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THE RELATIONSHIP BETWEEN HUMAN SMOKING HABITS AND DEATH RATES

A FOLLOW-UP STUDY OF 187,766 MEN

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and

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TABLE I.—*Smoking Questionnaire*

Page 1

Division No.: Area No.: Group No.:

Unit No.: District No.: Researcher No.:

Researcher's Name..... Case No.:

Dear Sir:

This is a study of differences in health between nonsmokers and smokers. From time to time all sorts of claims have been made as to the effects of smoking on health. Many of these are poorly founded. We hope to determine statistically the effects of smoking in a group of men 50 years of age and over. Thank you for your cooperation.

AMERICAN CANCER SOCIETY

Your Name..... Date.....

Address (Street) (City) (State)

How old are you? 50-54 55-59 60-64 65-69

READ QUESTIONS CAREFULLY BEFORE CHECKING ANSWERS

A. Have you ever done smoking of any kind? Yes No
(IF "YES") For how many years have you smoked? Enter no. of years

B. During your entire life

Yes No

Have you ever smoked at least as many as 5 to 10 packs of cigarettes? (check If or No)

Have you ever smoked at least as many as 50 to 75 cigars? (check If or No)

Have you ever smoked at least as many as 3 to 5 packages of pipe tobacco? (check If or No)

If your answers to the 3 types of smoking in question B are all "No," we need no further information.

However, if any answer has been "Yes," please answer the questions on the following pages.

Page 2

CIGARETTE SMOKING

(IF MORE THAN 5 TO 10 PACKS OF CIGARETTES SMOKED DURING YOUR LIFETIME, COMPLETE THIS PAGE ON CIGARETTE SMOKING HABIT.)

1. At the present time, how much cigarette smoking are you doing? (Check One)

None

Smoke cigarettes once in a while but not every day

Regularly smoke cigarettes, but less than $\frac{1}{2}$ pack a day

Regularly smoke from $\frac{1}{2}$ to 1 pack of cigarettes a day

Regularly smoke more than 1 pack but less than 2 packs of cigarettes a day

Regularly smoke 2 or more packs of cigarettes a day

2. If you do not smoke cigarettes now, how long has it been since you last smoked them? Enter Years

3. How old were you when you first smoked cigarettes? Enter Age

4. How many years altogether have you, or did you smoke cigarettes? Enter Years

5. Thinking back over the years you smoked,

For how many of those years did you smoke cigarettes occasionally, but not every day?

For how many of those years did you regularly smoke cigarettes, but less than $\frac{1}{2}$ pack a day?

For how many of those years did you regularly smoke from $\frac{1}{2}$ to 1 pack of cigarettes a day?

For how many of those years did you regularly smoke more than 1 pack but less than 2 packs of cigarettes a day?

For how many of those years did you regularly smoke 2 or more packs of cigarettes a day?

Total

1516

~~Years smoked, and smoked related to~~

- Death rates
- Cardiovascular disease
- Cancer

recognize possible role of air pollution
(urban vs. rural death rates)

The study described here was undertaken for two reasons. One reason was to ascertain whether smoking has an influence on death rates from lung cancer. The other reason was to ascertain whether smoking has an appreciable influence on the over-all death rate and, if so, what diseases are involved. The plan was to obtain smoking histories on a very large number of persons; to follow them for from three to five years; to ascertain the causes of death of those who died; and, finally, to correlate the mortality data with the previously obtained smoking histories. It was decided to limit the study to white men between the ages of 50 and 69, because this is the group in which the majority of deaths from lung cancer occur.

It was anticipated that the men would have to be followed for at least three years before an accurate estimate could be made of the extent of the association between smoking habits and lung cancer death rates. At the present time, most of the men have been followed up for only about 20 months. Therefore, the findings in respect to the degree of association should be considered preliminary. It can no longer be doubted that an association exists between smoking habits and lung cancer death rates.

An analysis of information now available indicates that the over-all death rate, the death rate from diseases of the coronary arteries, and the death rate from cancer are much higher among men with a history of regular cigarette smoking than among men who never smoked. The present report is concerned with these findings.

