

The value of $c(\mathrm{VSLY})$ for this case is given by

$$c(\mathrm{VSLY}) = \sum_{t=24}^{100} \frac{(x_{\mathrm{st}} - x_{\mathrm{nt}})\mathrm{VSLY_s}(24)\left[\sum_{t'=t}^{100} (y_{\mathrm{st'}}/y_{\mathrm{st}})/(1+r)^{t'-t}\right]}{(1+r)^{t-24}}. \tag{10}$$

This formulation parallels the second term in Eq. (7). The estimate of the discounted number of packs smoked is given by Eq. (9) as before. We define the cost per pack in this case as $c(\mathrm{VSLY})/d$.

Table 4 summarizes the present value of total mortality cost and the mortality cost per pack using the two different approaches. All estimates are in $2000, so to convert to $2006 the cost estimates should be increased by 17% based on the change in the CPI-U over that period. Panel A reports the present value of the total cost, and Panel B reports the cost per pack amounts $c(\mathrm{VSL})$ and $c(\mathrm{VSLY})$. The present value of mortality cost of smoking averages over $1.54 million for male smokers and $0.56 million for female smokers. In $2006 these values are $1.80 million for males and $0.66 million for females. The VSLY cost estimates for men and women are closer in relative terms, with costs of $562,000 for men and $259,000 for women. Men have a higher mortality cost because of both their higher mortality risk from smoking and their higher wage rates, which boost their VSL estimates. Their greater loss of life expectancy due to smoking also boosts the VSLY(60) estimate used to calculate the value of mortality cost at age 65 and above. The $c(\mathrm{VSL})/d$ of $189 per pack for men is 2.4 times the $80 cost for women.

Our estimated ratios of the male to female costs are somewhat greater than the ratio derived from estimates of $175,000 in costs for men and $94,000 for women in the study by Sloan et al. (2004) because their study used the same $v(t)$ for men and women. The more striking difference is the much higher level of cost estimates, which are six times greater based on the VSL approach and at least three times greater based on the VSLY estimates.

The cost per pack estimates shown in Table 4, Panel B indicate cost levels that dwarf past estimates as well. The mortality costs per pack based on the VSL approach are $189 for men and $80 for women. In $2006, these values are $222 for men and $94 for women. The VSLY costs per pack estimates are $69 for men and $37 for women. These latter estimates are based on a methodology most similar to that in Gruber and Köszegi (2001), Cutler (2002), and Sloan et al. (2004), who estimated mortality costs per pack of $30, $22, and $20.

A substantial portion of the discrepancy between our estimates and those in the literature is our accounting for mortality risks throughout life rather than assuming that the mortality risk is at the end of life. Suppose first that the mortality consequence of smoking is to reduce 6 years at the end of one's life. Incorporating this assumption in our analysis, which is in line with the approach in Gruber and Köszegi (2001) and Cutler (2002), produces a cost per pack value of $121.12 for men and $84.98 for women. If instead the lost life expectancy at the end of life is 4.4 years for men and 2.4 years for women, as in Sloan et al. (2004), the cost per pack is $90.83 for men and $35.76 for women.[29] The Sloan et al. (2004) estimates are the more direct counterpart to our mortality cost values because

[29] All these calculations assume remaining life expectancy at age 24 of 47 years for committed male smokers and 53 years for committed female smokers.

our calculations use the age-specific mortality rates developed by Sloan et al. (2004). Up to half of the difference between our estimates and those in the literature stems from our recognition of the mortality risks of smoking at all ages.

