Smoking Cessation and Mortality Trends among 118,000 Californians, 1960–1997

James E. Enstrom[1] *and Clark W. Heath, Jr.*[2,3]

We assessed the impact of smoking cessation on subsequent death rates among a cohort of 51,343 men and 66,751 women in California enrolled in late 1959 in the original American Cancer Society (ACS) Cancer Prevention Study (CPS I) and followed for 38 years. We compared the age-adjusted death rate, expressed as deaths per 1,000 person-years, among all subjects who smoked cigarettes in 1959 but who had largely quit as of 1997 with the death rate among never smokers over a 38-year period. The all causes death rate for males decreased from 20.67 during 1960–1969 to 18.68 during 1960–1997 for smokers and decreased from 10.51 to 9.46 for never smokers. The lung cancer death rate for males increased from 1.558 to 1.728 for smokers and increased from 0.127 to 0.133 for never smokers. The all causes death rate for females increased from 9.54 to 10.14 for smokers and decreased from 6.95 to 6.44 for never smokers. The lung cancer death rate for females increased greatly from 0.208 to 0.806 for smokers and increased from 0.094 to 0.116 for never smokers. These results indicate there has been no important decline in either the absolute or relative death rates from all causes and lung cancer for cigarette smokers as a whole compared with never smokers in this large cohort, in spite of a substantial degree of smoking cessation. While cessation clearly reduces the mortality risk among long-term former smokers, the population impact of cessation appears to be less than currently believed. (Epidemiology 1999; 10:500–512)

Keywords: cigarette smoking, smoking cessation, mortality, lung cancer, trends, Cancer Prevention Study.

It has been estimated that cigarette smoking causes about one-fifth of all U.S. deaths.[1] This figure represents over 400,000 deaths per year, mainly from coronary heart disease, lung cancer, and other respiratory diseases, that in principle can be substantially reduced by smoking cessation. Nevertheless, in spite of a substantial degree of cigarette smoking cessation and a large reduction in tar and nicotine levels in cigarettes during the past 35 years in the general U.S. population,[2] the lung cancer death rate remains persistently high.[3] Indeed, among U.S. adults since 1966 the percentage of current cigarette smokers has declined from 43% to 25% and the percentage of former smokers has increased from 13% to 25%, and yet the lung cancer death rate has increased by about 100%. Thus, it is important to evaluate the impact of smoking cessation from a perspective that may explain these trends.

From the [1]School of Public Health and Jonsson Comprehensive Cancer Center, University of California, Los Angeles, CA, and [2]American Cancer Society, Atlanta, GA. [3]Present address: Radiation Effects Research Foundation, 5-2 Hijiyama Park, Minami-ku, Hiroshima City, 732-0815, Japan.

Address correspondence to: James E. Enstrom, School of Public Health, University of California, Los Angeles, CA 90095-1772.

This study was initiated by the American Cancer Society and extended follow-up was supported by a research grant from the Tobacco-Related Disease Research Program of the University of California.

Submitted June 2, 1998; final version accepted February 11, 1999.

The mortality benefits of smoking cessation are based primarily on nonexperimental observational epidemiologic studies, which consistently indicate that the death rates of former cigarette smokers are lower than those of current cigarette smokers, and that the former smoker death rates converge toward those of never smokers the longer the former smokers have not smoked.[4] Among former smokers whose smoking status was determined at the time they entered an epidemiologic study, the decline in risk of death compared with never smokers begins during the first 5 years after quitting and continues for at least 10–15 years. After 15–20 years, the risk of all-cause mortality returns nearly to that of never smokers and the risk of lung cancer mortality drops to about twice that of never smokers.

These nonexperimental studies have the limitation that the reported benefits of cessation are based on mortality patterns among persons who were already former smokers at the time they enrolled and were classified by the number of years since they last smoked at time of enrollment. The self-selected former smokers who enrolled in these studies are those who were alive at the time the study began. A former smoker who stopped 15 years before the study began is by definition one who remained alive those 15 years. Former smokers who died before the study began would obviously not be included and might be different from the self-selected former smokers who were included. Also, former smokers who have only stopped for a short time period (generally less than 5 years) and/or former smokers who were in poor

TABLE 1. Cigarette Smoking Trends among California CPS I Subjects and U.S. Whites by Age As of December 31, 1959

Age as of 1959 (Years)	Population	Percentage of Current Cigarette Smokers									
		Males					Females				
		1959	1965	1972	1994	1999	1959	1965	1972	1994	1999
30–34	CPS	57	45	36	0	6	44	39	32	0	5
	U.S.	74	67	56	16		49	47	43	16	
35–39	CPS	52	41	32	8	3	45	40	35	0	5
	U.S.	72	64	52	13		46	44	39	12	
40–44	CPS	54	44	31	0	2	44	40	32	2	3
	U.S.	70	61	49	10		45	43	36	9	
45–49	CPS	51	40	28	2	1	42	37	29	6	2
	U.S.	68	59	45	7		40	38	31	6	
50–54	CPS	49	37	24	5	1	35	29	22	0	1
	U.S.	63	53	38	4		32	29	23	2	
55–59	CPS	44	32	20	25	2	27	21	15	0	0
	U.S.	57	46	30	2		23	20	15	1	
60–64	CPS	38	27	14			19	14	10		
	U.S.	48	37	22			17	14	10		
65–69	CPS	32	20	10			14	10	6		
	U.S.	40	31	19			11	9	6		
70–74	CPS	26	17	6			11	8	4		
	U.S.	33	24	8			8	6	5		
75–79	CPS	21	12	3			7	5	3		
80–84	CPS	13	10	10			4	1	0		
85–99	CPS	7	6	0			3	3	0		
Total (All respondents)	CPS	46% (51,343)	34% (44,990)	23% (26,255)	4% (114)	2% (2,252)	32% (66,751)	28% (61,236)	23% (38,083)	2% (167)	3% (4,796)

Percentage of current cigarette smokers among CPS I subjects are based on responses to the original 1959 questionnaire and to the follow-up questionnaires in 1965, 1972, 1994, and 1999. Total number of CPS I respondents are shown in parentheses. Percentage among U.S. whites are based on national surveys.[18]

health at the time of cessation do not have lower death rates than current smokers. These limitations are generally not mentioned when stating the benefits of cessation.

The most rigorous way to evaluate cessation is to assign smokers randomly to either a cessation intervention or no intervention in a randomized controlled trial (RCT). Given the evidence from nonexperimental studies, it would be expected that in an RCT with a smoking cessation intervention, smoking-related mortality would be lower in the intervention group than in the control group. There has been just one completed RCT designed to evaluate smoking cessation alone: the Whitehall Civil Servants Study of 1,445 middle aged white men in London.[5] There has been one RCT where smoking cessation was the major risk factor change during 6 years of intervention: the Multiple Risk Factor Intervention Trial (MRFIT) of 12,866 middle-aged white men in America.[6] There is currently one ongoing RCT designed to evaluate smoking cessation: the Lung Health Study (LHS) of 3,702 men and 2,185 women in the United States and Canada.[7]

Initially these RCTs showed substantially more smoking cessation in the intervention group relative to the control group (about 45% *vs* 20% in MRFIT averaged over 6 years, about 60% *vs* 25% in Whitehall averaged over 5 years), but the cessation differences diminished substantially over time. For the intervention groups relative to their respective control groups, the total mortality during 16–20 years of follow-up was 6% less in MRFIT and 7% less in Whitehall; lung cancer mortality was 17% more in MRFIT and 11% less in Whitehall. No differences in total and lung cancer mortality were observed in the first 5 years of follow-up in LHS. A systematic review of nine RCTs shows that multifactorial interventions, including smoking cessation, resulted in a reduction of only 3% in total mortality.[8] So the RCTs have not definitively confirmed the value of smoking cessation, but they are limited by the fact that they were not able to sustain a large difference in smoking cessation between intervention and control groups.