SMOKING QUESTIONNAIRE

The first step, undertaken in the summer and fall of 1951, was to design a smoking questionnaire that would yield reliable information under field conditions. A number of alternative forms were drawn up and tested. The one finally selected for use was the four page booklet shown in table 1. The first page contains general questions and was designed so as to start the subject thinking about his own smoking history. The second page has detailed questions on present and past cigarette smoking habits. The third and fourth pages have parallel questions about cigar and pipe smoking. Before being used, this questionnaire was pretested, first in the hands of paid professional interviewers and second in the hands

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A condensed version of this paper was read in the General Scientific Meetings at the 103rd Annual Meeting of the American Medical Association, San Francisco, June 21, 1954.

Lawrence Garfinkel, M.A., Constance L. Percy, M.S., and Leonard Craig, M.A., assisted in this study.

Aid in this study was given by volunteer researchers and subjects; county, division, and national office personnel of the American Cancer Society; state departments of health; and private physicians.

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CIGAR SMOKING

(MORE THAN 50 TO 75 CIGARS SMOKED DURING YOUR LIFE-TIME, COMPLETE THIS PAGE ON CIGAR SMOKING HABIT.)

1. At the present time, how much cigar smoking are you doing? (Check One)

None
.....

Smoke cigars once in a while but not every day
.....

Regularly smoke 1 to 2 cigars a day
.....

Regularly smoke 2 to 4 cigars a day
.....

Regularly smoke 4 to 8 cigars a day
.....

Regularly smoke 8 or more cigars a day
.....

2. If you do not smoke cigars now, how long has it been since you last smoked them? Enter Years.....

3. How old were you when you first smoked cigars? Enter Age

4. How many years altogether have you, or did you smoke cigars? Enter Years.....

5. Thinking back over the years you smoked, No. of Years
For how many of those years did you smoke cigars occasionally, but not every day?
.....

For how many of those years did you regularly smoke 1 to 2 cigars a day?
.....

For how many of those years did you regularly smoke 2 to 4 cigars a day?
.....

For how many of those years did you regularly smoke 4 to 8 cigars a day?
.....

For how many of those years did you regularly smoke 8 or more cigars a day?
.....

Total

Page 4

PIPE SMOKING

(MORE THAN 3 TO 5 PACKAGES OF PIPE TOBACCO SMOKED DURING YOUR LIFETIME, COMPLETE THIS PAGE ON PIPE SMOKING HABIT.)

1. At the present time, how much pipe smoking are you doing? (Check One)

None
.....

Smoke a pipe once in a while but not every day
.....

Regularly smoke a pipe but less than 5 pipefuls a day
.....

Regularly smoke from 5 to 10 pipefuls a day
.....

Regularly smoke from 10 to 20 pipefuls a day
.....

Regularly smoke 20 or more pipefuls a day
.....

2. If you do not smoke a pipe now, how long has it been since you last smoked a pipe? Enter Years.....

3. How old were you when you first smoked a pipe? Enter Age

4. How many years altogether have you, or did you smoke a pipe? Enter Years.....

5. Thinking back over the years you smoked, No. of Years
For how many of those years did you smoke a pipe occasionally, but not every day?
.....

For how many of those years did you regularly smoke a pipe but less than 5 pipefuls a day?
.....

For how many of those years did you regularly smoke from 5 to 10 pipefuls a day?
.....

For how many of those years did you regularly smoke from 10 to 20 pipefuls a day?
.....

For how many of those years did you regularly smoke 20 or more pipefuls a day?
.....

Total

volunteer workers of the American Cancer Society in York, Pa. These tests indicated that it was highly satisfactory for the purpose at hand.

PROCEDURES

Three hundred ninety-four counties were selected as study areas on the basis of population and the availability of a nucleus of well-organized volunteers to carry on the field work. These counties are located in 10 administrative divisions of the American Cancer Society;

namely, New Jersey, Pennsylvania, New York, Michigan, southeastern Michigan, Illinois, Wisconsin, Minnesota, Iowa, and California. The study areas varied from very large cities to small towns and farming districts.

