TABLE 3.—Outline of prospective studies of smoking and overall mortality

Authors	Doll Hill Peto Pike (*4-10*)	Hammond (*14,16-19*)	Dorn Kahn Rogot (*11,26,31,33*)	Hirayama (*21,23-25*)	Best Josie Walker (*1,13*)	Hammond Horn (*20*)	Weir Dunn Linden Breslow (*12,38*)	Cederlof Friberg Hrubec Lorich (*2*)
Subjects	British doctors	Males and females in 25 States	U.S. veterans	Total population of 29 health districts in Japan	Canadian pensioners	White males in nine States	California males in various occupations	Probability sample of the Swedish population
Population size Females	40,000 6,000	1,000,000 562,671	290,000 <1%	265,000 142,857	92,000 14,000	187,000	68,000	55,000 27,700
Age range	20–85+	35–84	35–84	40 and up	30–90	50–69	33–64	18–69
Year of enrollment	1951	1960	1954 1957	1966	1955	1952	1954	1963
Years of followup reported	20 years	12 years	13 years 10 years	8 years	6 years	4 years	5–8 years	10 years
Number of deaths	10,072	150,000	87,000	21,000	11,000	12,000	4,700	4,500
Person years of experience	600,000	8,000,000	3,500,000	2,000,000	500,000	670,000	480,000	550,000

information on age, sex, race, education, place of residence, family history, past diseases, present physical complaints, occupational exposures, and various habits. Information on smoking included: type of tobacco used, number of cigarettes smoked per day, inhalation, age started smoking, and the brand of cigarettes used from which tar and nicotine content of the cigarette could be calculated. Nearly 93 percent of the survivors were successfully followed for a 12-year period.

The U.S. Veterans Study (*26*)

This study followed the mortality experience of 250,000 U.S. veterans who held Government life insurance policies in December of 1953. Almost all policy holders were white males. This group has been followed for 16 years. The most recent analysis was limited to overall mortality, as death certificates were not obtained for those who died during the last half of the study period. Smoking habits were determined only once, at the onset of the study.

Japanese Study of 29 Health Districts (*24*)

In late 1965, a total of 265,118 men and women in 29 health districts in Japan were enrolled in a prospective study. This represented from 91 to 99 percent of the population aged 40 and older in these districts. This study provides a unique opportunity to examine the relationship of cigarette smoking to death rates in a population with genetic, dietary, and other cultural differences from previously examined Western populations. At the time of the 8th year of follow-up, 11,858 deaths had occurred and there were 1,269,382 person-years of observation. The overall mortality rate for Japanese males who began smoking at a young age was quite similar to that reported for U.S. males by Hammond (*17*). Mortality ratios for most categories, however, are considerably lower than those reported for the United States, Canada, and Great Britain. This most likely reflects a lower average number of cigarettes smoked per day, an older age at initiation of smoking, or reduced inhalation of cigarette smoke among the Japanese.

In spite of these differences, the overall results of this study, including the dose-response relationships for the various diseases caused by smoking, are similar to the results of all the other major epidemiological studies. The reliability and accuracy of the methods of population selection used in other studies based on limited samples of the population are confirmed by this study based on a total population in a study area.

The Canadian Veterans Study (*1*)

Beginning in 1955, the Canadian Department of National Health and Welfare enrolled 78,000 men and 14,000 women in a study of smoking-related mortality. Information was obtained on age, detailed smoking

history, residence, and occupation. During the 6 years of follow-up, there were 9,491 deaths of males and 1,794 deaths of females. No recent follow-up has been reported.

The American Cancer Society 9-State Study (*20*)

In this study, 187,783 white males were followed for an average of 44 months. The study began in early 1952. There were 11,870 deaths in this population aged 50 to 70. The last significant report on this study was published in 1958.

California Men in Various Occupations (*12*)

This study examined the mortality experience of 68,153 men, 35 to 64 years of age, over a period of 482,658 person-years of observation. A total of 4,706 deaths occurred. These men were in nine occupational groups. The last published report from this study was in 1970.

The Swedish Study (*2*)

A probability sample of 55,000 Swedish men and women was surveyed in 1963. A 10-year follow-up on smoking-related mortality was published in 1975.

Mortality and Male Cigarette Smokers

Overall mortality rates for male cigarette smokers are significantly higher than for nonsmoking males. The mortality ratios are as low as 1.25 for Japanese males and as high as 1.83 for the males in the ACS 25-State Study. These results are shown in Table 4. Important evidence for a causal relationship between smoking and overall mortality is the demonstration of dose-response relationships. In most epidemiological studies, dosage has been measured by the number of cigarettes smoked daily at the time of entry into the study. Other dose variables include the maximum number of cigarettes smoked per day, age began smoking, the depth of inhalation, years of smoking, pack-years, tar and nicotine levels of the brand of cigarettes used, the number of puffs per cigarette, and the length of the unburned portion of the cigarette, as well as combinations of these variables into various dosage scores. All of these dosage variables have been shown in one study or another to contribute to the degree of risk involved in smoking. Several of the dosage variables as related to overall mortality are examined in this section.

Mortality and Amount Smoked

Mortality ratios for males currently smoking cigarettes only by amount smoked are presented for the eight major prospective studies in Table 4. Even males smoking one to nine cigarettes a day have a

TABLE 4.—Mortality ratios for males currently smoking cigarettes only, by amount smoked

Number of cigarettes per day	Doll (9)	Hammond (17)	Rogot (31,33)	Hirayama (25)	Best (13)	Hammond Horn (20)	Weir Dunn (38)	Cederlof (2)
	British doctors	Males in 25 States	U.S. veterans	Japanese	Canadian pensioners	Males in 9 States	California occupations	Swedish
Nonsmokers	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1-9	1.41(1-15)	1.45	1.25		1.41	1.34	1.44	1.20(1-7)
10-20	1.57(16-25)	1.75	1.51		1.56	1.70	1.79	1.40(8-15)
21-39	2.16(>25)	1.90	1.69		1.65(>20)	1.96	2.27	1.80(>16)
40+		2.20	1.89			2.23	1.83	
All smokers	1.63	1.83	1.55	1.25	1.54	1.74	1.78	1.58

TABLE 5.—Mortality ratios for male cigarette-only smokers, by number of cigarettes smoked per day and age. U.S. veterans 1954 cohort, 16-year followup

Number of cigarettes per day	Age				
	30–34	35–44	45–54	55–64	65–74
Nonsmokers	1.00	1.00	1.00	1.00	1.00
less than 10	1.94	1.44	1.44	1.20	1.15
10–20	1.27	1.79	1.64	1.49	1.30
21–39	1.76	2.23	2.10	1.67	1.42
40+	2.33	2.72	2.13	1.86	1.65
All smokers	1.52	1.95	1.83	1.53	1.32

SOURCE: Rogot, E. (*31,33*).

significant mortality ratio that varies from 1.25 to 1.45. Smokers of more than two packs of cigarettes a day have an overall mortality ratio that varies from 1.83 to 2.23.