We provide additional insight into this issue in two ways. First, we analyze the conventional observational data on the benefits of cessation among a large cohort of Californians, making use of repeated measurements of smoking status and extended follow-up not previously analyzed. Second, we evaluate the "natural experiment" of long-term smoking cessation that has occurred among this cohort. Here, the smokers as a whole can be considered as an intervention group that has undergone extensive, sustained cessation and the never smokers as a whole can be considered as a control group that has never smoked. The smoking-related death rates of both groups would be expected to converge as a consequence of smoking cessation.

Although a "natural experiment" does not involve randomization of subjects and is not nearly as rigorous as an RCT, inferences about etiologic relations derived from such situations are stronger than inferences derived solely from an observational study.[9] The study of British physicians is a prime example of this approach,[10] as is our somewhat similar study of California physicians.[11] The British study involved 34,440 physicians who substantially reduced their cigarette smoking from 1951 to 1971 and whose lung cancer death rate declined relative to the general population rate and converged toward that

TABLE 2. Number of Subjects Followed, Percentage Followed Only to September 1972, Percentage Lost As of December 1997, Number of 1960–1969 and 1960–1997 Person-Years for Current Cigarette Smokers and Never Smokers among California CPS I Subjects

Age as of 1959 (Years)	Males					Females				
	Number of Subjects Followed	Follow-up (%)		Person-Years of Observation		Number of Subjects Followed	Follow-up (%)		Person-Years of Observation	
		Only to 1972	Lost as of 1997	1960–1969	1960–1997		Only to 1972	Lost as of 1997	1960–1969	1960–1997
Current cigarette smokers										
30–34	410	6.1	12.3	821	821	649	12.4	13.4	1,398	1,398
35–39	707	6.1	10.9	3,523	3,523	1,661	9.9	13.4	6,625	6,625
40–44	1,593	5.1	9.4	7,608	8,354	3,737	8.6	12.5	17,826	19,104
45–49	5,560	3.0	7.5	22,840	25,843	5,997	9.5	12.5	37,782	43,395
50–54	4,821	2.9	6.5	42,976	50,025	4,194	9.5	12.8	49,751	65,755
55–59	3,151	3.8	6.4	43,078	64,965	2,406	8.4	14.8	39,685	75,404
60–64	1,808	2.3	3.1	28,155	67,798	1,276	8.6	7.4	23,186	74,953
65–69	1,056	2.2	2.4	15,815	63,312	715	7.0	7.3	12,443	70,178
70–74	527	1.9	1.1	8,148	52,962	346	5.0	4.6	6,450	61,153
75–79	215	0.5	0.0	3,701	38,364	116	0.9	1.7	2,933	47,409
80–84	44	0.0	0.0	1,275	22,270	30	0.0	0.0	989	28,797
85–99	7	0.0	0.0	265	9,635	10	0.0	0.0	257	14,666
Total	19,899	3.3%	6.5%	178,206	407,874	21,137	9.1%	12.2%	199,324	508,837
Never smokers										
30–34	198	8.5	15.5	443	443	681	10.6	13.6	1,439	1,439
35–39	353	3.7	7.3	1,735	1,735	1,615	8.8	11.4	6,724	6,724
40–44	693	2.4	11.2	3,659	4,058	3,820	7.7	11.8	17,759	19,115
45–49	2,458	2.6	8.4	10,392	11,876	6,610	8.5	11.9	39,511	45,335
50–54	2,112	1.9	7.4	19,367	22,980	6,546	8.7	13.2	59,021	75,602
55–59	1,662	2.3	7.3	20,257	30,987	5,665	7.7	16.5	61,434	100,332
60–64	1,199	1.8	4.8	15,525	35,439	5,006	8.1	9.6	54,381	117,260
65–69	911	2.4	4.0	11,206	37,181	4,180	7.6	6.6	46,814	128,118
70–74	668	0.6	1.3	7,926	35,814	2,630	5.3	5.7	36,768	128,313
75–79	395	0.3	0.2	5,205	31,187	1,473	0.8	0.6	23,202	115,124
80–84	162	0.0	0.0	2,811	22,865	680	0.5	0.1	11,556	86,883
85–99	59	1.7	0.0	1,214	15,198	310	0.3	0.0	5,849	72,404
Total	10,870	2.2%	6.7%	99,741	249,764	39,218	7.5%	10.8%	4,464	96,654
All subjects										
Total	51,343	2.7%	6.2%	462,397	1,093,429	66,751	8.2%	11.3%	623,552	1,563,058

All ages are as of December 31, 1959, and smoking status is defined in text.

of nonsmokers during those 20 years. The major mortality benefits of cessation were among smoking-related causes in physicians under age 65 at death, with no overall benefit for ages 65 and above.[10]

Methods

The original ACS Cancer Prevention Study (CPS I) of 1 million Americans from 25 states is a prospective epidemiologic cohort study begun in October 1959. It is described in detail elsewhere.[12–14] CPS I used 68,000 ACS volunteer researchers to distribute and collect questionnaires from friends, relatives, and others with whom they would expect to be in contact for 6 years. A total of 1,078,000 men and women were enrolled, including 118,094 Californians (51,343 men and 66,751 women). The four-page confidential questionnaire contained data on many factors suspected as being related to cancer, such as, family history of disease; medical history; smoking, drinking, and diet; use of drugs and medicines; occupational history; and environmental exposures. In 1961, 1963, 1965, and 1972, surviving subjects were asked to complete a short questionnaire regarding changes in smoking habits and detailed summaries of the smoking changes after 6 and 13 years have been published.[15,16]

The subjects were followed annually for 6 years, with 99% traced through September 1965. Follow-up was begun again in 1971, with 93% traced through September 1972. ACS secured death certificates from state health departments for those known dead. There were difficulties in distributing the 1972 questionnaire and only 75% of survivors returned it. Most follow-ups were terminated in 1972 because tracing became increasingly difficult owing to movement and/or death of the researchers and subjects. Follow-up was continued through 1987 for the 5% of subjects born before 1887.[17]

After a 1990 feasibility study showed that it was possible to successfully follow most of the persons in a 0.3% sample beyond 1972, follow-up was undertaken on all 118,094 California CPS I subjects, excluding 22,210 deaths previously found by ACS and 6,844 persons with an incomplete or missing name who could not be followed beyond 1972. To identify new deaths, the CPS I subjects were matched several times with the 1960–1997 California death file. We evaluated death matches based on the following variables available on most subjects: last name, first name, middle initial, marital status, spouse's initials, sex, race, birth year, birth month, country of birth, county of residence, and initial health status.

