Smoking and Causes of Death Among U.S. Veterans: 16 Years of Observation

EUGENE ROGOT, MA
JAMES L. MURRAY, DVM, MS

To DESCRIBE THE RELATIONSHIP BETWEEN TOBACCO USE and mortality experience, the Public Health Service in 1954 initiated a study of a cohort of U.S. veterans. In the first reports on this study, covering the first 2½ years of the cohort's mortality experience, Dorn provided evidence that cigarette smokers are subject to increased risk of dying from lung cancer as well as from cardiovascular disease, certain respiratory diseases, ulcers, and cirrhosis of the liver (1,2). Kahn, reporting on the mortality experience of this cohort after 8½ years of observation, through December 1962 (3), had results which were similar to, and reinforced, Dorn's. The cohort has since been followed for a total of 16 years, through December 1969, and its general mortality has been reported over that period (4–6). We are now able to report on the specific causes of death of members of the cohort during this 16-year period.

Materials and Methods

The study population, the study design, and other re-

Mr. Rogot is a statistician, Epidemiology Branch, National Heart, Lung, and Blood Institute, Federal Bldg., Rm. 2C-08, Bethesda, Md. 20205, and Dr. Murray is an epidemiologist, Biometry Branch, National Cancer Institute. Tearsheet requests to Mr. Rogot.

lated details have been described in previous reports (1–3). The initial study population consisted of 293,958 U.S. veterans 31–84 years of age who held U.S. Government life insurance policies in December 1953. Beginning in January 1954, questionnaires on smoking habits were mailed to these policyholders, of whom about 200,000 (68 percent) responded. These respondents are called the "1954 cohort." Beginning in January 1957, a second questionnaire, similar to the first, was mailed to those not responding in 1954. It elicited about 50,000 additonal replies, raising the response rate to 85 percent. These respondents are called the "1957 cohort." The remaining persons are called the "No reply group." All the smoking classifications used in our current report are taken from these questionnaires, and for the sake of convenience we considered them to have been as of January 1 both for the 1954 and the 1957 cohort. The numbers of persons in each cohort by age were as follows:

Age group	1954 cohort	1957 cohort	No reply group
31–54	34,473	8,441	8,417
55–64	137,820	26,579	31,468
65–74	25,002	13,683	5,603
75–84	1,525	523	424
Total ...	198,820	49,226	45,912

Almost all the policyholders were white males, drawn mainly from the middle and upper socioeconomic classes. Most were veterans of World War I. The Veterans Administration provided the names of all policyholders known to have died in the study period (Jan. 1, 1954—Dec. 31, 1969). The VA staff made special searches to ascertain deaths for about 75,000 persons whose insurance policies had lapsed during the period. The overall mortality followup of the fact of death and the year of death is considered to be almost 100 percent complete. Full details of the various followup procedures have appeared in the previous reports (1–3).

With respect to the cause of death, special searches were made by the American Cancer Society for the 34,644 death certificates that were needed to complete the latter part of the 16-year followup. The society was successful in collecting all but 2,541 death certifi-

cates. Causes of death were coded according to the Seventh Revision of the International Classification of Diseases, 1955. The underlying cause of death was used. Overall, the underlying cause was available for 97.6 percent of all deaths (table 1).

Table 1. Number of persons, number of deaths, and number of death certificates found and not found, by cohort, U.S. veterans study, 1954–69

Item	1954 cohort	1957 cohort	No reply group	Total
Number of persons ..	198,820	49,226	45,912	293,958
Number of deaths ...	69,858	16,877	20,828	107,563
Death certificates:				
Found	68,446	16,521	20,055	105,022
Not found	1,412	356	773	2,541
Percent found	98.0	97.9	96.3	97.6

Table 2. Observed deaths, expected deaths, and mortality ratios (O÷E) for current cigarette smokers (category 2..) and ex-cigarette smokers (category 1..), by cause of death, U.S. veterans study, 1954–69

Cause of death (7th Revision ICD numbers)	Cigarette smokers			Ex-cigarette smokers [1]		
	Observed deaths	Expected deaths	O÷E [2]	Observed deaths	Expected deaths	O÷E [2]
All causes	36,143	20,857	1.73	14,487	11,962	1.21
All cardiovascular diseases (330–334, 400–468)	21,413	13,572	1.58	9,027	7,865	1.15
Coronary heart disease (420)	13,845	8,787	1.58	5,823	5,028	1.16
Rheumatic fever (400–402, 410–416)	301	272	1.11	154	147	1.04
Hypertensive heart disease (440–443)	909	590	1.54	389	333	1.17
Myocardial degeneration (422)	700	427	1.64	306	255	1.20
Other heart disease (421, 430–434)	525	316	1.66	209	186	1.13
Cor pulmonale (434.4)	44	8	5.57	11	5	(³)
Stroke (330–334)	2,728	2,075	1.32	1,279	1,254	1.02
Peripheral vascular disease (453)	20	6	3.52	2	3	(³)
Aortic aneurysm (451)	900	172	5.23	253	98	2.58
Other aneurysm (452)	16	2	(³)	6	1	(³)
Phlebitis and pulmonary embolism (463–466)	214	175	1.22	109	102	1.07
Other circulatory disease (454–456, 460–462, 467–468)	143	55	2.59	29	32	.91
Hypertension (444–447)	198	134	1.47	83	77	1.08
Hypertensive disease (440–447)	1,107	724	1.53	472	410	1.15
General arteriosclerosis (450)	870	554	1.57	374	343	1.09
Parkinson's disease (350)	57	180	.32	74	106	.70
Benign tumors (210–239)	73	33	2.23	27	18	1.52
Ulcer of duodenum (541)	216	60	3.61	55	34	1.64
Ulcer of stomach and gastrojejunum (540, 542)	149	32	4.60	54	19	2.90
Aneurysm of aorta and other cardiovascular syphilis (022, 023) ..	23	7	3.20	6	4	(³)
Nephritis, nephrosis and other kidney diseases (590–594, 600–603)	349	261	1.34	155	149	1.04
Cirrhosis of liver (581)	404	150	2.69	114	81	1.41
Cholelithiasis and cholecystitis (584–586)	72	60	1.20	33	38	.87
Diabetes (260)	215	221	.97	100	130	.77
Benign prostatic diseases (610–614)	51	65	.79	39	40	.96
Pulmonary tuberculosis (001, 002)	81	36	2.27	36	21	1.72