Mortality at Different Ages

Overall mortality ratios by amount smoked at different ages for several studies are presented in Tables 5 through 8. There is a decrease in the mortality ratio with each increase in age for each smoking category. Mortality ratios are consistently more than 2.00 for heavy smokers between the ages of 30 to 50. These ratios decrease gradually with age, but are still about 1.35 for men over 75 years of age. This decline does not imply a decrease in the effect of cigarette smoking on health. Overall mortality rates increase dramatically with age in both smokers and nonsmokers. If one uses another measure of mortality and looks at the difference in death rates between smokers and nonsmokers as illustrated in Table 1, it can be seen that the difference in overall mortality rates increases with age even though the mortality ratio decreases.

The decreasing mortality ratio with age is probably due to another factor that should be considered. The population of older males who smoke two packs of cigarettes per day is probably quite different than a younger group of two-pack-a-day smokers.

Mortality by Duration of Smoking

Overall mortality ratios increase with the duration of the smoking habit. Mortality ratios by number of years smoked from two studies are presented in Tables 9 and 10. The mortality ratios remain quite low, only slightly above the rates for nonsmokers for the first 5 to 15 years of the smoking habit, and then increase more rapidly as the years

TABLE 6.—Mortality ratios for male cigarette-only smokers, by number of cigarettes smoked per day and age. Males in 25 States

Number of cigarettes per day	Age				
	35–44	45–54	55–64	65–74	75–84
Nonsmokers	1.00	1.00	1.00	1.00	1.00
1–9	**	1.84	1.53	1.50	1.36
10–19	1.36	2.26	1.92	1.65	1.55
20–39	1.91	2.41	2.05	1.71	1.26
40+	2.59	2.76	2.26	1.81	**
All smokers	1.82	2.20	1.86	1.58	1.35

SOURCE: Hammond, E.C. (*17*).

TABLE 7.—Mortality ratios for male cigarette-only smokers, by number of cigarettes smoked per day and age. Canadian pensioners

Number of cigarettes per day	Age					
	30–34	35–44	45–54	55–64	65–74	75+
Nonsmokers	1.00	1.00	1.00	1.00	1.00	1.00
1–9	0.72	1.25	1.07	1.50	1.32	1.31
10–20	1.22	1.36	1.20	1.94	1.40	1.33
20+	1.01	1.35	1.27	2.15	1.45	1.42
All smokers	0.90	1.63	1.21	1.89	1.45	1.31

SOURCE: Doll, R. (*9*).

TABLE 8.—Mortality ratios for male cigarette-only smokers, by number of cigarettes smoked per day and age. Males in nine States

Number of cigarettes per day	Age			
	50–54	55–59	60–64	65–69
Nonsmokers	1.00	1.00	1.00	1.00
1–9	1.43	1.15	1.46	1.37
10–20	1.72	1.65	1.83	1.59
21–39	2.11	1.83	2.20	1.65
40+	2.30	2.84	1.56	1.84
All smokers	1.85	1.69	1.84	1.55

SOURCE: Hammond, E.C. (*20*).

of smoking increase. Mortality ratios are as high as 1.66 for male cigarette smokers who have smoked for 35 or 40 years.

TABLE 9.—Age-adjusted mortality ratios for male cigarette-only smokers, by duration of smoking. Canadian veterans

Duration of smoking in years	Mortality ratio
Under 5	1.05
5–14	1.30
15–29	1.33
30–39	1.53
40+	1.66
All smokers	1.52

SOURCE: Best, E.W.R. (*1*)

TABLE 10.—Age-adjusted mortality ratios for male cigarette smokers who began smoking after the age of 20, by duration of smoking. U.S. veterans

Duration of smoking in years	Mortality ratio
Under 15	1.10
15–24	1.34
25–34	1.44
35+	1.66

SOURCE: Kahn, H.A. (*26*).

Mortality by Age Began Smoking

Overall mortality ratios exhibit an inverse relationship with age of initiation of the smoking habit. Table 11 displays data from the U.S. Veterans Study. Cigarette-only smokers who began smoking after the age of 25 have a mortality ratio of 1.32. For individuals who began smoking under the age of 15, the mortality ratio is 1.86. Data from the Japanese study are shown in Table 12. Again, a dose-response relationship is demonstrated but at a lower level than in the United States. When the Japanese data are broken down further "by age at start of study" and "age began smoking," as seen in Table 13, it is demonstrated that smokers who began smoking under the age of 15 have mortality ratios that are very similar to those in the United States data. Tables 14 and 15 show overall mortality ratios by "age began smoking" and "age at beginning of study" for the U.S. veterans and U.S. males in 25 States.

Overall mortality ratios by "age began smoking" and "number of cigarettes smoked per day" for the ACS Study of 25 States and the U.S. Veterans Study are presented in Tables 16 and 17. As expected,

TABLE 11.—Age-adjusted mortality ratios for male cigarette-only smokers, by age began smoking. U.S. veterans 1954 cohort

Age began smoking in years	Mortality ratio
Nonsmokers	1.00
25+	1.32
20–24	1.51
15–19	1.64
Under 15	1.86

SOURCE: Rogot, E. (*51, 53*).

TABLE 12.—Age-adjusted mortality ratios for male cigarette-only smokers, by age began smoking. Japan

Age began smoking in years	Mortality ratio
Nonsmokers	1.00
25+	1.19
20–24	1.19
Under 20	1.27

SOURCE: Hirayama, T. (*22*).