TABLE 3. Age-Adjusted Death Rate (Deaths per 1,000 Person-Years for Ages 35–84 Standardized to 1960 U.S. Population) during 1960–1969 for Former Cigarette Smokers by Length of Time Quit Compared with Current and Never Smokers among California CPS I Subjects

	Males			Females	
1959 Smoking Status	Number of Subjects	All Causes	Lung Cancer	Number of Subjects	All Causes
Current (as of 1959 and followed 1960–1969)	19,899	20.67 [3,604]	1.558 [307]	21,137	9.54 [1,517]
Former (quit <1 year as of 1959)					
Followed 1960–1961	1,137	28.13 [28]	2.396 [4]	693	15.28 [12]
Survived through 1961 and followed 1962–1964	1,106	21.47 [59]	1.762 [5]	681	12.00 [15]
Survived through 1964 and followed 1965–1969	1,040	16.47 [103]	1.276 [9]	663	7.22 [29]
Former (as of 1959 and followed 1960–1969)					
Quit <1 year as of 1959	1,137	18.68 [190]	1.651 [18]	693	9.87 [56]
Quit 1–4 years as of 1959	2,291	16.31 [411]	1.135 [33]	1,228	9.10 [94]
Quit 5–9 years as of 1959	2,467	13.80 [389]	0.599 [18]	1,032	10.65 [85]
Quit 10–19 years as of 1959	2,535	13.58 [405]	0.342 [10]	1,211	8.58 [88]
Quit 20+ years as of 1959	2,149	10.69 [384]	0.224 [8]	675	5.35 [32]
Never (as of 1959 and followed 1960–1969)	10,870	10.51 [1,414]	0.127 [18]	39,218	6.95 [3,712]

Number of subjects of all ages and number of deaths with attained ages 35–84 [ ] are shown in this and other tables.

Follow-up was done without knowledge of the smoking status of the subjects.

To confirm that cohort members are still alive, those not known to be dead were matched by the California Department of Motor Vehicles (DMV) with California driver's license information. Matches were established based on name, sex, date of birth, height, weight, and spouse's address. Other sources of follow-up have been used extensively: the Social Security death index, voter registration records, and national name and address files. Subjects are considered to be alive if they have a valid driver's license match and are not known to be dead from any source. The drivers' licenses for most of these matches were last renewed in 1995–1998. We believe most deaths through 1997 have now been identified through the above sources.

Thus, we selected a cutoff date of December 31, 1997, representing 38 years of follow-up. As of this date, among 51,343 males, there were 36,274 (71%) deaths with underlying cause known, 2,451 (5%) deaths with cause unknown (mostly outside of California since 1972), 8,023 (16%) known alive through DMV records, 1,395 (3%) not followed beyond 1972, and 3200 (6%) lost as of 1997. Among 66,751 females, there were 35,183 (53%) deaths with underlying cause known, 2,030 (3%) deaths with cause unknown, 16,552 (25%) known alive, 5,449 (8%) not followed beyond 1972, and 7537 (11%) lost as of 1997.

To determine recent smoking patterns in the cohort, a mailing was done in 1994 to random samples of 200 households where both husband and wife were alive and 100 households with a single female using driver's license addresses obtained from the DMV. A total of 114 men (57%) and 167 women (56%) completed a simple one-page smoking questionnaire. A second questionnaire was mailed in 1999 to 6,354 men and 12,918 women with a driver's license address as of 1995 or later. Preliminarily, a total of 2,252 (43%) men and 4,796 (45%) women completed a two-page smoking and lifestyle questionnaire, out of 5,275 men and 10,738 women who apparently received the questionnaire; at least 3,259 questionnaires were undeliverable owing to an incorrect address or recent death. Also, comparison is made with recent U.S. smoking surveys by birth cohort.[18]

To determine the mortality impact of smoking cessation, we have used a survival program developed by Monson to determine person-years of follow-up, deaths and death rates by attained age, and age-adjusted death rates for attained ages 35–84, standardized to the 1960 U.S. population in 5-year age groups.[19] Also, we used the Cox proportional hazards model to evaluate the age-adjusted relative risk of death as a function of smoking status and time period of follow-up.[20] Current, former, and never smoking status has been determined initially as of the 1959 questionnaire and then again as of the 1965 and 1972 questionnaires. Current smokers are defined to be those persons who smoked cigarettes only. Former smokers in 1965 are defined as those 1959 smokers who did not smoke in 1965; former smokers in 1972 are defined as those 1965 smokers who did not smoke in 1972. Never smokers are defined to be those persons who never smoked any form of tobacco.

Age at entry is defined to be 30–99 years as of December 31, 1959. The follow-up period is from time of entry into the study (January 1 to March 31, 1960) until death, withdrawal (date last known alive), o end of follow up (December 31 1997). Person-years of obser-

TABLE 4. Age-Adjusted Death Rate by 2-Year Follow-Up Periods for Current and Former Cigarette Smokers Compared with Never Smokers among California CPS I Subjects for All Causes, with Smoking Status Determined As of 1959, 1965, and 1972 Questionnaires

	Males				Females			
		Death Rate by Follow-Up Period				Death Rate by Follow-Up Period		
Smoking Status	Number of Subjects	1960–1961	1962–1963	1964–1965	Number of Subjects	1960–1961	1962–1963	1964–1965
1959								
Current	19,899	17.61 [510]	19.17 [656]	21.63 [763]	21,137	8.55 [198]	8.51 [256]	11.32 [355]
Former (quit 0–6 years)	4,773	17.56 [147]	17.70 [161]	16.55 [167]	2,526	14.32 [37]	8.96 [34]	7.14 [33]
Never	10,870	9.02 [206]	11.16 [281]	10.87 [299]	39,218	6.39 [586]	6.67 [656]	7.31 [771]
1965		1966–1967	1968–1969	1970–1971		1966–1967	1968–1969	1970–1971
Current	12,366	20.05 [526]	20.61 [601]	19.58 [601]	15,244	9.37 [238]	8.19 [264]	11.30 [378]
Former (quit 0–5 years since 1959)	4,224	22.90 [218]	20.44 [220]	17.47 [194]	3,381	11.02 [80]	7.72 [70]	9.91 [84]
Never	9,330	10.72 [278]	10.34 [292]	12.32 [327]	34,052	6.90 [743]	7.02 [817]	7.53 [952]
1972		1973–1974	1975–1976	1977–1978		1973–1974	1975–1976	1977–1978
Current	4,892	18.74 [295]	20.14 [351]	19.23 [325]	6,122	9.96 [152]	10.00 [187]	12.71 [249]
Former (quit 0–6 years since 1965)	2,838	16.06 [164]	15.56 [189]	13.95 [167]	2,128	10.02 [65]	12.54 [80]	9.18 [76]
Never	5,435	8.60 [192]	9.10 [236]	9.63 [240]	17,355	5.71 [478]	6.15 [484]	6.62 [534]

vation and deaths in 1959 were excluded. Persons living past age 100 are assumed dead at age 99. Causes of death, as defined by the Ninth Revision of the International Classification of Diseases (ICD9), are limited here to lung cancer (ICD9 = 162) and all causes. Causes of deaths before 1979 under the Seventh and Eighth Revisions have been reclassified to the Ninth Revision. Similar methodology has been used recently for 19-year follow-up of a U.S. sample of males and females and 26-year follow-up of the U.S. male veterans cohort.[21,22]