[1] Only ex-cigarette smokers who stopped smoking cigarettes for reasons other than physicians' orders.

[2] O÷E values are based on expected numbers to 2 decimal places.

[3] Ratios are not shown for observed values of less than 20.

NOTE: For explanation of smoking categories, see p. 215.

The smoking classifications used in the present analysis are the same as those used in earlier reports (4,5). The "occasional" smokers (persons who smoke once in awhile but not every day) have in all instances been included in the nonsmoking categories. Lifetime smoking and current smoking are distinguished for each form of tobacco.

Lifetime categories

0—Never smoked

1—Ex-smoker (regular smoker in the past, but not now)

2—Regular smoker now or current smoker (that is, as of 1954 for the 1954 cohort or 1957 for the 1957 cohort)

6—Never smoked or ex-smoker, but unknown which

7—Never smoked or current smoker, but unknown which

8—Current or ex-smoker, but unknown which

9—Unknown whether never smoked, ex-smoker, or current smoker

(Categories 6–9 represent the different kinds of unknowns.)

Current smoking categories

Nonsmoker (lifetime categories 0, 1, and 6)

Regular smoker (lifetime category 2)

Unknown if nonsmoker or regular smoker (lifetime categories 7–9)

For ease of reference, the lifetime smoking categories for the three forms of tobacco studied are shown as 3-digit numbers, with the first digit representing cigarettes, the second cigars, and the third pipes. Thus, for example, 126 means those persons who at the time they answered the smoking questionnaire were ex-cigarette smokers but were currently smoking cigars

Table 2. (Continued)

Cause of death (7th Revision ICD numbers)	Cigarete smokers			Ex-cigarette smokers [1]		
	Observed deaths	Expected deaths	O÷E [2]	Observed deaths	Expected deaths	O÷E [2]
Influenza and pneumonia (480–481, 490–493)	460	259	1.78	163	165	.99
Pulmonary fibrosis, bronchiectasis, atelectasis (525–527.0)	144	48	3.02	59	27	2.15
Emphysema (527.1)	1,201	81	14.82	313	50	6.22
Bronchitis (500–502)	163	32	5.11	45	19	2.43
Bronchitis and emphysema (500–502, 527.1)	1,364	113	12.07	358	69	5.20
Asthma (241)	90	27	3.28	29	15	1.95
All respiratory diseases (241, 480–481, 490–502, 520–527)	2,107	488	4.31	628	302	2.08
Suicide (E970–E979)	376	282	1.33	154	136	1.14
Accidents and violence (E800–E965, E980–E999)	780	633	1.23	329	326	1.01
Suicide, accidents, and violence (E800–E999)	1,156	915	1.26	483	461	1.05
All cancers (140–207)	7,608	3,590	2.12	2,816	2,025	1.39
Cancer of buccal cavity (140–144)	110	26	4.22	24	14	1.67
Cancer of pharynx (145–148)	92	7	14.05	11	4	([3])
Cancer of esophagus (150)	156	24	6.43	35	15	2.41
Cancer of stomach (151)	390	257	1.52	158	143	1.10
Cancer of intestines (152–153)	662	597	1.11	431	334	1.29
Cancer of rectum (154)	239	215	1.11	131	116	1.13
Cancer of liver and biliary passages (155)	176	75	2.33	78	44	1.79
Cancer fo pancreas (157)	459	256	1.79	170	145	1.17
Cancer of larynx (161)	94	8	11.49	22	5	4.78
Cancer of lung and bronchus (162.1, 162.8, 163)	2,609	231	11.28	517	130	3.97
Cancer of prostate (177)	660	504	1.31	360	304	1.18
Cancer of kidney (180)	175	124	1.41	82	68	1.21
Cancer of bladder and other urinary organs (181)	326	151	2.16	126	90	1.41
Malignant lymphomas (200–201, 203, 206)	370	347	1.07	188	189	.99
Leukemia (204, 207)	333	207	1.61	175	119	1.47
Cancer of brain (193)	160	152	1.05	85	79	1.08
All other cancers	597	407	1.47	223	227	.98
Ill defined conditions (780–795)	372	220	1.69	159	130	1.22
All other diseases	948	576	1.65	396	322	1.23
Unknown (no death certificate)	849	390	2.17	285	217	1.31

[1] Only ex-cigarette smokers who stopped smoking cigarettes for reasons other than physicians' orders.

[2] O÷E values are based on expected numbers to 2 decimal places.

[3] Ratios are not shown for observed values of less than 20.

NOTE: For explanation of smoking categories, see p. 215.

and either had never smoked a pipe or were ex-pipe smokers. Category 200 denotes persons who at the time of the questionnaire were current cigarette smokers but had never smoked cigars or a pipe. Category 2.. denotes all current cigarette smokers and includes categories 200–209, 210, 211, and so forth.

