

**The Relative Risk of Death for Former Smokers:
The Influence of Age and Years Quit**

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Abstract

Objectives. In this study we estimate the all-cause relative risk of death (compared to that of never smokers) for men and women current and former smokers as a function of age and, for former smokers, years quit.

Methods. With data from Cancer Prevention Study II, we use logistic regression to estimate the effect of age and years quit on the relative risk of death for current and former smokers.

Results. We produced charts describing the all-cause relative risk of death for former smokers, as a function of gender, age, and years-quit.

Conclusions. Our results will be useful to researchers who need to evaluate the time path of mortality savings attributable to tobacco control interventions as well as to smokers and their health care providers.

The Relative Risk of Death for Former Smokers: The Influence of Age and Years Quit

A substantial body of research has established that quitting smoking reduces the overall risk of death and the risk of dying from specific tobacco-related illnesses, such as lung cancer and heart disease.^{1,2} This research demonstrates that mortality risks associated with smoking fall the longer a person has quit. However, with one exception, no previous research has modeled the relationship between overall smoking mortality risk and the combination of age at cessation and years since cessation took place. Such an analysis would describe the pattern of risk decline following smoking cessation. The exception provides only a partial picture of this relationship: one study presented estimates on the probability of dying in the next 16.5 years for current smokers, never smokers, and former smokers who quit at different ages.^{1(p. 83)} However, that analysis showed neither the pattern of risk decline over the 16.5 years, nor what happens to risk after 16.5 years.

In the present paper we estimate the all-cause relative risk of death (compared to that of never smokers) for men and women current and former smokers as a function of age and, for former smokers, years quit. Our results demonstrate that substantial risk reduction is achieved shortly after cessation, yet substantial excess risk persists for decades after quitting smoking. Our findings will be useful to individuals who will be able to assess not only the magnitude of the mortality avoidance benefits of smoking cessation, but also when those benefits will accrue. Put differently, smokers can use the findings to evaluate the mortality risk associated with a failure to quit smoking. In

addition, our results provide data and a model that can be applied to research intended to evaluate the benefit over time of smoking cessation policies or programs.

Methods

Data

We employ data from the American Cancer Society's Cancer Prevention Study II (CPS-II), previously described in detail by Stellman et al.³ and by Stellman and Garfinkel.⁴ Beginning in 1982, American Cancer Society volunteers enrolled nearly 1.2 million participants (509,000 men and 677,000 women) in all 50 states, the District of Columbia, and Puerto Rico to participate in this prospective study. Participants completed a confidential four-page survey on their health habits and their cancer and other disease histories. We included approximately 900,000 participants in our analysis. The remaining 300,000 were excluded due to incomplete data or age younger than 40 or older than 80. The age exclusions reflected the fact that relatively few deaths occurred before age 40 among the individuals in the database, and the study included a small representation of individuals over 80 years old.

Given the non-random method of selecting study subjects, participants are not representative of the entire U.S. population. On average, they are older (focusing on the health of older adults, the study enrolled participants with a mean age of 57 years), more educated, and healthier, and a smaller percentage are minorities. However, as CPS-II involved 1.5% of all Americans aged 45 and older, it is widely regarded as an important subgroup for study. Approximately half of the subjects in this study were never smokers, a majority of whom were women. The other subjects were divided approximately evenly

between current smokers and former smokers. Follow-up of participants occurred every other year through 1988. For the 6-year follow-up, 98.2% of the subjects were traced (dead or alive). A total of 79,820 deaths were reported, and death certificates were obtained for 94% of them. Causes of death were coded with the International Classification of Diseases, volume 9. Smoking status was not updated at follow-up, so some participants classified as smokers, due to their status at base-line interview, likely quit smoking during the follow-up period, and some former smokers (at base-line) may have resumed smoking.

The data set provided information on survival status, cause of death for decedents, age, gender, race, education, and several variables related to smoking status and history. Especially at older ages, former smokers who quit only a few years earlier, experience higher mortality rates than current smokers of the same age, reflecting the fact that a large proportion of these former smokers quit due to illness. This quitting-ill effect has been observed in a number of studies for 2 to 5 years after cessation^{5,6,7}. We excluded subjects who had quit smoking for less than 5 years at base-line to avoid including among “former smokers” most of those who quit due to smoking-related illness.

Analysis

To estimate the relative risk of death due to all causes for former and current smokers, we first estimated the absolute risk of death for never, current, and former smokers and then took the ratio of the latter two to the risks calculated for never smokers. Absolute risks of death were obtained by employing the person-year method for survival analysis. This method is a logistic regression based alternative to the Cox proportional

hazards models. It has been demonstrated to produce similar results to those obtained with Cox regression when the rates being estimated are small (e.g., < 10%), as they are in the present case. The logistic regression approach has the advantage that it can easily incorporate time-varying covariates in the risk set. In our problem, the relevant time-varying covariates are age and years-since-quit.