Results

The cigarette smoking habits of the California CPS I cohort in 1959 have been described and compared with follow-up smoking data from 1965, 1972, 1994, and 1999 in Table 1. Based on surviving subjects with complete smoking histories, the percentage of cigarette smokers declined from 46% in 1959 to 3% in 1994/1999 among males and from 32% in 1959 to 2% in 1994/1999 among females. The declines were more rapid among the older subjects. These data demonstrates the high degree of smoking cessation among this cohort and extend previous findings.[15,16] These findings agree qualitatively with the cessation data for U.S. whites[18] as shown in Table 1. Even if the 1994 and 1999 CPS I surveys were inaccurate, the national surveys indicate that the 1994 smoking prevalence among those born during 1900–1929 (aged 30–59 in 1959) would average less than 10%.[18]

Although the 1994 and 1999 surveys are based on selected samples, the baseline characteristics of the respondents and nonrespondents are similar. Thus, these two surveys should be reasonably representative of recent survivors. The main finding in both is that there has been almost total cessation among the respondents. Of the men who smoked cigarettes in 1959, 51% smoked in 1972 and 7% smoked in 1994/1999; of the women who smoked in 1959, 66% smoked in 1972 and 7% smoked in 1994/1999. Among other respondents, there is good agreement between smoking status reported in 1959 and 1994/1999. Of the former smokers in 1959, 100% of males and 85% of females were former smokers in 1994/1999, with the other females reported to be never smokers. Of the never smokers in 1959, 94% of males and 93% of females were never smokers in 1994/1999.

Table 2 shows the number of subjects by age as of December 31, 1959 and 1959 smoking status, the percentage followed only to 1972, the percentage lost as of 1997, and 1960–1969 and 1960–1997 person-years of observation. The percentage withdrawn from follow-up at each age is independent of smoking status and declines with age. The person-years of observation during 1960–1997 have been 1,093,429 among men and 1,563,058 among women, making this the largest epidemiologic cohort followed for 38 years.

Table 3 shows the benefits of smoking cessation based on the traditional method of examining self-selected former smokers who had quit for a number of years as of the beginning of the study.[2] The death rates for former cigarette smokers compared with never smokers have been calculated during the follow-up period 1960–1969. The death rates for those who had quit for <1 and 1–4 years were close to the death rates for current smokers, whereas the death rates for former smokers who had not smoked for 20+ years were close to the death rates for

TABLE 5. Age-Adjusted Death Rate and Rate Difference and Relative Risk of Death (Ratio of Age-Adjusted Death Rates and Cox Proportional Hazards Ratio) by Follow-Up Period for 1959 Current Cigarette Smokers Compared with Never Smokers among California CPS I Subjects

1959 Smoking Status	Number of Subjects	Cause of Death and Follow-Up Period			
		All Causes		Lung Cancer	
		1960–1969	1960–1997	1960–1969	1960–1997
Males (age-adjusted rates)					
All subjects (T)	51,343	15.30 [8,519]	14.13 [30,856]	0.793 [489]	0.888 [1,883]
Current smokers (C)	19,899	20.67 [3,604]	18.68 [13,681]	1.558 [307]	1.728 [1,305]
Never smokers (N)	10,870	10.51 [1,414]	9.46 [5,327]	0.127 [18]	0.133 [76]
Difference (C−N)		10.16	9.22	1.431	1.595
Ratios					
Age-adjusted rates (C/N)		1.97 (1.85–2.09)	1.97 (1.91–2.03)	12.27 (7.68–19.59)	12.99 (10.46–16.13)
Proportional hazards (C/N)		1.95 (1.83–2.07)	1.74 (1.69–1.79)	12.63 (7.91–20.16)	11.96 (9.63–14.85)
Females (age-adjusted rates)					
All subjects (T)	66,751	7.72 [5,746]	7.70 [24,779]	0.138 [106]	0.339 [996]
Current smokers (C)	21,137	9.54 [1,517]	10.14 [9,353]	0.208 [52]	0.806 [743]
Never smokers (N)	39,218	6.95 [3,712]	6.44 [13,249]	0.094 [46]	0.116 [197]
Difference (C−N)		2.59	3.70	0.114	0.690
Ratios					
Age-adjusted rates (C/N)		1.37 (1.29–1.45)	1.57 (1.54–1.61)	2.21 (1.46–3.35)	6.95 (6.01–8.04)
Proportional hazards (C/N)		1.47 (1.38–1.57)	1.53 (1.50–1.57)	2.49 (1.65–3.77)	6.13 (5.30–7.09)

never smokers, in agreement with previous results for this cohort.[13] The top rows of Table 3 show the death rate for former smokers who had not smoked for <1 year as of 1959 and those who survived for 2 years through 1961 had higher death rates than current smokers. The death rate for the former smokers who survived through 1964 was somewhat less than the death rate for current smokers. These data show that in the first few years after cessation, the death rates for former smokers are at least as high as the death rates for current smokers.

To examine the mortality risk among former smokers more closely, Table 4 shows the death rates by 2-year follow-up periods for former cigarette smokers who had not smoked for 0–6 years as of 1959, 1965, and 1972. The 1959 data are for former smokers who had quit 0–6 years according to the 1959 questionnaire; the 1965 data are for the 1959 smokers who did not smoke in 1965; the 1972 data are for the 1965 smokers who did not smoke in 1972. The death rates by 2-year follow-up periods for current cigarette smokers as of 1959, 1965, and 1972 are also shown. Note that for 2-year follow-up of males and 2-year and 4-year follow-up of females, the death rates for former smokers are slightly larger than those for current smokers.

These findings are consistent with a previously noted finding of the 1959 questionnaire data, namely, that around the time they answer a questionnaire a substantial number of recent quitters are in relatively poor health.[23] The poor health effect is largest in the 1st year of cessation and diminishes with each additional year of cessation before the questionnaire and each additional year of follow-up after the questionnaire. The results in Tables 3 and 4 indicate that the benefits of cessation are very limited during the first 5 years of cessation, but are substantial for those who survive many years after quitting.

The special value of this study is that it is possible to examine the overall impact of cessation on a large cohort of persons who smoked cigarettes in 1959 and then largely quit smoking during the next 38 years. This assessment is not just of long-term healthy former smokers, but of a cohort of smokers as a whole as it underwent almost total cessation, which includes both short-term and long-term quitters, a portion of whom were not healthy.

Table 5 compares the death rates for an initial period, 1960–1969, when most of the 1959 smokers were still smoking, with the death rates for the entire follow-up period, 1960–1997, during which there was a substantial degree of cessation. All subjects and all 1959 current cigarette smokers are compared with 1959 never smokers for death from lung cancer and all causes. Both absolute and relative differences in death rates are presented.