The method of analysis used in this report is similar to that described in an earlier one (6). The probability of dying within 1 year by specified cause of death (y) and single year of age (x) is first estimated for the nonsmokers (000 category). A given year of age attained at any time in the 16-year period is considered. A person who is x years old in 1954 is counted as x + 1 year old in 1955, x + 2 years old in 1956, and so forth, provided he survives. A person who dies is counted as entering each year from 1954 up through the year of death. The following table may serve to illustrate.

	Age in—					
Age attained	*1954*	*1955*	*1956*	*1957*	...	*1969*
31	31	32	33	34		46
32	32	33	34			47
33	33	34				48
34	34					49
84	84	85	86	87	...	99

The numbers of persons entering a given age (x) are pooled (along a diagonal) and constitute the total persons at risk for the given age (Nx). The numbers of deaths from a specified cause (y) for a given age are collected in the same way. Dividing y by Nx provides the 1-year probability of death from that cause for that age (q_{xy}).

The values of q_{xy} for nonsmokers were obtained for each year of age (x) from 31 to 99 for each cause of death (y) as described. By applying the probability q_{xy} to the number of persons at risk for a given smoking group (Nx), an "expected" number of deaths (E_{xy}) was obtained. The expected values for the specified cause y were summed over all ages, separately by cohort, and then pooled. A mortality ratio of the cause-specific mortality risks for the given smoking group as compared with nonsmokers was then formed by dividing the observed number of deaths by the expected number.

Results

The number of persons in each cohort, the number of deaths in each cohort, and the number of deaths for which death certificates were found or not found are shown in table 1. The 2 percent of deaths for which certificates were not found were treated as unknown with respect to the cause of death and discounted from

the analyses of specific causes of death. Because of the small number of these deaths, their effect upon mortality ratios is considered negligible.

Table 2 provides a summary of the mortality experience for selected causes of death over the entire study period in terms of mortality ratios. That is, the mortality ratios both for current (at time of the questionnaire) cigarette smokers and for ex-cigarette smokers who had stopped smoking for reasons other than physicians' orders were compared with the mortality ratios for the nonsmokers. Nearly all the mortality ratios for the cigarette smokers were greater than unity. The highest ratios (those greater than 5) were observed for cor pulmonale (5.57), aortic aneurysm (5.23), emphysema and bronchitis (14.82), cancer of pharynx (14.05), cancer of esophagus (6.43), cancer of larynx (11.49), and cancer of lung and bronchus (11.28). Mortality ratios for ex-cigarette smokers for these causes were much lower than those for current cigarette smokers, although in all instances the mortality ratios were greater than 1.0.

In terms of observed deaths minus expected (O—E) for all causes, an excess of 15,286 deaths was associated with current cigarette smoking. By cause, the largest O—E was for all cardiovascular diseases, which accounted for nearly 8,000 excess deaths. About 5,000 of these excess deaths were from coronary heart disease, 728 were from aortic aneurysm, 653 were from stroke, 383 were from hypertensive disease, and 316 were from general arteriosclerosis.

About 4,000 excess deaths associated with current cigarette smoking were noted for all cancers. More than half of this excess (2,378 deaths) was from lung cancer. The number of excess deaths from all respiratory diseases was 1,619, with bronchitis and emphysema accounting for 1,251.

For ex-smokers, the mortality ratios for nearly all cardiovascular causes of death shown were close to unity (1.20 or less). The only notable exception was aortic aneurysm with a mortality ratio of 2.58.

Few conditions in table 2 exhibit mortality ratios of less than 1.0. The only exception of note is Parkinson's disease with an O—E of 0.32 for current cigarette smokers and 0.70 for ex-cigarette smokers.

Mortality ratios for selected causes of death are shown in table 3 for "pure" cigarette smokers (category 200), "pure" cigar smokers (020), and "pure" pipe smokers (002). The pure cigarette smokers had much higher values than the pure cigar or pure pipe smokers for each cause shown. Also, for each cause, mortality ratios were somewhat higher for the 200 group than for the 2.. group (see table 2); for all causes, ratios

for the 200 group were 1.86 compared with 1.73 for the 2.. group.

For all causes of death, pure cigar smokers showed an excess mortality of 15 percent compared with non-smokers (000 category); pure pipe smokers showed an excess mortality of 8 percent compared with non-smokers. For cigar smokers, the highest mortality ratios were for aortic aneurysm (2.04), lung cancer (1.66), and all cancers (1.32). Mortality ratios were near or below unity for stroke (1.07), influenza and pneumonia (0.82), and respiratory diseases (0.84).

For pipe smokers, the highest mortality ratios were for bronchitis and emphysema (2.53), lung cancer (2.14), aortic aneurysm (2.07), respiratory diseases (1.44), and all cancers (1.29). Mortality ratios were near or below 1.0 for all cardiovascular diseases (1.04), coronary heart disease (1.02), stroke (0.99), and influenza and pneumonia (0.97).

Mortality ratios according to the amount of tobacco smoked are shown in figures 1 and 2 for selected causes for both current cigarette smokers and those ex-cigarette smokers who stopped smoking for reasons other than physicians' orders. The observed numbers of deaths are given in tables 4 and 5. A clear gradient by the amount of tobacco smoked is evident for current smokers and, also, for ex-smokers. For each cause of death, the mortality ratio varies directly with the amount smoked.

When the mortality ratios for the ex-smokers are compared with those for the current smokers (figs. 1 and 2), the ex-smokers have a lower mortality ratio at each level of smoking for each cause shown.