Beginning in November, 1951, over 22,000 volunteers, many of whom had worked on other projects for the society, were recruited and trained as researchers for the study. The key volunteer leaders and many of the individual researchers were given verbal instructions by members of our office or by division office personnel as well as written instructions. Slightly different procedures from those described here were used in some areas, but the same smoking questionnaire was used in all instances. The volunteer researchers were then organized in groups, usually of 5 to 15 persons, and a chairman was appointed to be responsible for the work of each group. Each researcher was given a packet containing 11 questionnaires and a set of instructions. She was then instructed to ask 5 or 10 men (or more if possible) to fill out smoking questionnaires. They were all to be white

TABLE 2.—Follow-Up of Men Interviewed

American Cancer Society—Research Study on Smoking (Form 3)

Researcher's Name:

Address:

Telephone:

Substitute's Name:

Address:

Telephone:

Division No.:..... Area No.:..... Group No.:.....

Unit No.:..... District No.:..... Researcher No.:.....

Date of Follow-up Report:	Check One for Each Man			If dead, enter date and place of death.
Case No.	Name and Address	Alive	Dead	If man has moved, enter his new address.
.....
.....

men between the ages of 50 and 69. It was emphasized that the researcher would have to report on them annually and, therefore, that she should ask the cooperation only of men with whom she expected to be in contact for the next several years.

The names and addresses of all the men questioned by each volunteer were entered on a follow-up report form, four copies of which were prepared immediately (table 2). The follow-up form also carried the name and address of the researcher and a substitute. The completed smoking questionnaires were then forwarded to us while the follow-up forms were retained in the field for future use. The actual questioning of men began in January, 1952, and was largely completed by the end of May; but in a few counties it continued through the summer and fall of that year.

The first follow-up was started on Nov. 1, 1952. Each researcher was given a follow-up form with the names of the men she had previously given a questionnaire. For each man on her list, she was asked to check "alive," "dead," or "don't know." If the man had died, she also recorded the date and place of death. The group chair-

Berkson
friends
cooperative

man, county chairman, and division office personnel made an attempt to trace all men checked "don't know" by the researcher. They were successful in a large proportion of cases. In some instances, the original researcher was unavailable, and in such cases a substitute or the group chairman filled out the follow-up form.

When the volunteers had completed their work, the state health department was asked to supply either an abstract or a photostatic copy of the death certificate of each man reported as having died. In all instances in which cancer was recorded any place on the death certificate, an attempt was made to obtain further details

174 questionnaires were too incomplete or confused to be used; this left 190,134 men with usable smoking questionnaires. Of these, 187,766 (98.8%) were successfully traced through Oct. 31, 1953. A total of 4,854 (2.6%) of them were reported as having died up to that date.

SMOKING HABITS

For purposes of this analysis, the 187,766 men were first divided into the following groups according to their smoking habits:

Never Smoked.—Men who checked "no" for question A on the first page of the questionnaire and those who

TABLE 3.—*Distribution of Population by Type of Smoking (Lifetime History) and by Age*

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total
	No.	%	No.	%	No.	%	No.	%	
Never smoked	9,170	15.0	9,138	16.4	7,786	18.6	6,287	21.6	32,381
Occasional only	3,677	5.4	3,257	5.8	2,898	6.9	2,288	7.9	11,710
Cigars only	3,519	5.8	4,153	7.4	3,670	8.8	3,108	10.7	14,450
Pipes only	2,323	3.8	3,084	5.5	3,342	8.0	3,341	11.5	12,008
Cigars and pipes	2,957	3.4	2,433	4.4	2,583	6.2	2,288	7.7	9,360
Cigarettes only	26,365	43.2	19,882	35.5	11,000	27.8	5,907	20.3	63,761
Cigarettes and cigars	2,873	4.6	2,855	5.1	1,975	4.7	1,817	4.6	9,000
Cigarettes and pipes	8,193	13.3	7,252	13.0	5,014	12.0	2,618	9.1	29,007
Cigarettes, cigars, and pipes	3,846	5.5	3,812	6.8	2,945	7.0	1,938	6.7	12,911
Total	63,973	100.0	55,816	100.0	41,872	100.0	29,105	100.0	157,780
Subtotals:									
Noncigarette smokers (never smoked cigarettes regularly)	20,336	33.4	22,065	39.5	20,278	48.4	17,265	50.3	79,944
Cigarettes and other	14,272	23.4	13,919	24.9	9,984	23.7	5,933	20.4	44,068
All regular cigarette smokers	40,637	66.6	33,751	60.5	21,594	51.6	11,840	40.7	107,822