The analysis thus far has assumed a rate of discount equal to 3%, which is one of the rates recommended by the US Office of Management and Budget for regulatory policy evaluations. Because of the long latency period for cigarette-related illnesses and death, most of the risks of smoking are deferred, increasing the importance of the

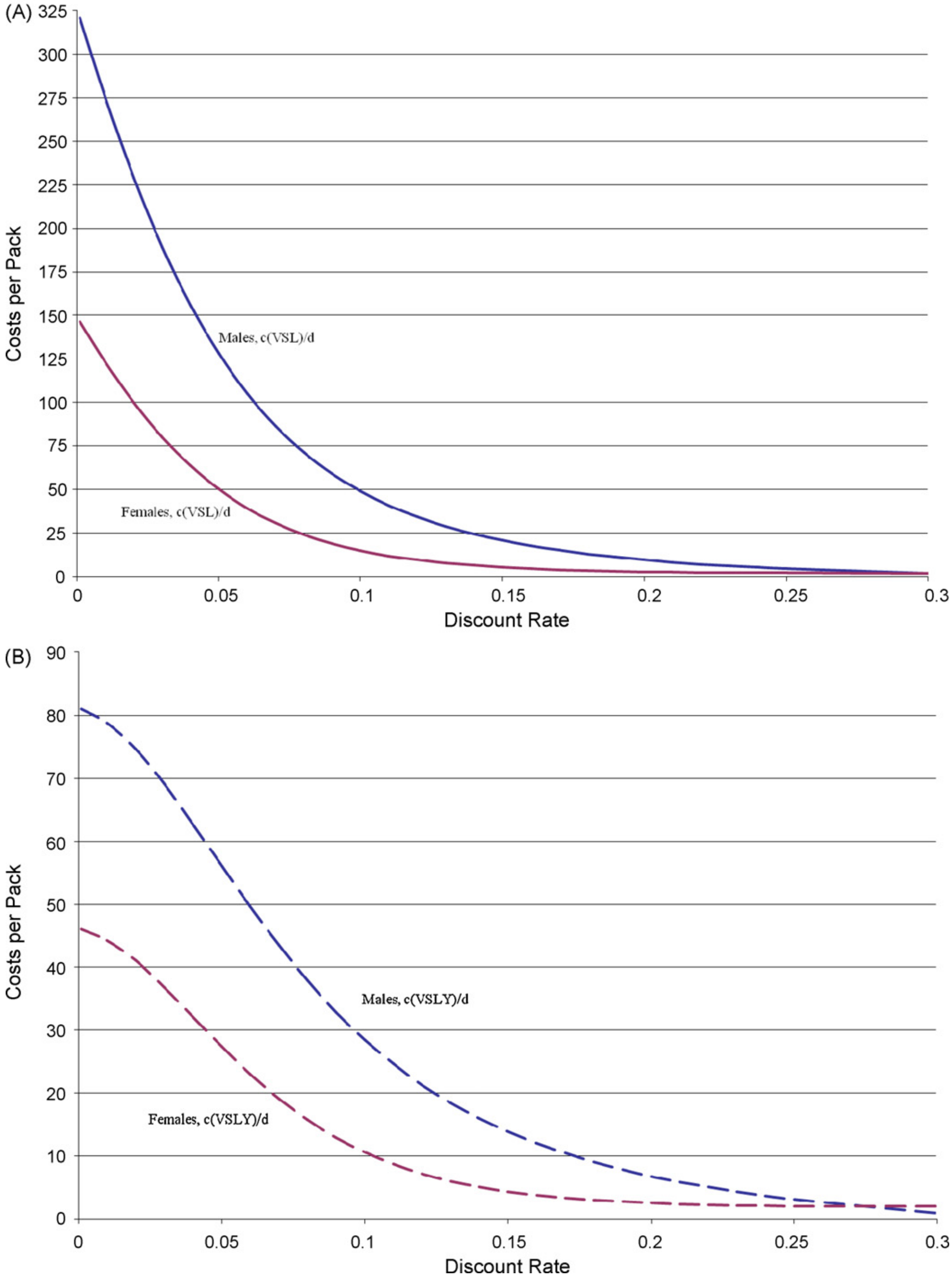

Fig. 2. (A) Mortality costs per pack ($2000), $c(\text{VSL})/d$ (B) Mortality costs per pack ($2000), $c(\text{VSLY})/d$.