To implement the person-year method, we structured the data set to include one observation for each year a subject was present within the window of the study. A subject will have fewer observations than the number of years of the study if he or she dies or is lost to follow up. The dependent variable used in our analysis is death, coded 0 if a subject was alive during a specific year within the follow-up period, or 1 if the subject died during that period.

We postulated four logistic regression models, two describing male and female never-smokers and two characterizing male and female current and former smokers. The models are as follows:

$$P(\text{Death} | \text{age}) = \frac{\exp(\beta_0 + \beta_1 \times \text{age})}{(1 + \exp(\beta_0 + \beta_1 \times \text{age}))}$$

for male and female never smokers and

$$P(\text{Death} | \text{age}) = \frac{\exp(\beta_0 + \beta_1 \times \text{age} + \beta_2 \times \text{yearsquit} + \beta_3 \times \text{age} \times \text{yearsquit})}{(1 + \exp(\beta_0 + \beta_1 \times \text{age} + \beta_2 \times \text{yearsquit} + \beta_3 \times \text{age} \times \text{yearsquit}))}$$

for male and female current and former smokers.

In the second equation, *yearsquit* represents the time elapsed since the subject quit smoking. For current smokers this value is zero. We have included an interaction term between *yearsquit* and *age* to acknowledge the possibility of a systematic differential effect of age at the time of quitting.

Results

The results of the logistic regressions are presented in Table 1. In all four models, all the parameters are statistically significant at $p < 0.01$. The results are qualitatively consistent with what one would expect. In general, never smokers are at a lower risk than current or former smokers; male smokers face a higher risk than females, reflecting the greater number of years that males in the sample have smoked; and risk diminishes with the number of years since smoking cessation occurred.

[Table 1 here]

Figures 1 and 2 show the all-cause relative risk of death, compared to that of never smokers, for male and female current and former smokers, by age and years quit. For both males and females, relative risk declines with age for smokers and with age and years quit for former smokers. For a man who quits smoking at age 50, for example, the relative risk of death will drop from 3.1 (at 50) to 1.6 by the age of 65, compared to 2.6 if that person had continued smoking. Similarly, the relative risk for a woman who quits smoking at age 50 would drop from 2.3 at the time of quitting to 1.4 at age 65, compared to 2.2 if she had not quit.

[Figures 1 and 2 here]

Male current smokers' relative risk declines from 3.5 at age 40 to 2.1 at age 80. These results closely match previously published estimates of the relative risk for smokers. For females, the comparable figures are 2.4 and 2.0 respectively.

[Note to reviewers: 95% confidence intervals for the estimated relative risks were developed through Monte Carlo simulation using @Risk, a spreadsheet add-in. They are shown in Table A1, appended for purposes of review only. To obtain these confidence intervals, the relative risks for former and current smokers were simulated in @Risk. The random inputs for the simulation were the logistic regression coefficients previously estimated in SPSS. We modeled these coefficients as following a normal distribution with mean and standard deviation reported by the SPSS output. Correlations among the estimated coefficients were acknowledged in the Monte Carlo simulations. The correlation values were also taken from the logistic regression outputs.]

Discussion

Consistent with previous studies, we find that quitting smoking generates substantial health benefits relatively quickly. This is true regardless of the age at which a smoker quits. As seen in Figures 1 and 2, even quitting at age 70 significantly reduces an individual's risk of dying prematurely. According to our model, if one quits at age 40 the excess risk associated with smoking drops by fully half only 6-8 years after quitting.

The downside message, one that all young people contemplating smoking should consider, is that it takes a long time after quitting – often decades – for the excess risk of death due to smoking to disappear nearly completely. This primarily reflects the

lingering risks associated with smoking-related lung cancer and chronic obstructive pulmonary disease, which fall far more gradually than does the risk of cardiovascular disease death. Indeed, analyses of the relative risks of disease-specific mortality in smokers and former smokers will exhibit different patterns of decline.¹

If individuals or their physicians wish to use the results reported here to assess the benefits of smoking cessation, they should interpret the patterns in Figures 1 and 2 with caution. These figures show smokers' and former smokers' *relative* risk of death, not their *absolute* risk of death. The absolute risk of mortality increases rapidly with age, regardless of smoking status. Thus, a high relative risk due to smoking at a young age almost certainly implies a lower total risk of death than does a lower relative risk for older smokers.

We hope that, in addition to smokers and their health care providers, our results will prove useful to researchers who need to evaluate the time path of mortality savings attributable to tobacco control interventions.