TABLE 13.—Age-adjusted mortality ratios for Japanese male cigarette smokers, by age began smoking and age at start of study

Age began smoking in years	Age at start of study		
	40–49	50–59	60–69
Nonsmokers	1.00	1.00	1.00
35+	1.53	1.08	1.02
30–34	0.89	1.11	1.29
25–29	0.91	1.17	1.19
20–24	0.82	1.16	1.19
15–19	0.92	1.31	1.29
Under 15	2.26	3.04	1.86

SOURCE: Hirayama, T. (*22*).

overall mortality ratios increase the younger a person begins smoking and the greater the number of cigarettes smoked per day.

Mortality by Inhalation of Cigarette Smoke

Inhalation of tobacco smoke is an important dosage variable. Most of the excess mortality associated with cigarette smoking results from diseases that require inhalation of smoke well into the lungs in order to

TABLE 14.—Age-adjusted mortality ratios for male cigarette-only smokers, by age began smoking and age at start of study. U.S. veterans 1954 cohort

Age began smoking in years	Age at start of study				
	30–34	35–44	45–54	55–64	65–74
Nonsmokers	1.00	1.00	1.00	1.00	1.00
25+	**	1.48	1.67	1.36	1.20
20–24	1.41	1.87	1.72	1.56	1.39
15–19	1.44	2.00	2.17	1.70	1.45
Under 15	2.00	2.18	2.25	2.02	1.42

SOURCE: Rogot, E. (*51, 53*).

TABLE 15.—Age-adjusted mortality ratios for male cigarette-only smokers, by age began smoking and age at start of study. Males in 25 States

Age began smoking in years	Age at start of study			
	45–54	55–64	65–74	75–84
Nonsmokers	1.00	1.00	1.00	1.00
30+	1.40	1.33	1.23	1.10
25–29	1.81	1.75	1.25	**
20–24	2.13	1.73	1.52	1.27
15–19	2.49	2.11	1.84	1.58
Under 15	3.01	2.26	2.00	1.59

SOURCE: Hammond, E.C. (*17*).

TABLE 16.—Age-adjusted mortality ratios for male cigarette-only smokers aged 55–64, by age began smoking and current number of cigarettes smoked per day. Males in 25 States

Age began smoking in years	Current number of cigarettes per day				
	Nonsmokers	1–9	10–19	20–39	40+
25+	1.00	1.34	1.68	1.48	1.77
15–24	1.00	1.45	1.89	2.05	2.23
Under 15	1.00	**	2.15	2.19	2.58

SOURCE: Hammond, E.C. (*17*).

expose target organs directly or through absorption of toxic substances into the circulatory system. Ischemic heart disease, lung cancer, and chronic obstructive disease are not as likely to develop in individuals who do not inhale smoke. Techniques for quantitating inhalation have been developed using carboxyhemoglobin as an index of smoke inhalation, but these methods have not been applied to studies of overall mortality. Most studies asked the smoker to report subjectively

TABLE 17.—Age-adjusted mortality ratios for males smoking cigarettes only, by amount smoked and age began smoking. U.S. veterans 1954 cohort

Age began smoking in years	Current number of cigarettes per day		
	Nonsmokers	1–20	21+
20+	1.00	1.36	1.59
Under 20	1.00	1.56	1.82

SOURCE: Rogot, E. (*31, 33*).

on his own inhalation practices. Certainly, self-reporting of inhalation is subject to considerable variation, but it may not be as inaccurate as might be presumed. Available data show the expected dose-response relationship between inhalation of cigarette smoke and overall mortality. Table 18 demonstrates that with advancing age the percentage of moderate and deep inhalers drops and the percentage of none-to-slight inhalers increases. This is consistent with increased mortality for those who inhale. It also makes the interesting point that a smoker who survives to old age is different from the younger smoker. It is likely that the lower mortality ratios experienced by older smokers are partly a reflection of the fact that they smoke in a less hazardous fashion than do younger smokers. Older smokers are less likely to inhale than younger smokers. It is also likely that they take fewer puffs per cigarette and smoke fewer cigarettes per day. If they have been faithful to their brand of cigarettes, they are likely to be smoking an "older" brand. The brand is likely to be unfiltered and more typical of the cigarettes sold 30 to 40 years ago which contained twice the tar and nicotine of the average cigarettes sold today. Tables 19, 20, and 21 show age-adjusted mortality ratios by degree of inhalation and number of cigarettes smoked per day and age at start of study for three of the large prospective studies. The overall mortality ratio is 2.80 for the moderate-to-deep inhaler who smokes 40 or more cigarettes per day. The overall mortality ratio is 2.53 for 45- to 54-year-old men who inhale deeply, but is 1.02 for noninhalers who are 75 to 84 years old. In the Canadian study, the highest mortality ratio was 2.11 for those 60 to 69 years old who reported inhaling cigarette smoke. Hammond reported a mortality ratio of 1.41 for noninhalers who are 45 to 54 years old (*15*). This suggests that cigarette smokers may underestimate the extent to which they inhale cigarette smoke.

Mortality by Tar and Nicotine Content of Cigarettes

Overall mortality increases with the tar and nicotine content of cigarette smoke. This relationship was recently examined by Hammond, et al. (*19*). In this study, tar and nicotine levels (T/N) were defined as follows: "High" T/N, 25.8–35.7 mg tar and 2.0–2.7 mg

TABLE 18.—Percent distribution of male cigarette smokers by degree of inhalation of cigarette smoke and age. Males in 25 States

Degree of inhalation	Age			
	40–49	50–59	60–69	70–79
None	3.62	6.11	11.46	19.74
Slight	10.97	13.64	20.18	25.56
Moderate	57.94	56.31	51.10	40.82
Deep	27.65	23.91	17.25	13.88
Total	100.00	100.00	100.00	100.00

SOURCE: Hammond, E.C. (*19*).

TABLE 19.—Age-adjusted mortality ratios for male cigarette-only smokers, by degree of inhalation of cigarette smoke and current number of cigarettes per day. Subjects aged 45–54 at start of study. Males in 25 States

Degree of inhalation	Number of cigarettes per day			
	1-9	10-19	20-39	40+
None-slight	1.70	1.99	2.34	2.33
Moderate-deep	1.95	2.35	2.42	2.80

SOURCE: Hammond, E.C. (*17*).