When comparing the 1960–1969 and 1960–1997 periods, the death rates generally decrease slightly for all causes and generally increase substantially for lung cancer. The absolute difference in death rates between current smokers and never smokers remains relatively constant for males but increases substantially for females. The ratio of death rates for current smokers to never smokers has remained at 1.97 for males and has increased for females from 1.37 to 1.57 for all causes. The proportional hazards ratio, based on all deaths and not just those with attained age 35–84, decreased from 1.95 to 1.74 for males and increased from 1.47 to 1.53 for females. The corresponding ratios for lung cancer remained roughly constant for males and increased threefold for females. Detailed trends in death rates for all

TABLE 6. Age-Adjusted Death Rate for 1959 Current Cigarette Smokers by Number of Cigarette Per Day Compared with Never Smokers among California CPS I Subjects

1959 Smoking Status	Number of Subjects	Death Rate by Cause and Follow-Up Period			
		All Causes		Lung Cancer	
		1960–1969	1960–1997	1960–1969	1960–1997
Male current smokers					
40+ cigs/day	2,623	24.52	23.02	3.107	2.581
		[516]	[1,943]	[54]	[227]
21–39 cigs/day	4,790	23.85	20.13	2.096	2.138
		[784]	[3,442]	[80]	[394]
20 cigs/day	7,194	20.66	19.24	1.767	1.816
		[1,289]	[4,984]	[123]	[477]
10–19 cigs/day	3,742	19.29	15.94	0.987	1.021
		[731]	[2,414]	[42]	[164]
1–9 cigs/day	1,550	14.67	11.68	0.415	0.631
		[284]	[898]	[8]	[43]
Male never smokers	10,870	10.51	9.46	0.127	0.133
		[1,414]	[5,327]	[18]	[76]
Female current smokers					
21+ cigs/day	2,884	11.33	14.11	0.785	1.911
		[204]	[1,513]	[17]	[204]
20 cigs/day	6,875	11.47	11.86	0.284	1.100
		[525]	[3,361]	[23]	[320]
10–19 cigs/day	6,691	9.34	9.30	0.085	0.500
		[479]	[2,827]	[9]	[166]
1–9 cigs/day	4,687	7.56	6.98	0.077	0.249
		[309]	[1,652]	[3]	[53]
Female never smokers	39,218	6.95	6.44	0.094	0.116
		[3,712]	[13,249]	[46]	[197]

causes are presented in 5-year intervals for current and never smokers in Appendix Tables 1–4. Detailed comparison of death rate ratios and proportional hazards ratios by follow-up period is presented in Appendix Table 5.

As further assessment, the death rates for all causes and lung cancer for smokers subdivided by the number of cigarettes smoked per day in 1959 are shown in Table 6. The death rate and ratio trends in this table are similar to those for smokers as a whole. The results in Tables 4–6 suggest that the impact of smoking cessation on cigarette smokers as a whole in this cohort is quite limited. Furthermore, it appears that the death rates for self-selected long-term former smokers as shown in Table 3 cannot be used to describe accurately the impact of smoking cessation on cigarette smokers as a whole.

Discussion

This study provides valuable new evidence regarding the relation of smoking cessation to the prevention of tobacco-related diseases in a large California population. First, it confirms the well-established relation that the relative risk of death among former smokers compared with never smokers decreases as the number of years quit increases based on self-selected former smokers and approaches 1.0 after 15–20 years of cessation. It shows, however, that the impact of cessation is limited during the first 5 years of cessation among these former smokers.

Furthermore, it shows that cessation has had little impact on the absolute and relative risk of total mortality among all 1959 cigarette smokers compared with never smokers during the next 38 years. The relative lung cancer risk has remained essentially constant among the males and has increased markedly among the females, although lung cancer is the disease most strongly linked with cigarette smoking and is the one that should be most affected by cessation over a long follow-up period. These results help explain why there has not yet been a substantial decline in the lung cancer death rate among older U.S. males as a whole and why the lung cancer death rate among U.S. females as a whole has risen so much despite a considerable degree of smoking cessation during the past 35 years (Refs 3, 18, and Enstrom, unpublished). Our findings are similar to those found recently among U.S. male veteran smokers over a 26-year period and among a representative sample of U.S. males and females over a 19-year period.[21,22]

Since the impact of cessation on the smokers as a whole in this cohort is substantially less than one might have expected based on the established results for self-selected former smokers,[4,13,24] we have tried to identify factors that may explain this discrepancy. The results for all causes of death could be affected by lifestyle or environmental changes other than cessation that might have negated the benefits of smoking cessation, but it is not clear what these changes might have been. If cessation is accompanied by other changes that negate the benefit of cessation, these changes would have to be considered when evaluating the overall impact of cessation. It is much less likely that other changes would have affected the results for lung cancer, since cigarette smoking is by far the strongest risk factor for this disease.

Furthermore, the impact of cessation might be reduced because most of the subjects in this cohort were 45+ years of age at entry and most of the smokers were long-term smokers who quit after the age of 55 years. The heavy, long-term smokers with higher death rates probably quit later than the lighter, short-term smokers.

Also, the cohort as a whole includes all those who quit and all those who continued smoking, and healthy persons as well as unhealthy persons with preexisting diseases. In addition, recent evidence indicates the lungs of smokers sustain permanent genetic damage that would reduce the benefits of cessation.[25,26]

It is not possible to make a death rate comparison of continuing smokers with quitters over the entire follow-up period, since extensive smoking data were collected only through 1972. Other studies have shown that the death rates for current smokers and never smokers have diverged since the 1960s for unexplained reasons (Ref 27 and Enstrom, unpublished), as seen from 1960–61 to 1972–73 in Table 4. This trend would suggest that if there had been no cessation, the death rates for a 1959 cohort of continuing smokers would be even larger than those observed in Table 5. On the other hand, such an increase might be moderated by the fact that the death rates for current smokers converge toward those of never smokers with increasing age (Appendix Tables 1–4).

There are several limitations that we believe do not affect the findings. The limited smoking data available on the cohort since 1972 are a weakness; however, they still support a high degree of cessation among the cohort even if the exact degree is uncertain. Substantial cessation occurred in the cohort as of 1972 and the 1994/1999 findings are consistent with numerous national surveys that show most American smokers stop smoking as they age into their 70s and 80s. The percentage of persons lost to follow-up, 9% as of 1997, is independent of smoking status and would not substantially affect relative comparisons, although it could affect the absolute death rates in the later years of follow-up.

This paper has presented data on the impact of smoking cessation on both the absolute and relative risk of mortality in one major cohort of Californians. Even with the reservations noted, the above findings, along with results of RCTs, suggest that the impact of cessation on mortality, particularly lung cancer mortality, among cigarette smokers as a whole is less than currently believed. The excess mortality risk associated with smoking can be avoided by never smoking and can be reduced among smokers only by becoming a long-term former smoker.

Acknowledgments

We thank Lawrence Garfinkel for initiating the study and facilitating the extended follow-up, Michael Thun for helpful critiques, and Linda E. Kanim, Michael Succar, and Betty Isbell for technical assistance.