choice of the discount rate. Fig. 2A illustrates the cost per pack based on the VSL approach for different levels of r.[30] Both the present value of mortality cost and the present value of packs smoked are functions of r, with the net relationship being a steeply declining value of $c(\text{VSL})/d$. Undiscounted, the costs per pack are about \$150 for females and over \$300 for males in \$2000. At a discount rate of 10%, the cost per pack for males is \$49, while for females the cost per pack is \$15. At discount rates of 15% or more, the costs per pack are under \$25 for both groups. Thus, if the personal rates of time preference for smokers are higher than the social rate of discount, then the mortality cost will not loom as large as in our calculations.[31] Given the high costs per pack, it seems unlikely that smokers value their future well-being using a 3% discount rate. If people do not anticipate the preferences of their future selves, as Schelling (1984) hypothesizes in his model of self control, then individual smoking decisions also will not be optimal.

Fig. 2B shows the comparable results based on the VSLY approach. These estimates have a more complicated dependence on r, as the VSLY value used in computing $v(t)$ is also a function of r. These costs per pack numbers are consistently well below those in Fig. 2A. At discount rates of 15%, the costs per pack are under \$15 for both men and women.

The methodology of this paper is based on the direct theoretical linkage between the labor market wage-risk tradeoffs and the price-risk tradeoffs for risky products such as cigarettes. If individuals face continuous choices with respect to levels of job risk and levels of product safety, then they will equate their implicit value of statistical life across products and jobs.[32] This equivalence is, however, for small changes in risk. Whereas the average annual occupational fatality risk faced by smokers is 1/25,000, the lifetime mortality risk from cigarettes is on the order of one-sixth to one-third, which is considerably larger. The willingness-to-pay amount for any incremental reduction in risk diminishes with the extent of the risk reduction.[33] Analogously, the willingness-to-accept value for incremental increases in the risk will increase with the amount of the risk increase. Applying local estimates of the VSL from the job safety context will consequently lead to estimates that bracket the willingness-to-accept and willingness-to-pay values for changes in the risk level of cigarettes.

The interpretation of this result for smoker behavior is as follows. Suppose that the smoker is completely unaware of the risks of smoking but otherwise makes fully rational decisions. For simplicity, consider the marginal smoker who currently reaps no consumer surplus from smoking behavior. Then the estimate for the mortality cost per pack will understate the amount that the smoker must be compensated to continue smoking. Similarly, if the smoker is currently fully knowledgeable of the risks of smoking, then the estimate of the mortality costs per pack will overstate how much the smoker is willing to pay for a risk-free cigarette.

5. Conclusion

The economic value of the premature mortality due to smoking dwarfs the purchase price of cigarettes. At a 3% discount rate, the mortality cost per pack for men is \$222 in \$2006. For women, the cost is much lower than that for men but is still large, with a cost per pack of \$94 in \$2006. The sources of the gender difference include the greater mortality effect of smoking on men, the nearer term impact of these mortality losses for men, and the greater VSL for men due to their higher wage rate.

The substantial costs per pack stem from two principal factors. First, the discounted expected value of the mortality risks of smoking is high because smoking increases the mortality risk throughout a smoker's life, not just at the end of the smoker's expected lifetime. Second, using VSL estimates by age to value the mortality cost indicates that the value of this loss is quite substantial. Notwithstanding their smoking decision, smokers have a high VSL throughout their lives, which in turn implies that their premature mortality imposes enormous personal costs.

[30] Appendix C reports the numerical values corresponding to Fig. 2A.

[31] High personal rates of discount also could contribute to smoker choices. See the discussion by Gruber and Köszegi (2001).

[32] Viscusi (1994) develops a model in which the marginal value of statistical life is equated across different domains of individual decision.

[33] For a single-period model of the diminishing willingness-to-pay for successive improvements in product safety, see Viscusi et al. (1987).