In figure 3, mortality ratios for ex-cigarette smokers who had stopped smoking for reasons other than physicians' orders are shown for selected causes of death, by the number of years of smoking cessation. (The observed numbers of deaths for this group are given in table 6.) Initially, we divided these ex-cigarette smokers into 5-year groups according to the length of time that they had stopped smoking cigarettes as of the beginning of followup. With each year of followup, the length of time that smoking had been discontinued was increased by 1 year, and the ex-cigarette smokers were classified into one of the five categories shown in figure 3. The approximate midpoint of the 5-year interval was used to measure the length of time the person had stopped smoking. These midpoints were A = 2, B = 7, C = 12, and D = 17. For example, an ex-smoker in the 1954 cohort who had stopped smoking less than 5 years as of the start of the study would be counted in the A group for the first 3 years of followup, in the B group for the next 5 years of followup, in the C group for the next 5 years, and in the D group for the last 3 years—provided the person survived. Similarly, a person in the B group at the start would be counted in the B group for the first 3 years of followup, in the C group for the next 5 years, and so forth. Persons in the E group at the start of the study were counted in the E group throughout. The assumption was made that a person who was an ex-smoker at the beginning of the study would remain an ex-smoker throughout the followup period.

For all causes of death, a consistent inverse relationship existed between the years that the persons had

Table 3. Observed deaths, expected deaths, and mortality ratios (O÷E) for pure cigarette smokers, pure cigar smokers, and pure pipe smokers for selected causes of death, U.S. veterans study, 1954–69

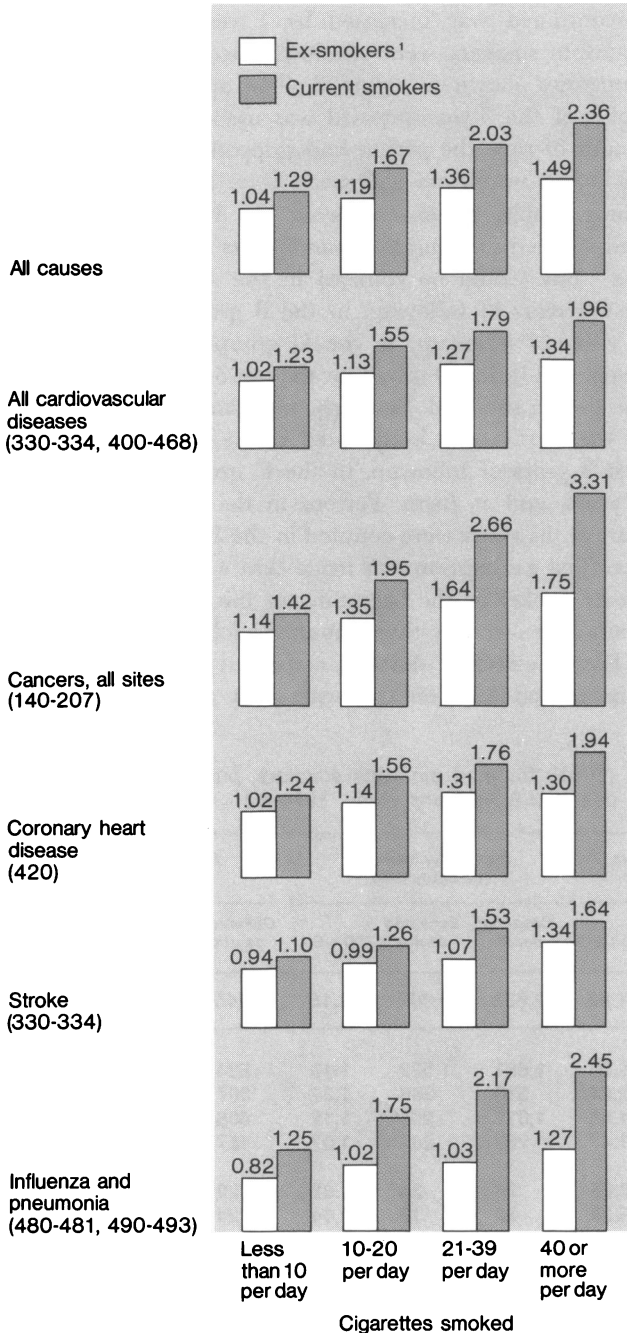| Cause of death (7th Revision ICD numbers)	Pure cigarette smokers (category 200)			Pure cigar smokers (category 020)			Pure pipe smokers (category 002)		
	Observed deaths	Expected deaths	O÷E [1]	Observed deaths	Expected deaths	O÷E [1]	Observed deaths	Expected deaths	O÷E [1]
All causes	15,091	8,112	1.86	2,653	2,302	1.15	1,545	1,432	1.08
Cardiovascular diseases (330–334, 400–468)	8,920	5,257	1.70	1,681	1,522	1.10	984	948	1.04
Cancers, all sites (140–207)	3,138	1,401	2.24	510	386	1.32	307	237	1.29
Coronary heart disease (420)	5,740	3,414	1.68	1,077	965	1.12	606	596	1.02
Stroke (330–334)	1,172	796	1.47	267	249	1.07	157	159	.99
Influenza and pneumonia (480–481, 490–493)	200	96	2.08	28	34	.82	22	23	.97
Aortic aneurysm (451)	359	68	5.28	38	19	2.04	24	12	2.07
Respiratory diseases (241, 480–481, 490–502, 520–527)	879	185	4.75	51	61	.84	57	39	1.44
Bronchitis and emphysema (500–502, 527.1)	568	43	13.13	10	14	([2])	22	9	2.53
Lung cancer (162.1, 162.8, 163)	1,095	91	12.06	41	25	1.66	32	15	2.14

[1] Based on expected number to 2 decimal places.
[2] Ratio not shown for observed values of less than 20.