TABLE 20.—Age-adjusted mortality ratios for male cigarette-only smokers, by degree of inhalation of cigarette smoke and age at start of study. Males in 25 States

Degree of inhalation	Age at start of study			
	45–54	55–64	65–74	75–84
None	1.41	1.43	1.32	1.02
Slight	1.67	1.71	1.31	1.19
Moderate	2.06	1.68	1.53	1.10
Deep	2.53	1.88	1.68	**

SOURCE: Hammond, E.C. (*17*).

nicotine; "Medium" T/N, 17.6–25.7 mg tar and 1.2–1.9 mg nicotine; "Low" T/N, less than 17.6 mg tar and less than 1.2 mg nicotine. Table 22 shows the overall mortality ratios of male and female smokers by these tar and nicotine levels. In this instance, the mortality ratio of the "high" T/N smokers is represented as 1.00 so as to illustrate the reduction in overall mortality that occurs with lower T/N cigarettes. There is a small but statistically significant (P. less than 0.0005) reduction in the risk of dying with the use of lower T/N cigarettes. The mortality ratio was reduced to 0.91 for the "medium" T/N smokers and

TABLE 21.—Age-adjusted mortality ratios for male cigarette-only smokers, by degree of inhalation of cigarette smoke and age at start of study. Canadian veterans

Degree of inhalation	Age at start of study			
	30–39	40–49	50–59	60–69
Nonsmokers	1.00	1.00	1.00	1.00
Do not inhale	0.61	0.61	1.10	1.78
Inhale smoke	1.29	1.12	1.58	2.11

SOURCE: Best, E.W.R. (*1*).

TABLE 22.—Adjusted mortality ratios for males and females, by tar and nicotine content of cigarettes usually smoked

Sex	Mortality ratios		
	"High" T/N	"Medium" T/N	"Low" T/N
Males	1.00	0.94	0.85
Females	1.00	0.88	0.83
Total	1.00	0.91	0.84

SOURCE: Hammond, E.C. (*19*).

TABLE 23.—Adjusted mortality ratios for males and females smoking low T/N cigarettes and subjects who never smoked regularly

Sex	Mortality ratios	
	"Low" T/N	Nonsmokers
Males	1.00	0.61
Females	1.00	0.74
Total	1.00	0.66

SOURCE: Hammond, E.C. (*19*).

was further reduced to 0.84 for the "low" T/N smokers. The mortality ratios are lower for females than for males.

In a separate analysis, a comparison was also made between the mortality ratios of "low" T/N smokers and nonsmokers. These data are presented in Table 23. The mortality ratio of the "low" T/N group was designated as 1.00. Nonsmokers have overall mortality ratios that are about half those of "low" T/N smokers.

The combined data from these two tables are shown in Table 24. Here, mortality ratios are calculated using nonsmokers as the

TABLE 24.—Overall mortality ratios of cigarette smokers compared to nonsmokers, by sex and by tar and nicotine content of cigarettes usually smoked

Sex	Non-smokers	"Low" T/N	"Medium" T/N	"High" T/N
Males	1.00	1.66	1.85	1.96
Females	1.00	1.37	1.45	1.65
Total	1.00	1.52	1.64	1.80

SOURCE: Hammond, E.C. (*19*).

reference. Combining these data from two separate analyses that are not exactly comparable results in figures that are only approximate.

Hammond (*19*) also compared death rates of smokers of relatively few (1–19) "high" T/N cigarettes with those of smokers who smoked relatively large numbers (20–39) of "low" T/N cigarettes. The death rates of these two groups were very similar and the difference between them was not statistically significant.

Mortality and Female Cigarette Smokers

It is important that attention be called specifically to the mortality that females experience as a result of cigarette smoking. There has been an increase in smoking among teenage girls over the past 10 years. At present, the percentages of teenage boys smoking and teenage girls smoking are nearly identical. For some ages, there are more teenage girl smokers than boy smokers. Over the past 10 years, there has been a gradual reduction in the percentage of the adult population that is smoking. Men have quit in greater numbers than women. There has been only a modest drop in the percentage of women who are smoking. In Canada and several European countries, smoking is decreasing among men but increasing among women. In the United States, physicians, dentists, and pharmacists have been the most successful professional groups in giving up smoking, but in the past several years there has been an increase in smoking among nurses.

Several suggestions have been made as to why women do not quit smoking. It may be that women do not generally perceive smoking as a threat to their health. Lung cancer, heart attacks, and emphysema are diseases that affect men more commonly than women. Women may feel that they are in a low-risk group. Women took up smoking later than men, generally smoked filter cigarettes, and smoked fewer cigarettes per day than men. Lower overall death rates for women smokers are due to lower exposure to cigarette smoke.

Cigarette smoking for some women may be symbolic of equality with men. It is known that the smoking habits of women employed

TABLE 25.—Age-adjusted mortality ratios of female cigarette smokers, by number of cigarettes smoked per day and age. 25-State Study

Number of cigarettes per day	Age				
	35-44	45-54	55-64	65-74	75-84
Nonsmokers	1.00	1.00	1.00	1.00	1.00
1-9	0.90	0.95	0.99	1.09	1.07
10-19	0.97	1.22	1.31	1.18	1.21
20-39	1.35	1.54	1.46	1.51	**

SOURCE: Hammond, E.C. (17).

outside the home match the smoking habits of men in various occupations where men and women hold equal positions. Women with the lowest rate of smoking are housewives who at present have few male counterparts with whom to identify.

Recent surveys have shown that women are also concerned about weight gain that may accompany quitting smoking. Any significant weight gain on quitting represents an increased intake of food, but if one watches the diet on smoking cessation, weight gain can be avoided; in fact, weight loss can be achieved.

In recent years, a few investigators have studied the relationships between cigarette smoking and the development of lung cancer and coronary heart disease in women. Death rates for these diseases are similar in women and men who have similar levels of exposure to cigarette smoke; the associations are outlined in later chapters dealing with specific diseases. Overall mortality rates for women available at present are from studies initiated 10 to 20 years ago, and thus reflect the differences in accumulated exposure that were operative at that time.

Overall mortality in women varies in the same direction and in a similar degree as men for the dosage variables commonly measured. Overall mortality for women increases with the number of cigarettes smoked per day (Tables 25, 26, and 27). Table 26 shows that the overall mortality ratio is 2.19 for females smoking more than two packs a day and inhaling moderately to deeply. Table 27 demonstrates that the mortality ratio is 1.85 for females smoking more than two packs per day who began smoking between the ages of 15 and 24. Mortality ratios by "inhalation" and "age at start of study" are shown in Table 28. Noninhaling smokers have mortality ratios that are similar to nonsmokers. Females with an average age of 50 who inhale smoke deeply have a mortality ratio of 1.78.