Appendix A

Sample characteristics[a]

Variable	Mean (S.D.)	
	Nonsmokers	Smokers
Real wage per hour ($2000)	16.569 (11.508)	13.852 (8.886)
ln(Wage)	2.634 (0.572)	2.486 (0.513)
Fatality rate per 100,000 full-time workers	2.989 (4.549)	3.844 (5.192)
Lost workday injury rate per 100 full-time workers	1.264 (1.018)	1.469 (0.983)
Expected workers' compensation replacement rate	0.832 (0.676)	0.967 (0.652)
Potential experience	20.734 (11.475)	21.018 (10.923)
Years of education	13.963 (2.696)	12.807 (2.172)
Part-time employment	0.147 (0.354)	0.130 (0.336)
Union membership or coverage	0.161 (0.368)	0.145 (0.352)
Government employment	0.143 (0.350)	0.085 (0.279)
Metropolitan residence	0.782 (0.413)	0.748 (0.434)
Black	0.091 (0.288)	0.079 (0.270)
Native American	0.008 (0.091)	0.015 (0.121)
Asian	0.041 (0.199)	0.024 (0.153)
Hispanic	0.087 (0.282)	0.060 (0.237)
Female	0.518 (0.500)	0.462 (0.499)
Married	0.655 (0.475)	0.538 (0.499)
Executive, administrative, managerial	0.151 (0.358)	0.113 (0.317)
Professional specialty	0.206 (0.405)	0.088 (0.284)
Technicians and related support	0.040 (0.197)	0.032 (0.175)
Sales	0.109 (0.312)	0.110 (0.313)
Administrative support, including clerical	0.158 (0.364)	0.142 (0.349)
Protective services	0.006 (0.079)	0.009 (0.095)
Services, except protective and household	0.098 (0.297)	0.141 (0.348)
Precision production, craft and repair	0.101 (0.301)	0.159 (0.366)
Machine operators, assemblers, and inspectors	0.060 (0.237)	0.091 (0.288)
Transportation and material moving	0.039(0.192)	0.062 (0.241)
Handlers, equipment cleaners, helpers, and laborers	0.032 (0.326)	0.052 (0.222)
Northeast	0.223 (0.417)	0.211 (0.408)
South	0.285 (0.451)	0.302 (0.459)
Midwest	0.256 (0.436)	0.285 (0.451)
West	0.236 (0.425)	0.202 (0.402)
N	212,067	66,844

[a] All means or proportions differ significantly by smoking status at the 1% level with the exception of sales, which has a *t*-statistic of 0.62.

Appendix B

ln(Wage) regression estimates[a]

	Nonsmokers	Smokers
Fatality rate	0.0022 [0.0010]*	0.0026 [0.0012]*
Lost workday injury rate	0.0678 [0.0216]**	0.0696 [0.0200]**
Expected workers' compensation replacement rate	−0.0854 [0.0265]**	−0.1058 [0.0277]**
Potential experience	0.0257 [0.0025]**	0.0218 [0.0020]**
Potential experience squared	−0.0004 [4.9 E-5]**	−0.0003 [4.1 E-5]**
Years of education	0.0600 [0.0020]**	0.0558 [0.0023]**
Part-time employment	−0.1843 [0.0190]**	−0.1790 [0.0163]**
Union coverage or membership	0.1415 [0.0099]**	0.2086 [0.0125]**
Government employment	−0.1079 [0.0131]**	−0.0716 [0.0120]**
Metropolitan residence	0.1494 [0.0054]**	0.1211 [0.0051]**
Black	−0.0851 [0.0084]**	−0.0952 [0.0082]**
Native American	−0.0472 [0.0128]**	−0.0246 [0.0129]+
Asian	−0.0504 [0.0109]**	−0.0234 [0.0138]+
Hispanic	−0.0971 [0.0087]**	−0.0813 [0.0080]**

Appendix B (*Continued*)

ln(Wage) regression estimates[a]