NOTE: For explanation of smoking categories, see p. 215.

stopped smoking and the mortality ratio. Ex-smokers who had stopped smoking for 20 or more years had a mortality ratio fairly close to unity (1.09).

The pattern of mortality for all cardiovascular diseases was similar to that for all causes; the mortality ratio for the E group was close to unity (1.04). The

pattern for coronary heart disease was similar, with the E group having a mortality ratio of 1.05. For stroke, the pattern differed in that all ex-smoker groups except B had mortality ratios close to 1—ranging from 0.96 for the C group to 1.03 for the D group. For aortic aneurysm, the pattern appeared to be inverse

Figure 1. Mortality ratios for selected causes of death with mortality ratios of less than 5, for current cigarette smokers (category 2. .) and ex-cigarette smokers (category 1. .), by number of cigarettes smoked daily, U.S. veterans study, 1954–69.

Figure 2. Mortality ratios for selected causes of death with mortality ratios of less than 25, for current cigarette smokers (category 2. .) and ex-cigarette smokers (category 1. .), by number of cigarettes smoked daily, U.S. veterans study, 1954–69.

[1] Only ex-cigarette smokers who stopped smoking for reasons other than physicians' orders.
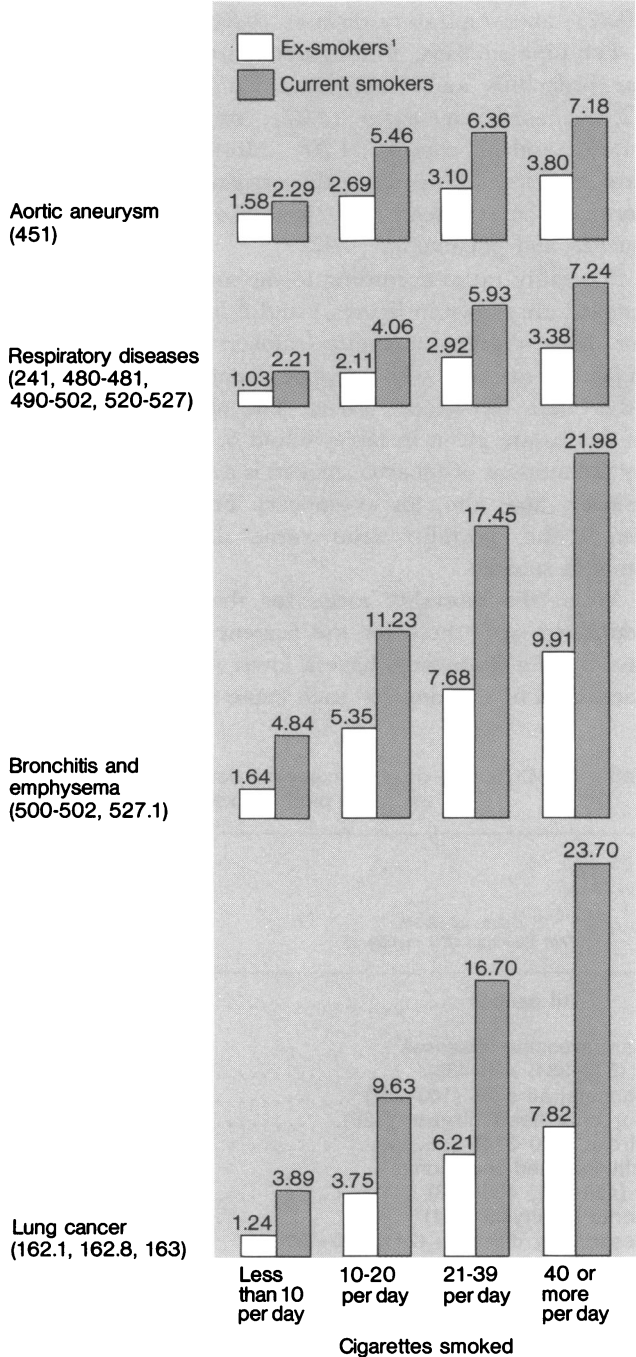
[1] Only ex-cigarette smokers who stopped smoking for reasons other than physicians' orders.

as well, but the mortality ratio for the E group was 1.80.

For all cancers, the pattern was also inverse, but it differed from that for the cardiovascular diseases in that the A group exhibited a higher mortality ratio than the current cigarette smokers. The mortality ratio for the E group was 1.27.

For lung cancer, the A group had a higher mortality ratio than current cigarette smokers (18.83 compared with 11.28). However, strong reductions in the mor-

tality ratio were observed for the other groups as the years of smoking cessation increased. The final value was 2.10 for the group that had stopped smoking for 20 or more years.

With the exception of the mortality ratio for the A group, respiratory diseases as a whole showed a consistent downward gradient with increases in the number of years of smoking cessation. The E group had a mortality ratio of 1.34. For the B group, however, the mortality ratio for these diseases was greater