References

1. McGinnis JM, Foege WH. Actual causes of death in the United States. JAMA 1993;270:2207–2212.
2. Centers for Disease Control. Surveillance for selected tobacco-use behaviors–United States. MMWR 1994;43:1–43.
3. Landis SH, Murray T, Bolden S, Wingo PA. Cancer Statistics, 1999. CA Cancer J Clin 1999;49:8–31.
4. The Health Benefits of Smoking Cessation–A Report of the Surgeon General, Public Health Service, DHHS Pub. No. (CDC) 90–8416, Rockville, MD, 1990.
5. Rose G, Colwell L. Randomized controlled trial of anti-smoking advice: final (20 year) results. J Epidemiol Community Health 1992;46:75–77.
6. The MRFIT Research Group: Mortality after 16 years for participants randomized to the Multiple Risk Factor Intervention Trial. Circulation 1996;94:946–951.
7. Anthonisen NR, Connett JE, Kiley JP, Altose MD, Bailey WC, Buist AS, Conway WA Jr, Enright PL, Kanner RE, O'Hara P, Owens GR, Scanlon PD, Tashkin DP, Wise RA. Effects of smoking intervention and the use of an inhaled anticholinergic bronchodilator on the rate of decline of FEV1 (The Lung Health Study). JAMA 1994;272:1497–1505.
8. Ebrahim S, Smith GD. Systematic review of randomised controlled trials of multiple risk factor interventions for preventing coronary heart disease. BMJ 1997;314:1666–1674.
9. Lilienfeld AM, Lilienfeld DE. Foundations of Epidemiology. New York: Oxford University Press, 1980; 10–11.
10. Doll R, Peto R. Mortality in relation to smoking: 20 years' observations on male British doctors. BMJ 1976;2:1525–1536.
11. Enstrom JE. Trends in mortality among California physicians after giving up smoking: 1950–79. BMJ 1983;286:1101–1105.
12. Hammond EC. Smoking in relation to mortality and morbidity. Findings in first thirty-four months of follow-up in a prospective study started in 1959. J Natl Cancer Inst 1964;32:1161–1188.
13. Hammond EC. Smoking in relation to death rates of one million men and women. NCI Monograph 1966;19:127–204.
14. Garfinkel L. Selection, follow-up, and analysis in the American Cancer Society prospective studies. Natl Cancer Inst Monogr 1985;67:49–52.
15. Hammond EC, Garfinkel L. Changes in cigarette smoking, 1959–1965. Am J Public Health 1968;58:30–45.
16. Garfinkel L. Changes in number of cigarettes smoked compared to changes in tar and nicotine content over a 13-year period. Banbury Report 3: A Safe Cigarette. Cold Spring Harbor Laboratory, 1980;19–28.
17. Lew EA, Garfinkel L. Mortality at ages 75 and older in the Cancer Prevention Study (CPS I). CA Cancer J Clin 1990;40:210–224.
18. Burns DM, Lee L, Shen LZ, Gilpin E, Tolley HD, Vaughn J, Shanks TG. Cigarette smoking in the United States. In Smoking and Tobacco Control Monograph 8, National Cancer Institute, NIH Publ No. 97–4213, 1997, pp. 13–112, and U. S. Bureau of the Census, Current Populations Surveys.
19. Monson RR. Analysis of relative survival and proportional mortality. Comp Biomed Res 1974;7:325–332.
20. Harrell F. The PHREG procedures. In: SUGI Supplemental Library User's Guide, 1989 Edition, Cary, NC: SAS Institute, 1989.
21. McLaughlin JK, Hrubec Z, Blot WJ, Fraumeni JF, Jr. Smoking and cancer mortality among U.S. veterans: a 26-year follow-up. Int J Cancer 1995;60:190–193.
22. Enstrom JE. Smoking cessation and mortality trends among two United States populations. J Clin Epidemiol 1999;52:999–999.
23. Hammond EC, Garfinkel L. The influence of health on smoking habits. NCI Monograph 1966;19:269–285.
24. Kawachi I, Colditz GA, Stampfer MJ, Willett WC, Manson JE, Rosner B, Hunter DJ, Hennekens CH, Speizer FE. Smoking cessation in relation to total mortality rates in women. A prospective cohort study. Ann Intern Med 1993;119:992–1000.
25. Mao L, Lee JS, Kurie JM, Fan YH, Lippman SM, Lee JJ, Ro JY, Broxson A, Yu R, Morice RC, Kemp BL, Khuri FR, Walsh GL, Hittelman WN, Hong WK. Clonal genetic alterations in the lungs of current and former smokers. J Natl Cancer Inst 1997;89:857–862.
26. Wistuba II, Lam S, Behrens C, Virmani AK, Fong KM, LeRiche J, Samet JM, Srivastava S, Minna JD, Gazdar AF. Molecular damage in the bronchial epithelium of current and former smokers. J Natl Cancer Inst 1997;89:1366–1373.
27. Thun MJ, Day-Lally CA, Calle EE, Flanders WD, Heath CW, Jr. Excess mortality among cigarette smokers: changes in a 20-year interval. Am J Public Health 1995;85:1223–1230.

Appendix

A1. 1960 CPS I Male Current Cigarette Smokers Followed to 1997

Age	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1997	1960–1997
All observed deaths by attained age									
30–34	2	0	0	0	0	0	0	0	2
35–39	11	3	0	0	0	0	0	0	14
40–44	25	16	1	0	0	0	0	0	42
45–49	105	28	18	4	0	0	0	0	155
50–54	238	179	47	21	7	0	0	0	492
55–59	274	384	236	47	28	11	0	0	980
60–64	285	428	486	315	95	35	9	0	1653
65–69	270	367	443	557	370	88	37	10	2142
70–74	193	335	409	556	651	438	89	39	2710
75–79	107	186	288	388	654	753	509	90	2975
80–84	49	121	174	235	359	537	706	337	2518
85–89	16	35	64	106	159	261	372	268	1281
90–94	4	3	14	27	42	70	111	85	356
95–99	0	1	2	5	11	13	23	15	70
30–99	1579	2086	2182	2261	2376	2206	1856	844	15390
Total person-years of observation by attained age									
30–34	821	0	0	0	0	0	0	0	821
35–39	2738	785	0	0	0	0	0	0	3523
40–44	5042	2565	747	0	0	0	0	0	8354
45–49	18064	4775	2357	646	0	0	0	0	25843
50–54	25877	17100	4334	2102	613	0	0	0	50025
55–59	19134	23944	15532	3772	2006	577	0	0	64965
60–64	11288	16867	20650	13227	3417	1830	519	0	67798
65–69	6407	9407	13846	17090	11490	3002	1658	411	63312
70–74	3336	4813	7052	10720	14077	9435	2554	976	52962
75–79	1407	2294	3228	4785	7731	10514	7034	1371	38364
80–84	438	838	1278	1821	2959	4723	6762	3452	22270
85–89	57	175	349	538	842	1386	2380	2085	7811
90–94	11	21	57	103	172	263	437	546	1610
95–99	0	1	10	19	25	43	60	56	214
30–99	94620	83586	69440	54824	43332	31772	21404	8897	407874
Age-specific death rate (1000*observed deaths/person-years)									
30–34	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.44
35–39	4.02	3.82	0.00	0.00	0.00	0.00	0.00	0.00	3.97
40–44	4.96	6.24	1.34	0.00	0.00	0.00	0.00	0.00	5.03
45–49	5.81	5.86	7.64	6.19	0.00	0.00	0.00	0.00	6.00
50–54	9.20	10.47	10.84	9.99	11.42	0.00	0.00	0.00	9.83
55–59	14.32	16.04	15.19	12.46	13.96	19.07	0.00	0.00	15.08
60–64	25.25	25.37	23.54	23.81	27.80	19.13	17.33	0.00	24.38
65–69	42.14	39.01	32.00	32.59	32.20	29.32	22.32	24.31	33.83
70–74	57.86	69.61	58.00	51.87	46.25	46.42	34.85	39.94	51.17
75–79	76.03	81.09	89.21	81.08	84.60	71.62	72.36	65.63	77.55
80–84	112.00	144.43	136.15	129.03	121.34	113.71	104.41	97.63	113.07
85–89	281.56	200.08	183.37	197.14	188.80	188.27	156.32	128.57	163.99
90–94	364.62	141.49	243.76	261.89	244.15	266.20	253.91	155.81	221.06
95–99	0.00	717.56	200.47	264.48	439.69	301.86	383.50	268.62	326.84
Death rate adjusted to 1960 U.S. population for attained ages 35–84									
35–84	19.57	21.47	18.95	17.38	16.83	14.18	10.44	8.87	18.68