Mortality and Ex-Smokers

There is a general recognition among smokers and nonsmokers alike that cigarette smoking is a major cause of disease and death in the

TABLE 26.—Age-adjusted mortality ratios of female cigarette smokers, by number of cigarettes smoked per day and degree of inhalation. Subjects aged 45–54 at start of study. 25–State Study

Number of cigarettes per day	Degree of inhalation of smoke	
	None-Slight	Moderate-Deep
1-9	0.85	1.04
10–19	1.27	1.17
20–39	1.41	1.58
40+	**	2.19

SOURCE: Hammond, E.C. (*17*).

TABLE 27.—Age-adjusted mortality ratios of female cigarette smokers, by number of cigarettes smoked per day and age began smoking. Subjects aged 45–54 at start of study. 25–State Study

Number of cigarettes per day	Age began smoking	
	25+	15–24
Nonsmokers	1.00	1.00
1–9	0.95	0.88
10–19	1.17	1.23
20–39	1.33	1.61
40+	**	1.85

SOURCE: Hammond, E.C. (*17*).

TABLE 28.—Age-adjusted mortality ratios of female cigarette smokers, by number of cigarettes smoked per day and degree of inhalation and age. 25–State Study

Degree of inhalation	Age				
	35–44	45–54	55–64	65–74	75–84
Nonsmokers	1.00	1.00	1.00	1.00	1.00
None	**	1.01	1.11	1.12	0.96
Slight	1.22	1.21	1.28	1.26	1.21
Moderate	1.05	1.30	1.32	1.41	**
Deep	1.40	1.78	1.64	**	**

SOURCE: Hammond, E.C. (*17*).

United States. Smokers are now asking the question: "Will it help me if I quit smoking?" Some of the first evidence concerning death rates in ex-smokers required explanation. The data from the Hammond and Horn study of men in nine States are presented in Table 29. It can be seen that the mortality ratios of ex-smokers were higher in the first year after quitting than for continuing smokers. After the first year,

TABLE 29.—Age-adjusted mortality ratios for males who are ex-smokers of cigarettes, by former amount smoked per day and years since stopped smoking. Males in nine States

Years since stopped smoking	Cigarettes formerly smoked per day	
	1–19	20+
0 (Smokers)	1.61	2.02
Under 1	2.04	2.69
1–10 years	1.30	1.82
10+ years	1.08	1.50

SOURCE: Hammond, E.C. (*20*).

however, death rates for ex-smokers fell progressively so that after 10 years the former smokers of 1 to 19 cigarettes had a mortality ratio of only 1.08.

The explanation for the higher death rates in the 1st year after quitting is found in the fact that both healthy and sick individuals quit smoking. The higher mortality ratio is experienced by those who quit because of illness and not by those who quit for better health. In the study of U.S. veterans, a differentiation was made between ex-smokers who stopped smoking on the recommendation of a doctor and those who quit for other reasons. About 10 percent of the smokers quit on doctors' orders; this group had much higher mortality ratios than those who stopped for other reasons.

These data are presented in Table 30, where the mortality ratios for ex-smokers by "years since stopping smoking," "maximum amount smoked," "age began smoking," and "reason for quitting" are examined. There is a direct relationship between mortality rates and the maximum amount smoked, an inverse relationship between mortality and "years since stopped smoking," and also an inverse relationship between mortality and "age began smoking."

A detailed analysis of the mortality experience of ex-smokers who stopped for reasons other than doctors' orders is given in Figures 1 through 4. This information is on ex-smokers, aged 55 to 64, from the 1954 cohort of the U.S. Veterans Study, who formerly smoked from 21 to 39 cigarettes per day. "Years since stopping smoking" is considered as a variable and the mortality rates are compared with those of current cigarette smokers and nonsmokers. Annual probabilities of dying are plotted on a logarithmic scale. This results in a fairly smooth and linear pattern for both smokers and nonsmokers. These lines also appear to be parallel, or perhaps to diverge slightly. This indicates an approximately constant or slightly increasing excess risk of dying

TABLE 30.—Mortality ratios of ex-smokers of cigarettes only who quit smoking on doctors orders and for other reasons, by certain dosage variables. U.S. veterans 1954 cohort, 16-year followup

Years since stopped smoking

Years since stopped	Mortality ratios: Quit for various reasons	Mortality ratios: Quit on doctors orders
<5	1.23	1.55
5–9	1.23	1.43
10–14	1.14	1.77
15–19	1.04	1.35
>19	1.06	1.16
Total	1.18	1.52

Number of cigarettes per day

No. of cigarettes per day	Mortality ratios: Quit for various reasons	Mortality ratios: Quit on doctors orders
<10	1.00	1.42
10–20	1.17	1.48
21–39	1.30	1.53
>39	1.32	1.60
Total	1.18	1.52

Age started smoking

Age began (years)	Mortality ratios: Quit for various reasons	Mortality ratios: Quit on doctors orders
<15	1.36	1.59
15–19	1.20	1.55
20–24	1.12	1.49
>24	1.15	1.34
Total	1.18	1.52

SOURCE: Rogot, E. (*33*).

among smokers, compared to nonsmokers over the 16-year period. It would be expected that the mortality experience of ex-smokers initially would be similar to that of smokers, but with the passing of time the mortality risk should move progressively closer to that of nonsmokers. Figure 1 illustrates this. For ex-smokers who quit less than 5 years prior to the beginning of the study, the mortality risk is at

first nearly identical to that of smokers. Over the years, the risk gradually falls to a position approximately halfway between that of smokers and nonsmokers. Figures 2 and 3 show that with longer periods of cessation the mortality risk continues to approach that of nonsmokers. In Figure 4, it can be seen that for ex-smokers who had been off cigarettes for 15 or more years before the start of this study, their mortality risk fluctuates about the mortality risk of nonsmokers for the entire 16-year period.

The mortality experience of British doctors who were ex-smokers is examined in Table 31. These data indicate that there are definite benefits from quitting smoking no matter how long one has smoked. After 10 to 15 years, ex-smokers have a risk of dying that is similar to that of those who have never smoked. The risk of dying from ischemic heart disease decreases rapidly immediately after stopping smoking, whereas the risk of dying from lung cancer decreases more slowly. Overall mortality measures the net benefit of quitting and, therefore, drops more slowly than do death rates for certain disease categories.