Figure 3. Mortality ratios for selected causes of death for current cigarette smokers (category 2. .) and ex-cigarette smokers (category 1. .), by number of years of smoking cessation, U.S. veterans study, 1954–69.
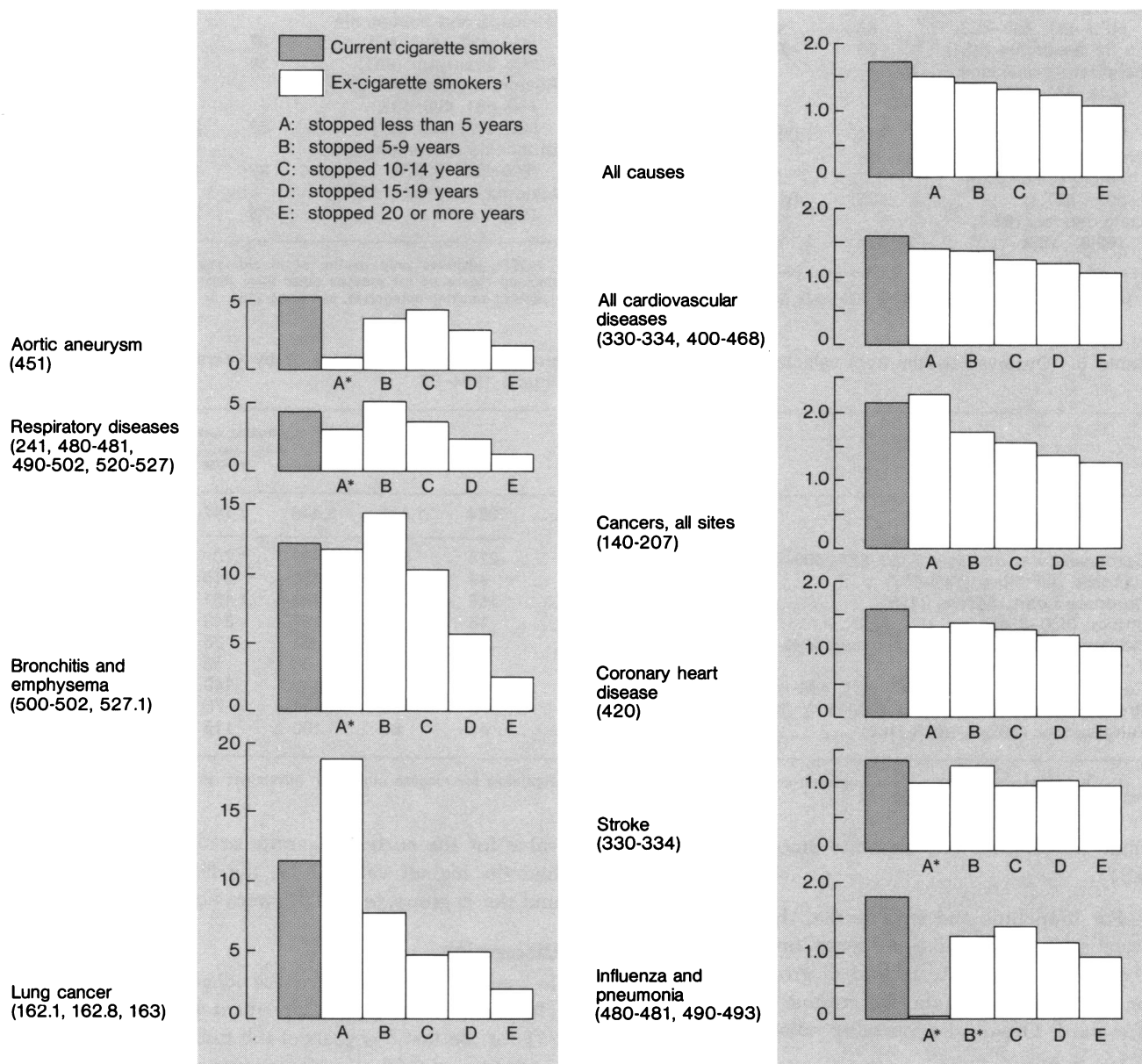
¹ Only ex-cigarette smokers who stopped smoking for reasons other than physicians' orders.
NOTE: Asterisk (*) indicates mortality ratio was based on less than 20 observed deaths.

Table 4. Observed deaths from selected causes among current cigarette smokers (category 2..), by number of cigarettes smoked daily, U.S. veterans study, 1954–69

Cause of death (7th Revision ICD numbers)	Cigarettes smoked daily			
	<10	10–20	21–39	40+
All causes	4,792	17,457	11,514	2,380
Cardiovascular diseases (330–334, 400–468) ..	2,995	10,594	6,533	1,291
Cancers, all sites (140–207)	891	3,502	2,632	583
Coronary heart disease (420)	1,932	6,859	4,216	838
Stroke (330–334)	435	1,321	816	156
Influenza and pneumonia (480–481, 490–493) ..	66	230	137	27
Aortic aneurysm (451) .	69	474	297	60
Respiratory diseases (241, 480–481, 490–493, 500–502, 520–527)	211	1,007	731	158
Bronchitis and emphysema (500–502, 527.1)	105	645	501	113
Lung cancer (162.1, 162.8, 163)	156	1,118	1,063	272

NOTE: For explanation of smoking categories, see p. 215.

Table 5. Observed deaths from selected causes among ex-cigarette smokers (category 1..), by maximum number of cigarettes they had smoked daily, U.S. veterans study, 1954–69

Cause of death (7th Revision ICD numbers)	Maximum number of cigarettes smoked daily			
	<10	10–20	21–39	40+
All causes	3,068	6,651	3,436	1,332
Cardiovascular diseases (330–334, 400–468)	1,994	4,153	2,092	788
Cancers, all sites (140–207)	561	1,283	707	265
Coronary heart disease (420)	1,256	2,684	1,393	490
Stroke (330–334)	303	581	272	123
Influenza and pneumonia (480–481, 490–493) ...	37	78	33	15
Aortic aneurysm (451) ...	38	123	64	28
Respiratory diseases (241, 480–481, 490–493, 500–502, 520–527)	82	296	176	74
Bronchitis and emphysema (500–502, 527.1)	29	172	107	50
Lung cancer (162.1, 162.8, 163)	39	228	173	77

NOTE: Includes only deaths of ex-cigarette smokers who stopped smoking cigarettes for reasons other than physicians' orders. For explanation of smoking categories, see page 215.