Weights for 1960 U.S. population for ages 35–84 in 5-year age groups: 35–39: 0.174; 40–44: 0.145; 45–49: 0.140; 50–54: 0.135; 55–59: 0.111; 60–64: 0.096; 65–69: 0.080; 70–74: 0.062; 75–79: 0.035; 80–84: 0.022.

A2. 1960 CPS I Male Never Smokers Followed to 1997

Age	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1997	1960–1997
All observed deaths by attained age									
30–34	1	0	0	0	0	0	0	0	1
35–39	1	1	0	0	0	0	0	0	2
40–44	3	3	2	0	0	0	0	0	8
45–49	26	7	7	0	0	0	0	0	40
50–54	47	35	8	5	1	0	0	0	96
55–59	62	79	60	11	12	2	0	0	226
60–64	71	93	96	65	16	7	1	0	349
65–69	111	125	151	152	97	28	14	2	680
70–74	114	136	176	159	183	121	43	7	939
75–79	120	139	177	207	223	269	183	36	1354
80–84	90	151	175	209	202	293	337	176	1633
85–89	41	103	138	150	183	237	346	234	1432
90–94	17	36	60	76	100	132	148	121	690
95–99	5	7	11	25	34	38	65	39	224
30–99	709	915	1061	1059	1051	1127	1137	615	7674
Total person-years of observation by attained age									
30–34	443	0	0	0	0	0	0	0	443
35–39	1311	424	0	0	0	0	0	0	1735
40–44	2409	1251	399	0	0	0	0	0	4058
45–49	8028	2364	1137	348	0	0	0	0	11876
50–54	11475	7892	2241	1030	343	0	0	0	22980
55–59	9201	11056	7369	2031	993	336	0	0	30987
60–64	6734	8791	10106	6588	1942	953	325	0	35439
65–69	5046	6160	7787	9008	6171	1833	913	263	37181
70–74	3530	4396	5152	6672	8184	5663	1643	574	35814
75–79	2362	2843	3436	3985	5655	7106	4855	944	31187
80–84	1106	1705	1965	2346	2969	4343	5559	2871	22865
85–89	358	630	972	1062	1407	1870	2721	2120	11140
90–94	67	131	235	374	453	586	857	699	3402
95–99	9	19	25	73	84	110	172	164	656
30–99	52078	47663	40824	33517	28201	22801	17046	7634	249764
Age-specific death rate (1000*observed deaths/person-years)									
30–34	2.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.26
35–39	0.76	2.36	0.00	0.00	0.00	0.00	0.00	0.00	1.15
40–44	1.25	2.40	5.01	0.00	0.00	0.00	0.00	0.00	1.97
45–49	3.24	2.96	6.16	0.00	0.00	0.00	0.00	0.00	3.37
50–54	4.10	4.43	3.57	4.86	2.92	0.00	0.00	0.00	4.18
55–59	6.74	7.15	8.14	5.42	12.08	5.95	0.00	0.00	7.29
60–64	10.54	10.58	9.50	9.87	8.24	7.35	3.07	0.00	9.85
65–69	22.00	20.29	19.39	16.87	15.72	15.27	15.33	7.61	18.29
70–74	32.29	30.94	34.16	23.83	22.36	21.37	26.17	12.21	26.22
75–79	50.80	48.89	51.52	51.94	39.43	37.85	37.69	38.12	43.42
80–84	81.39	88.54	89.07	89.08	68.03	67.46	60.62	61.30	71.42
85–89	114.58	163.50	142.02	141.21	130.05	126.74	127.15	110.40	128.55
90–94	253.52	274.08	255.13	203.39	220.91	225.19	172.75	173.06	202.82
95–99	534.93	368.83	438.64	342.28	403.68	346.66	377.71	237.80	341.27
Death rate adjusted to 1960 U.S. population for attained ages 35–84									
35–84	10.41	10.78	11.32	8.81	8.05	6.72	5.80	4.05	9.46

A3. 1960 CPS I Female Current Cigarette Smokers Followed to 1997

Age	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1997	1960–1997
All observed deaths by attained age									
30–34	0	0	0	0	0	0	0	0	0
35–39	5	1	0	0	0	0	0	0	6
40–44	29	6	3	0	0	0	0	0	38
45–49	78	51	28	3	0	0	0	0	160
50–54	109	118	82	27	2	0	0	0	338
55–59	112	173	191	73	34	12	0	0	595
60–64	114	144	236	252	96	56	11	0	909
65–69	83	136	232	265	300	194	62	12	1284
70–74	52	106	197	281	394	461	189	51	1731
75–79	33	87	158	226	402	563	553	184	2206
80–84	24	56	101	173	249	423	675	385	2086
85–89	6	18	48	85	143	275	389	332	1296
90–94	2	9	11	43	73	109	146	126	519
95–99	2	1	4	4	18	30	40	35	134
30–99	649	906	1291	1432	1711	2123	2065	1125	11302
Total person-years of observation by attained age									
30–34	1398	0	0	0	0	0	0	0	1398
35–39	5273	1352	0	0	0	0	0	0	6625
40–44	12779	5046	1278	0	0	0	0	0	19104
45–49	25463	12319	4573	1039	0	0	0	0	43395
50–54	25287	24464	11116	3859	1029	0	0	0	65755
55–59	15753	23932	21725	9281	3714	999	0	0	75404
60–64	8597	14589	20440	18098	8828	3482	921	0	74953
65–69	4683	7759	12055	16877	16814	8093	3164	733	70178
70–74	2389	4060	6008	9422	15204	14924	7154	1991	61153
75–79	983	1950	3073	4390	7768	12743	12327	4175	47409
80–84	252	737	1272	1994	3096	5705	9531	6210	28797
85–89	70	140	456	723	1167	1825	3526	3596	11502
90–94	13	28	51	215	308	480	760	921	2778
95–99	3	4	1	10	62	84	111	110	386
30–99	102944	96380	82047	65908	57989	48336	37495	17737	508837
Age-specific death rate (1000*observed deaths/person-years)									
30–34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35–39	0.95	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.91
40–44	2.27	1.19	2.35	0.00	0.00	0.00	0.00	0.00	1.99
45–49	3.06	4.14	6.12	2.89	0.00	0.00	0.00	0.00	3.69
50–54	4.31	4.82	7.38	7.00	1.94	0.00	0.00	0.00	5.14
55–59	7.11	7.23	8.79	7.87	9.16	12.01	0.00	0.00	7.89
60–64	13.26	9.87	11.55	13.92	10.88	16.08	11.95	0.00	12.13
65–69	17.72	17.53	19.25	15.70	17.84	23.97	19.59	16.37	18.30
70–74	21.76	26.11	32.79	29.82	25.91	30.89	26.42	25.62	28.31
75–79	33.58	44.62	51.41	51.48	51.75	44.18	44.86	44.07	46.53
80–84	95.13	75.98	79.40	86.78	80.44	74.14	70.82	61.99	72.44
85–89	86.32	128.86	105.36	117.59	122.56	150.67	110.31	92.33	112.68
90–94	153.80	316.10	217.54	199.81	236.81	227.01	192.00	136.75	186.86
95–99	650.04	270.42	2708.29	387.01	289.46	355.85	360.00	318.42	347.05
Death rate adjusted to 1960 U.S. population for attained ages 35–84									
35–84	9.60	9.54	11.40	10.37	8.94	9.89	7.48	5.80	10.14