Acknowledgment

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Table 1. Logistic regressions relating age and years quit to probability of death

	Constant	Age	Years quit	Interaction
Male never smokers	-12.39	0.1155		
Female never smokers	-11.94	0.1020		
Male current and former smokers	-10.69	0.1044	-0.0919	0.0009
Female current and former smokers	-10.91	0.098	-0.0878	0.0009

Table A1. 95% Confidence Intervals for the Current and Former Smokers Relative Risk of Death (For review purposes only)

		Age Quit	Age of Largest 95% CI	Largest 95% CI	
Male	Current Smoker		40	3.14	3.89
	Former Smoker	40	40	3.14	3.89
		50	50	2.90	3.36
		60	60	2.67	2.91
		70	70	2.38	2.54
Female	Current Smoker		40	2.16	2.64
	Former Smoker	40	40	2.16	2.64
		50	50	2.14	2.45
		60	60	2.11	2.29
		70	70	2.03	2.18

Figure 1. Male relative risk of death, current and former smokers, by age and smoking status

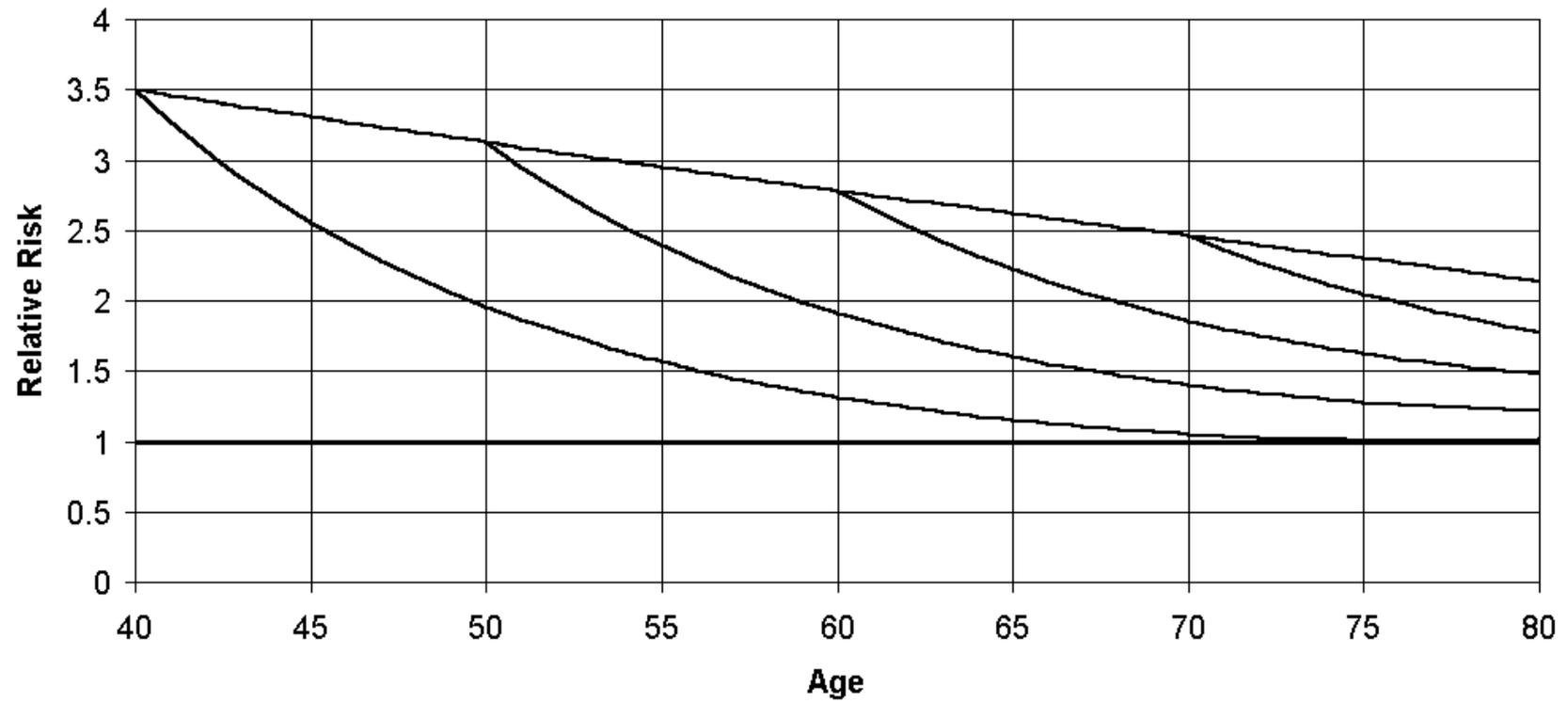


Figure 2. Female relative risk of death, current and former smokers, by age and smoking status