Mortality and Pipe and Cigar Smoking

Pipe and cigar smokers have mortality rates that are similar to those of cigarette smokers for cancers of the oral cavity, pharynx, larynx, and esophagus. Pipe and cigar smokers have much lower death rates than cigarette smokers for cancer of the lung, ischemic heart disease, and chronic obstructive lung disease. Since these last three disease categories account for the bulk of the excess mortality associated with cigarette smoking, pipe and cigar smokers experience overall mortality rates that are much lower than cigarette smokers. Inhalation of smoke is necessary to expose the heart and lungs to the harmful constituents found in tobacco smoke, and pipe and cigar smokers report much less inhalation of smoke than cigarette smokers. Pipe smoke and cigar smoke contain nearly all the same chemical compounds found in cigarette smoke, but pipe and cigar smoke tends to be alkaline in pH rather than acid as is cigarette smoke. Alkaline smoke is irritating to the respiratory tract. This is likely to be an important reason why pipe and cigar smokers report a much lower level of smoke inhalation than cigarette smokers.

Table 32 summarizes the mortality ratios for male smokers by the type of tobacco used for the five studies that obtained data on pipe and cigar smoking. Cigar smokers have overall mortality ratios that are from 6 to 25 percent higher than nonsmokers. Mixing cigarette smoking with pipe or cigar smoking substantially increases the mortality ratios, although they remain somewhat less than the mortality ratios of cigarette-only smokers.

Dose-response relationships between overall mortality and the amount of tobacco smoked were examined in several studies. Data

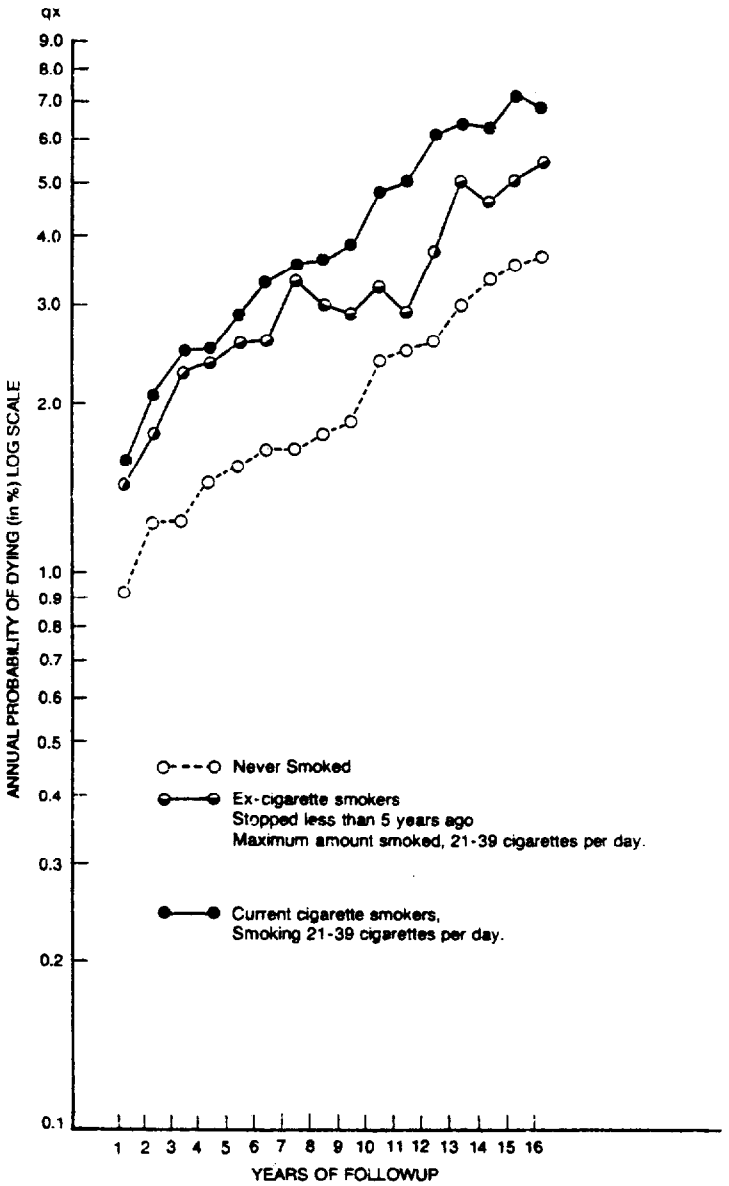

FIGURE 1.—Annual probability of dying for ex-smokers who quit smoking less than 5 years, current cigarette smokers and nonsmokers, aged 55–64, U.S. veterans 1954 cohort, 16-year follow-up

SOURCE: Rogot, E. (*55*).