	Nonsmokers	Smokers
Female	−0.1962 [0.0126]**	−0.1775 [0.0115]**
Married	0.0649 [0.0051]**	0.0570 [0.0037]**
Executive, administrative, managerial	0.4871 [0.0187]**	0.4385 [0.0223]**
Professional specialty	0.4511 [0.0288]**	0.4519 [0.0308]**
Technicians and related support	0.3980 [0.0183]**	0.3900 [0.0184]**
Sales	0.2019 [0.0299]**	0.1621 [0.0280]**
Administrative support, including clerical	0.1704 [0.0164]**	0.1930 [0.0162]**
Protective services	0.0307 [0.0291]	0.0036 [0.0362]
Precision production, craft and repair	0.2849 [0.0155]**	0.2702 [0.0150]**
Machine operators, assemblers, and inspectors	0.1221 [0.0180]**	0.1383 [0.0170]**
Transportation and material moving	0.1360 [0.0177]**	0.1504 [0.0187]**
Handlers, equipment cleaners, helpers, and laborers	0.0171 [0.0195]	0.0374 [0.0201]+
South	−0.0808 [0.0059]**	−0.0808 [0.0058]**
Midwest	−0.0562 [0.0057]**	−0.0455 [0.0066]**
West	−0.0244 [0.0054]**	−0.0243 [0.0082]**
Adjusted R^2	0.42	0.36
N	212,067	66,844

* Significant at 5%; ** significant at 1%; + significant at 10%. Each equation also includes a constant and indicators for eight survey months. Excluded occupation group is services, except protective and household services.

[a] Robust standard errors accounting for clustering by industry-age groups given in brackets.

Appendix C

Mortality costs per pack by discount rate ($2000)[a]

Discount rate	Mortality costs per pack	
	Male	Female
0.001	320.95	146.30
0.01	274.67	122.98
0.02	228.90	99.89
0.03	**189.35**	**80.09**
0.04	155.87	63.55
0.05	127.98	50.06
0.06	105.02	39.25
0.07	86.29	30.70
0.08	71.08	24.03
0.09	58.77	18.85
0.10	48.80	14.86
0.11	40.71	11.80
0.12	34.13	9.45
0.13	28.74	7.65
0.14	24.31	6.27
0.15	20.64	5.21
0.16	17.59	4.40
0.17	15.03	3.78
0.18	12.87	3.30
0.19	11.04	2.93
0.20	9.48	2.64
0.21	8.13	2.42
0.22	6.98	2.25
0.23	5.97	2.12
0.24	5.10	2.01
0.25	4.33	1.93
0.30	1.67	1.74

Numbers in bold correspond to the 3% discount rate used to construct the mortality costs of smoking reported in Table 4.

[a] These numbers are used to generate Fig. 2A.

References

Aldy, J., Viscusi, W.K., 2007. Age differences in the value of statistical life: revealed preference evidence. Review of Environmental Economics and Policy 1 (2), 241–260.

Black, D., Kniesner, T.J., 2003. On the measurement of job risk in hedonic wage models. Journal of Risk and Uncertainty 27 (3), 205–220.

Cutler, D.M., 2002. Health care and the public sector. In: Auerbach, A.J., Feldstein, M. (Eds.), Handbook of Public Economics. Elsevier Science, North Holland, pp. 2145–2243.

Cutler, D.M., Epstein, A.M., Frank, R., Hartman, R., King III, C., Newhouse, J.P., Rosenthal, M.B., Vigdor, E.R., 2000. How good was the tobacco settlement? Assessing payments to Massachusetts. Journal of Risk and Uncertainty 21 (2/3), 235–261.

Evans, W., Ringel, J.S., Stech, D., 1999. Tobacco taxes and public policy to discourage smoking. In: James Poterba (Ed.), Tax Policy and the Economy. MIT Press, Cambridge, MA, pp. 1–55.

Feenberg, D.R., Coutts, E., 1993. An introduction to the TAXSIM model. Journal of Policy Analysis and Management 12 (1), 189–194.