Table 6. Observed deaths from selected causes among ex-cigarette smokers (category 1..) by years of smoking cessation, U.S. veterans study, 1954–69

Cause of death (7th Revision ICD numbers)	Years of smoking cessation					
	<5	5–9	10–14	15–19	20+	Unknown
All causes	384	1,441	2,445	2,767	6,049	1,401
Cardiovascular diseases (330–334, 400–468)	224	892	1,488	1,707	3,832	884
Cancers, all sites (140–207)	99	305	488	515	1,160	249
Coronary heart disease (420)	150	599	997	1,101	2,418	558
Stroke (330–334)	16	98	167	243	604	151
Influenza and pneumonia (480–481, 490–493)	0	8	25	36	83	11
Aortic aneurysm (451)	2	34	66	53	80	18
Respiratory disease 241, 480–481, 490–493, 500–502, 520–527)	10	82	140	140	209	47
Bronchitis and emphysema (500–502, 527.1)	8	58	101	75	90	26
Lung cancer (162.1, 162.8, 163)	47	86	100	115	123	46

NOTE: Includes only deaths of ex-cigarette smokers who stopped smoking cigarettes for reasons other than physicians' orders. For explanation of smoking categories, see page 215.

than for the current cigarette smokers (5.04 versus 4.31).

For bronchitis and emphysema, the mortality ratios were somewhat similar to those for lung cancer, in that those for the A, B, and C groups were close to or higher than the ratio for current cigarette smokers. For the E Group, the mortality ratio was 2.64.

For influenza and pneumonia, the mortality ratios for the ex-smokers were all much less than the 1.77

value for the current cigarette smokers. The C group had the highest value, 1.35; the D group, with 1.11, and the E group, with 0.91, were near unity.

Discussion

In general, the results for the longer followup period (16 years) were in close agreement with those of Kahn (3) for the first 8½ years of the study, as the following mortality ratios for current cigarette smokers for selected causes show:

Mortality ratios for current smokers		
Cause of death	8½ years	16 years
All causes	1.71	1.73
Cardiovascular diseases ..	1.62	1.58
Cancers, all sites	2.08	2.12
Coronary heart disease ...	1.61	1.58
Stroke	1.40	1.32
Influenza and pneumonia	1.59	1.78
Aortic aneurysm	5.15	5.23
Parkinson's disease	0.23	0.32
Bronchitis and emphysema	8.65	12.07
Lung cancer	10.88	11.28

Mortality ratios for ex-smokers		
Cause of death	8½ years	16 years
All causes	1.27	1.21
Cardiovascular diseases	1.21	1.15
Cancers, all sites	1.49	1.39
Coronary heart disease	1.21	1.16
Stroke	1.07	1.02
Influenza and pneumonia	.93	.99
Aortic aneurysm	2.75	2.58
Parkinson's disease	.56	.70
Bronchitis and emphysema ...	7.64	5.20
Lung cancer	4.71	3.97

The agreement between the data for the two periods is remarkably good, considering that there were differences in the methods used to derive mortality ratios as well as minor differences in the classification of some categories. The one difference worth noting is that for bronchitis and emphysema, for which the mortality ratio was 8.65 for the first 8½-year period compared with 12.07 for the entire period. This difference suggests that mortality ratios for regular cigarette smokers have been increasing over time. A further comparison of the bronchitis and emphysema mortality ratios for the two periods by the number of cigarettes smoked yielded the following results:

	Mortality ratios for bronchitis and emphysema	
Cigarettes smoked daily	8½ years	16 years
Less than 10	4.14	4.84
10–20	8.73	11.23
21–39	11.13	17.45
40 or more	15.02	21.98

The preceding comparisons suggest that mortality ratios have been increasing over time at all levels of smoking, with the most pronounced increase being evident for persons smoking 21 or more cigarettes a day. This relationship, however, was not found for lung cancer, nor for aortic aneurysm, two diseases that are also closely associated with cigarette smoking:

	Mortality ratios for lung cancer		Mortality ratios for aortic aneurysm	
Cigarettes smoked daily	8½ years	16 years	8½ years	16 years
Less than 10	4.76	3.89	2.16	2.29
10–20	9.05	9.63	5.58	5.46
21–39	16.93	16.70	6.55	6.36
40 or more	23.63	23.70	7.21	7.18

In general, close agreement was obtained over the two periods of followup in the mortality ratios for ex-cigarette smokers who had stopped smoking for reasons other than physicians' orders.

Although agreement was close, mortality ratios tended to be lower for the 16-year period than for the 8½-year period. This was true for all causes shown except those for which the mortality ratios were less than 1.0. This result is consistent with the inverse relation between the number of years of smoking cessation and the mortality ratio (fig. 3).

Our study showed that in the case of some diseases, the mortality risk for ex-cigarette smokers who stopped smoking for reasons other than physicians' orders returned to normal (that is, to nonsmoker levels) almost immediately after cessation of smoking, whereas for other diseases the return to normal was more gradual. The first group includes stroke and the combined category of influenza and pneumonia; the second group includes cardiovascular diseases as a whole and coronary heart disease. For still other diseases, although the mortality ratios declined with the length of time smoking was discontinued, substantial excess risks remained even after 20 years of cessation. In this third group are aortic aneurysm, bronchitis and emphysema, and lung cancer—diseases with very high mortality ratios for the current cigarette smokers.