A4. 1960 CPS I Female Never Smokers Followed to 1997

Age	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1997	1960–1997
All observed deaths by attained age									
30–34	3	0	0	0	0	0	0	0	3
35–39	6	1	0	0	0	0	0	0	7
40–44	14	13	0	0	0	0	0	0	27
45–49	54	20	8	5	0	0	0	0	87
50–54	88	90	59	15	3	0	0	0	255
55–59	141	141	123	50	22	7	0	0	484
60–64	175	195	246	130	60	32	10	0	848
65–69	260	279	276	229	175	88	40	5	1352
70–74	289	409	387	316	318	297	121	28	2165
75–79	315	444	630	522	521	502	386	115	3435
80–84	276	500	632	661	659	757	731	371	4587
85–89	167	349	496	652	811	912	818	559	4764
90–94	91	148	238	370	518	719	756	445	3285
95–99	29	42	79	148	213	360	408	215	1494
30–99	1910	2631	3174	3098	3300	3674	3270	1738	22795
Total person-years of observation by attained age									
30–34	1439	0	0	0	0	0	0	0	1439
35–39	5294	1430	0	0	0	0	0	0	6724
40–44	12661	5099	1356	0	0	0	0	0	19115
45–49	27076	12436	4700	1124	0	0	0	0	45335
50–54	32592	26430	11411	4063	1107	0	0	0	75602
55–59	29744	31690	24021	9815	3990	1072	0	0	100332
60–64	25846	28535	27796	20648	9557	3863	1016	0	117260
65–69	22554	24260	24365	23311	19876	9213	3706	833	128118
70–74	16290	20478	19954	19713	21981	18752	8669	2476	128313
75–79	9043	14159	16301	15502	17619	19824	17104	5572	115124
80–84	4515	7042	10308	11622	12465	14508	16680	9743	86883
85–89	1640	2836	4191	6208	7876	8556	10192	7377	48876
90–94	460	679	1336	1934	3142	3933	4323	3331	19137
95–99	80	154	209	393	566	1018	1093	879	4391
30–99	189237	175227	145946	114334	98178	80737	62784	30210	896654
Age-specific death rate (1000*observed deaths/person-years)									
30–34	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
35–39	1.13	0.70	0.00	0.00	0.00	0.00	0.00	0.00	1.04
40–44	1.11	2.55	0.00	0.00	0.00	0.00	0.00	0.00	1.41
45–49	1.99	1.61	1.70	4.45	0.00	0.00	0.00	0.00	1.92
50–54	2.70	3.41	5.17	3.69	2.71	0.00	0.00	0.00	3.37
55–59	4.74	4.45	5.12	5.09	5.51	6.53	0.00	0.00	4.82
60–64	6.77	6.83	8.85	6.30	6.28	8.28	9.84	0.00	7.23
65–69	11.53	11.50	11.33	9.82	8.80	9.55	10.79	6.00	10.55
70–74	17.74	19.97	19.39	16.03	14.47	15.84	13.96	11.31	16.87
75–79	34.83	31.36	38.65	33.67	29.57	25.32	22.57	20.64	29.84
80–84	61.13	71.00	61.31	56.88	52.87	52.18	43.82	38.08	52.80
85–89	101.80	123.04	118.36	105.02	102.97	106.59	80.26	75.77	97.47
90–94	197.91	217.98	178.20	191.27	164.84	182.83	174.87	133.61	171.65
95–99	363.72	273.44	378.06	376.38	376.61	353.67	373.29	244.69	340.27
Death rate adjusted to 1960 U.S. population for attained ages 35–84									
35–84	6.76	7.14	7.16	6.50	5.38	5.30	4.43	2.74	6.44

A5. Age-Adjusted Death Rate (DR) and Relative Risk of Death [DR Ratio and Cox Proportional Hazards (PH) Ratio] by Follow-Up Period for 1959 Current Cigarette Smokers Compared with Never Smokers among California CPS I Subjects

Population	Follow-up Period								
	1960–1964	1965–1969	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1997	1960–1997
Males									
All causes									
Current smokers DR (C)	19.57	21.47	18.95	17.38	16.83	14.18	10.44	8.87	18.68
Never smokers DR (N)	10.41	10.78	11.32	8.81	8.05	6.72	5.80	4.05	9.46
DR ratio (C/N)	1.88	1.99	1.67	1.97	2.09	2.11	1.80	2.19	1.97
PH ratio (C/N)	1.95 (1.83–2.07)		1.74 (1.65–1.84)		1.80 (1.71–1.90)		1.48 (1.39–1.57)		1.74 (1.69–1.79)
Lung cancer									
Current smokers DR (C)	1.369	1.715	1.605	1.885	2.257	1.673	1.678	0.870	1.728
Never smokers DR (N)	0.124	0.128	0.151	0.085	0.121	0.090	0.103	0.015	0.133
DR ratio (C/N)	11.04	13.40	10.63	22.18	18.65	18.59	16.29	58.00	12.99
PH ratio (C/N)	12.63 (7.91–20.16)		12.09 (8.12–18.00)		12.48 (8.45–18.42)		10.21 (6.12–17.03)		11.96 (9.63–14.85)
Females									
All causes									
Current smokers DR (C)	9.60	9.54	11.40	10.37	8.94	9.89	7.48	5.80	10.14
Never smokers DR (N)	6.76	7.14	7.16	6.50	5.38	5.30	4.43	2.74	6.44
DR ratio (C/N)	1.42	1.34	1.59	1.60	1.66	1.87	1.69	2.12	1.57
PH ratio (C/N)	1.47 (1.38–1.57)		1.53 (1.46–1.61)		1.61 (1.54–1.68)		1.50 (1.44–1.58)		1.53 (1.50–1.57)
Lung cancer									
Current smokers DR (C)	0.132	0.286	0.656	1.006	1.056	1.187	0.728	0.644	0.806
Never smokers DR (N)	0.077	0.123	0.118	0.117	0.091	0.111	0.065	0.047	0.116
DR ratio (C/N)	1.71	2.33	5.56	8.60	11.60	10.69	11.20	13.70	6.95
PH ratio (C/N)	2.49 (1.65–3.77)		6.25 (4.70–8.31)		6.96 (5.39–9.00)		7.76 (5.81–10.36)		6.13 (5.30–7.09)

Cox proportional hazards ratio by decade.