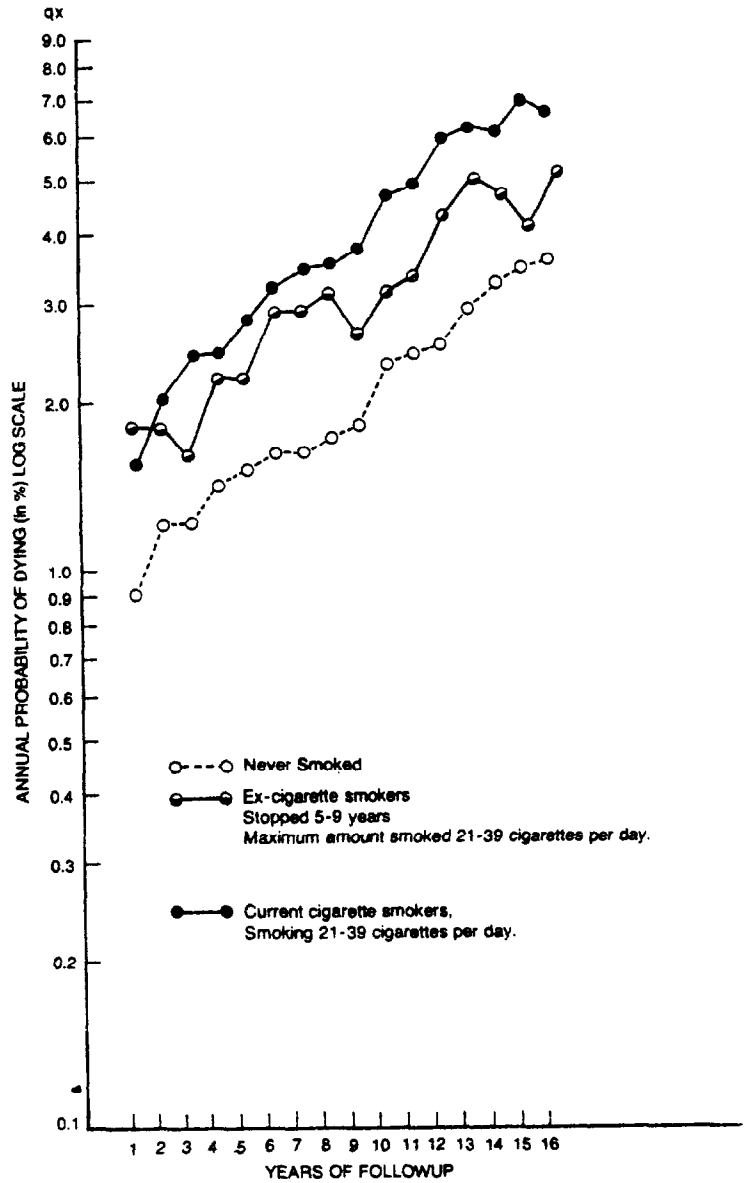

FIGURE 2.—Annual probability of dying for ex-smokers who quit smoking 5–9 years, current cigarette smokers and nonsmokers, aged 55–64, U.S. veterans 1954 cohort, 16-year follow-up

SOURCE: Rogot, E. (*55*).

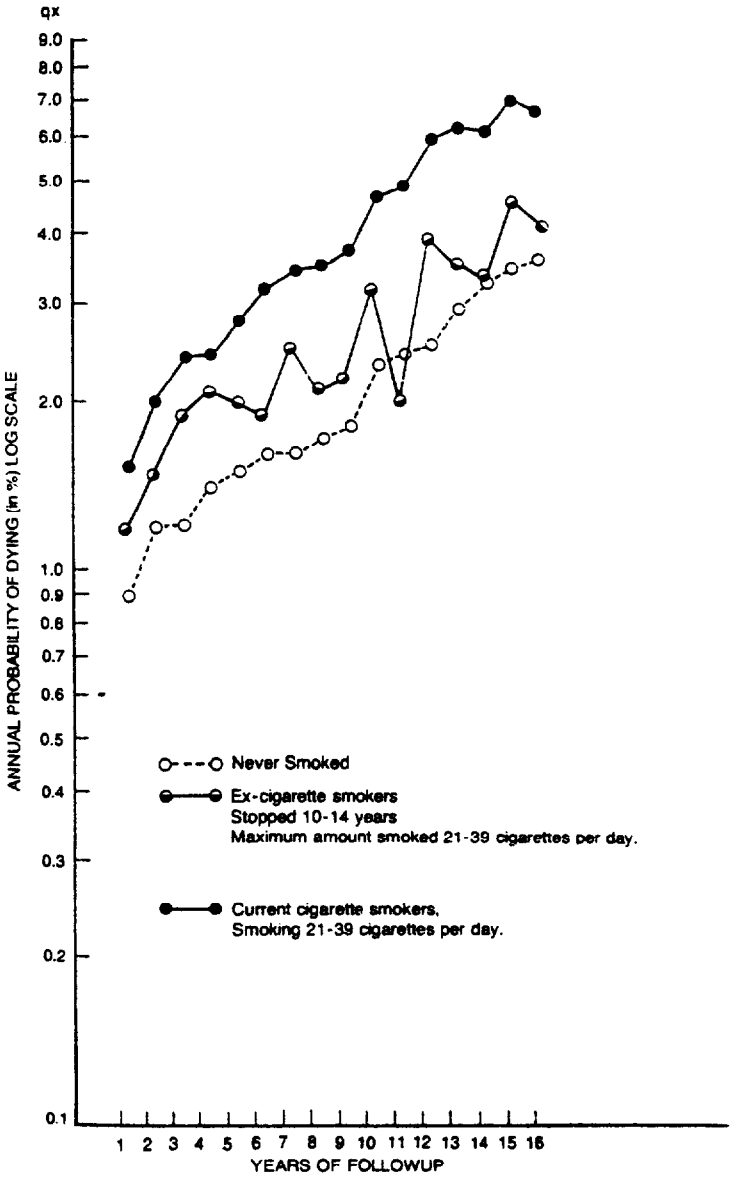

FIGURE 3.—Annual probability of dying for ex-smokers who quit 10–14 years, current cigarette smokers and nonsmokers, aged 55–64, U.S. veterans 1954 cohort, 16-year follow-up

SOURCE: Rogot, E. (*55*).