Goodman, L.A., 1960. On the exact variance of products. Journal of the American Statistical Association 55 (292), 708–713.

Gravelle, J., Zimmerman, D., 1994. Cigarette Taxes to Fund Health Care Reform: An Economic Analysis. Congressional Research Service, Washington, DC.

Gruber, J., Köszegi, B., 2001. Is addiction rational? Theory and evidence. Quarterly Journal of Economics 116 (4), 1261–1303.

Hersch, J., 1998. Compensating differentials for gender-specific job injury risks. American Economic Review 88 (3), 598–627.

Johansson, P.-O., 2002. On the definition and age-discrepancy of the value of a statistical life. Journal of Risk and Uncertainty 25 (3), 251–263.

Kniesner, T.J., Viscusi, W.K., Ziliak. J.P., 2006. Life cycle consumption and the age-adjusted value of life. Contributions to Economic Analysis & Policy 5(1), Article 4, BE Press.

Krupnick, A., 2007. Mortality-risk valuation and age: stated preference evidence. Review of Environmental Economics and Policy 1 (2), 261–282.

Leeth, J.D., Ruser, J., 2003. Compensating wage differentials for fatal and nonfatal injury risk by gender and race. Journal of Risk and Uncertainty 27 (3), 257–277.

Manning, W.G., Keeler, E.B., Newhouse, J.P., Sloss, E.M., Wasserman, J., 1989. Taxes of sin: do smokers, drinkers pay their own way? Journal of the American Medical Association 26 (11), 1604–1609.

Manning, W.G., Keeler, E.B., Newhouse, J.P., Sloss, E.M., Wasserman, J., 1991. The Costs of Poor Health Habits. Harvard University Press, Cambridge, MA.

Moore, M.J., Viscusi, W.K., 1988. The quantity-adjusted value of life. Economic Inquiry 26 (3), 369–388.

Schelling, T.C., 1984. Choice and Consequence. Harvard University Press, Cambridge, MA.

Shepard, D.S., Zeckhauser, R.J., 1984. Survival versus consumption. Management Science 30 (4), 423–439.

Shoven, J.B., Sundberg, J.O., Bunker, J.P., 1989. The social security cost of smoking. In: David Wise (Ed.), Economics of Aging. University of Chicago Press, Chicago, pp. 231–251.

Sloan, F.A., Osterman, J., Picone, G., Conover, C., Taylor Jr., D.H., 2004. The Price of Smoking. MIT Press, Cambridge, MA.

Smith, V.K., Evans, M.F., Kim, H., Taylor Jr., D.H., 2004. Do the near-elderly value mortality risks differently? Review of Economics and Statistics 86 (1), 423–429.

Viscusi, W.K., 1993. The value of risks to life and health. Journal of Economic Literature 31 (4), 1912–1946.

Viscusi, W.K., 1994. Mortality effects of regulatory costs and policy evaluation criteria. RAND Journal of Economics 25 (1), 94–109.

Viscusi, W.K., 1995. Cigarette taxation and the social consequences of smoking. In: James Poterba (Ed.), Tax Policy and the Economy. MIT Press, Cambridge, MA, pp. 51–101.

Viscusi, W.K., 2002. Smoke-Filled Rooms: A Postmortem on the Tobacco Deal. University of Chicago Press, Chicago.

Viscusi, W.K., Aldy, J., 2003. The value of a statistical life: a critical review of market estimates throughout the world. Journal of Risk and Uncertainty 27 (1), 5–76.

Viscusi, W.K., Aldy, J., 2007. Labor market estimates of the senior discount for the value of statistical life. Journal of Environmental Economics and Management 53 (3), 377–392.

Viscusi, W.K., Hersch, J., 2001. Cigarette smokers as job risk takers. Review of Economics and Statistics 83 (2), 269–280.

Viscusi, W.K., Magat, W.A., Huber, J., 1987. An investigation of the rationality of consumer valuations of multiple health risks. RAND Journal of Economics 18 (4), 465–479.