As stated earlier, all the smoking classifications in this report were taken from the original questionnaires and for this analysis are considered to be unchanged over the whole followup period. Short of a resurvey, there is of course no way of knowing just how many people actually changed their smoking habits and in what ways. In view of the age distributions of the starting cohorts (for example, 87 percent of all the nonsmokers were 55 years or older at the outset of the study), it seems reasonable to assume that relatively few nonsmokers began smoking during the course of the study. It is probable that a number of "current" smokers stopped smoking during the course of the study and also that a number of "ex-smokers" took up smoking again. Based on these assumptions, the mortality ratios observed for current cigarette smokers would tend to be too low, and those for ex-cigarette smokers would tend to be too high. Thus, the ratio of 1.73 for current cigarette smokers is an understatement, whereas for

ex-cigarette smokers, the mortality ratio of 1.21 is an overstatement. In other words, the mortality risk associated with smoking is greater than indicated by our statistics, and the benefits of stopping must also be greater than those shown.

The one disease reported by Kahn for which the mortality ratio for cigarette smokers was less than 1.0 was Parkinson's disease (paralysis agitans). The data for the longer followup period clearly confirmed this result. Like Kahn, we examined the possibility that this low ratio could be an artifact resulting from the inability of persons with this disease to continue as smokers. This possibility, however, was contradicted by the low risk observed among ex-cigarette smokers (mortality ratio 0.70). An artificially low ratio might also result if Parkinson's disease were mentioned on the death certificate in combination with other diseases that are strongly associated with a smoking history and that tend to be selected as the underlying cause of death. The data did not support this possibility either. Other prospective mortality studies (7,8), as well as two case-control morbidity studies (9,10), support our results. The negative association of Parkinson's disease with cigarette smoking needs serious study.

References

1. Dorn, H. F.: The mortality of smokers and nonsmokers. *In* Proceedings of Social Statistics Section, American Statistical Association, 1958, pp. 34–71. American Statistical Association, Washington, D.C.

2. Dorn, H. F.: Tobacco consumption and mortality from cancer and other diseases. Public Health Rep 74: 581–593 (1959).

3. Kahn, H. A.: The Dorn study of smoking and mortality among U.S. veterans; report on 8½ years of observation. *In* Epidemiological approaches to the study of cancer and other diseases, edited by W. Haenszel. National Cancer Institute Monograph 19. Bethesda, Md., 1966, pp. 1–125.

4. Rogot E.: Smoking and general mortality among U.S. veterans, 1954–1969. DHEW Publication No. (NIH) 75–544. National Institutes of Health, Bethesda, Md., 1974.

5. Rogot, E.: Smoking and mortality among U.S. veterans. J Chronic Dis 27: 189–203 (1974).

6. Rogot, E.: Smoking and life expectancy among U.S. veterans. Am J Public Health 68: 1023–1025 (1978).

7. Hammond, E. C.: Smoking in relation to the death rates of 1 million men and women. *In* Epidemiological approaches to the study of cancer and other diseases, edited by W. Haenszel. National Cancer Institute Monograph 19. Bethesda, Md., 1966, pp. 127–204.

8. Doll, R., and Peto, R.: Mortality in relation to smoking: 20 years' observations on male British doctors. Brit Med J 2: 1525–1536 (1976).

9. Nefzger, M. D., Quadfasel, F. A., and Karl, V. C.: A retrospective study of smoking in Parkinson's disease. Am J Epidemiol 88: 149–158 (1968).

10. Kessler, I. I., and Diamond, E. L.: Epidemiologic studies of Parkinson's disease. Am J Epidemiol 94: 16–25 (1971).

SYNOPSIS

ROGOT, EUGENE (National Heart, Lung, and Blood Institute), and MURRAY, JAMES L.: *Smoking and causes of death among U.S. veterans: 16 years of observation.* Public Health Reports, Vol. 95, May-June 1980, pp. 213–222.

In a 16-year mortality followup of some 293,000 insured U.S. veterans, specific causes of death were studied in relation to smoking status. The main results confirmed earlier findings.

Mortality ratios for cigarette smokers as compared with nonsmokers were 1.73 for all causes of death, 1.58 for all cardiovascular diseases, 2.12 for all cancers, and 4.31 for all respiratory diseases. The highest ratios (those greater than 5.0) were observed for cor pulmonale, aortic aneurysm, emphysema and bronchitis, cancer of the pharynx, cancer of the esophagus, cancer of the larynx, and cancer of the lung and bronchus. The greatest excess in deaths in terms of observed numbers minus expected was found for the cardiovascular diseases, in particular for coronary heart disease.

Mortality ratios for ex-cigarette smokers who had stopped smoking for reasons other than physicians' orders were much lower compared with nonsmokers than the mortality ratios for current cigarette smokers: 1.21 for all causes, 1.15 for all cardiovascular diseases, 1.39 for all cancers, and 2.08 for all respiratory diseases. For most causes of death, the mortality ratios for ex-cigarette smokers who had stopped smoking for reasons other than physicians' orders varied inversely with the number of years of cessation. For some diseases, the mortality risk for the ex-cigarette smoker returned to normal almost immediately after the cessation of smoking, whereas for others, the return to normal was more gradual. The first group included stroke and the combined category of influenza and pneumonia; the second group included cardiovascular diseases as a whole and coronary heart disease. For still other diseases, although the mortality ratio declined with the length of time smoking was discontinued, substantial excess risks remained even after 20 years of cessation. In this third group were aortic aneurysm, bronchitis and emphysema, and lung cancer—diseases with very high mortality ratios for current cigarette smokers. Parkinson's disease remained the one disease that clearly exhibited a negative association with cigarette smoking.