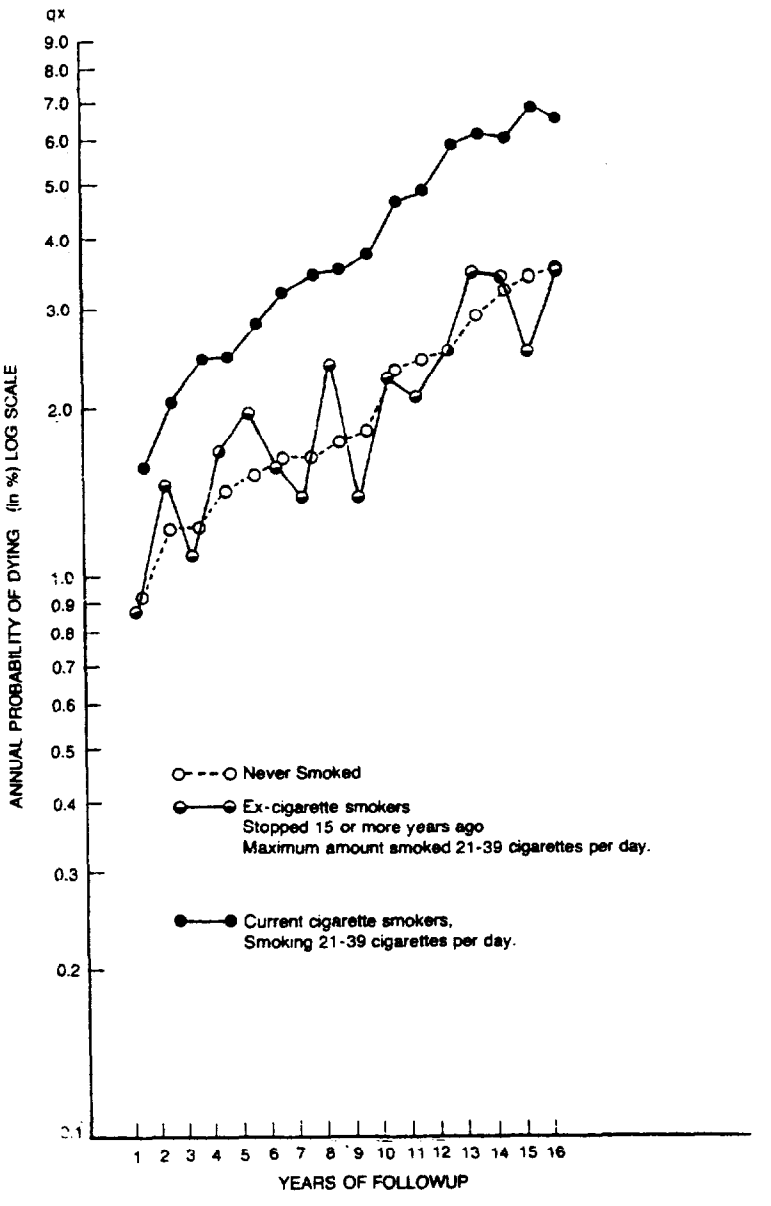

FIGURE 4.—Annual probability of dying for ex-smokers who quit 15+ years, current cigarette smokers and nonsmokers, aged 55–64, U.S. veterans 1954 cohort, 16-year follow-up

SOURCE: Rogot, E. (*55*).

TABLE 31.—Mortality ratios of ex-smokers compared to nonsmokers, by age and number of years since stopping smoking. Study of British doctors

Years since stopping smoking	Mortality ratios		
	Ages 30–64	Ages 65+	All ages
0 (Current smokers)	2.0	1.6	1.8
1–4	1.7	1.4	1.5
5–9	1.6	1.4	1.5
10–14	1.4	1.2	1.3
15+	1.1	1.1	1.1
Nonsmokers	1.0	1.0	1.0

SOURCE: Doll, R. (*8*).

TABLE 32.—Mortality ratios for male smokers, by type of tobacco used

Study	Non-smoker	Cigar only	Pipe only	Cigar & pipe	Cigarette & cigar or pipe	Cigarette only
Men in 9 States(*20*)	1.00	1.22	1.12	1.10	1.43	1.68
British Doctors(*4*)	1.00	**	**	1.09	1.31	1.73
Canadian Veterans(*1*)	1.00	1.06	1.05	0.98	1.13	1.54
U.S. Veterans(*26*)	1.00	1.16	1.07	1.08	1.51	1.55
Males in 25 States(*17*)	1.00	1.25	1.19	1.01	1.57	1.86

from the study of men in nine States, Canadian veterans, and the ACS 25-State Study are presented in Tables 33 through 35. There is a dose-response relationship evident for cigar smoking that is small but found consistently. There was no clear dose-response relationship for pipe smoking. Data from the U.S. Veterans Study are presented in Tables 36 through 39. Again, there appears to be a dose-response relationship for cigar smoking, both for the number of cigars smoked per day and for the age began smoking cigars. For pipe smokers, a dose-response relationship was found for the number of pipefuls per day, but not for the age began smoking.

The U.S. Veterans Study (*31*) contains the most detailed information on pipe, cigar, and cigarette smoking in various combinations and in various sequences. These data on mortality ratios are shown in Table 40 and have been arranged by "increasing risk of mortality." The first section shows the mortality experience of current cigarette smokers by the present, past, or nonuse of pipes and cigars. Cigarette smokers who have the lowest mortality ratio of 1.21 are those who also currently smoke both pipes and cigars. Current cigarette smokers who formerly smoked pipes and cigars have a mortality ratio of 1.48, which is only

TABLE 33.—Age-adjusted mortality ratios for male cigar and pipe smokers, by amount smoked. Males in nine States

Type and amount smoked	Mortality ratio
Nonsmokers	1.00
Cigar only	
1–4 per day	1.03
4+ per day	1.24
All cigar smokers	1.09
Pipe only	
1–10 pipefuls per day	1.05
10+ pipefuls per day	1.19
All pipe smokers	1.09

SOURCE: Hammond, E.C. (*20*).

TABLE 34.—Age-adjusted mortality ratios for male cigar and pipe smokers, by amount smoked. Canadian veterans

Type and amount smoked	Mortality ratio
Nonsmokers	1.00
Cigar only	
1–2 per day	1.14
3–10 per day	1.19
Pipe only	
1–10 pipefuls per day	1.01
10+ pipefuls per day	1.00

SOURCE: Best, E.W.R. (*1*).

slightly below the mortality ratio of 1.55 of cigarette-only smokers who have never smoked pipes or cigars.

The second section of Table 40 shows that the mortality ratios of current cigar smokers are slightly decreased among those also currently smoking pipes and significantly increased among those also currently smoking cigarettes. The third section shows that pipe smokers with the lowest mortality are those who have never smoked cigarettes or cigars. Mortality ratios increase slightly with the addition of current cigar smoking and jump moderately with the addition of current cigarette smoking.

TABLE 35.—Age-adjusted mortality ratios for male cigar and pipe smokers, by amount smoked. Males in 25 States

Type and amount smoked	Mortality ratio
Nonsmokers	1.00
Cigar only	
1–4 per day	1.03
4+ per day	1.18
All cigar smokers	1.09
Pipe only	
1–9 pipefuls per day	1.08
9+ pipefuls per day	0.92
All pipe smokers	1.04

SOURCE: Hammond, E.C. (*17*).

TABLE 36.—Age-adjusted mortality ratios of current smokers of cigars only, by amount smoked. U.S. veterans 1954 cohort, 16–year followup

No. of cigars per day	Mortality ratio
Nonsmokers	1.00
1–2	1.11
3–4	1.13
5–8	1.22
9+	1.39
Total	1.16

SOURCE: Rogot, E. (*55*).

TABLE 37.—Age-adjusted mortality ratios of current smokers of cigars only, by age began smoking. U.S. veterans 1954 cohort, 16–year followup

Age began (years)	Mortality ratio
Nonsmokers	1.00
<15	1.22
15–19	1.23
20–24	1.16
>24	1.13
Total	1.16

SOURCE: Rogot, E. (*55*).

Mortality by Cause of Death

The underlying cause of death was obtained from the death certificate