TABLE 4.—*Total Deaths and Death Rates* per 100,000 Population by Type of Smoking (Lifetime History) and by Age at Time of Questioning*

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Never smoked	91	992	158	1,729	167	2,145	281	4,470	897
Occasional only	32	979	51	1,566	72	2,484	114	4,983	269
Cigars only	41	1,165	79	1,902	104	2,884	141	4,537	365
Pipes only	22	947	55	1,783	80	2,394	150	4,486	897
Cigars and pipes	18	875	51	2,090	65	2,517	80	3,575	214
Cigarettes only	431	1,635	550	2,773	504	4,322	342	5,790	1,827
Cigarettes and cigars	41	1,447	58	2,082	76	3,848	64	4,751	229
Cigarettes and pipes	130	1,606	163	2,248	169	3,371	142	5,263	604
Cigarettes, cigars, and pipes	45	1,345	86	2,230	106	3,599	95	4,902	382
Total	851	1,896	1,251	2,241	1,343	3,207	1,409	4,811	4,851
Subtotals:									
Noncigarette smokers (never smoked cigarettes regularly)	204	1,003	384	1,786	488	2,407	766	4,437	1,852
Cigarettes and other	216	1,618	307	2,206	351	3,533	301	5,073	1,175
All regular cigarette smokers	617	1,592	857	2,539	855	3,959	643	5,431	3,002

* Computed by dividing number of deaths that occurred between the time of questioning and Oct. 31, 1953, by number of men in the corresponding age-smoking-habit group. The median period of exposure to risk was about 20 months.

on the case from the physician who signed the death certificate or from hospital, tumor clinic, or cancer registry records when available. The second follow-up was started on Nov. 1, 1953, and was carried out in the same way.

POPULATION STUDIED

A total of 204,547 smoking questionnaires were collected by the volunteers. Of these, 1,280 turned out to be duplicates (i.e. two questionnaires from the same man), and 4,805 were filled out by persons other than white men aged 50 to 69, leaving a net total of 198,462. In order to make the sample more homogeneous in time relationships, it was decided to limit the present analysis to the 192,174 men questioned between Jan. 1 and May 31, 1952. In coding, it was found that 2,040 of the 192,

checked "yes" for the same question, but said that never in their lives had they smoked as many as 10 packs of cigarettes, 75 cigars, or 5 packages of pipe tobacco, were included in this group.

Occasional Only.—Men who checked "yes" to question A, but on pages 2, 3, and 4 of the questionnaire indicated that they had never smoked more than occasionally, comprised this group. There were too few men in this group to divide them further according to type of smoking for this analysis.

Regular Smokers.—Men who smoked regularly or had done so at some time during their lives were included in this group. The regular smokers were further subdivided into seven groups according to the types of smoking they had done regularly. If a man said that he

I smoked one type regularly, occasional smoking of the other type was disregarded. This classification was based on the lifetime history: "cigarette only"; "cigarette and cigar"; "cigarette and pipe"; "cigarette, cigar, and pipe"; "cigar only"; "pipe only"; and "cigar and pipe." Table 3 shows the number and percentage of cases in each of these categories by five year age groups. It will be noted that smoking histories vary considerably with age. For example, 21.6% of the men in the age group 50 to 69 reported that they had never smoked as compared with only 15% of the men in the age group 50 to 64. Only 40.7% of the men in age group 65 to 69 had ever smoked cigarettes regularly, whereas 66.6% of the men in age group 50 to 54 gave such a history.

RESULTS—DEATHS REGARDLESS OF CAUSE

Table 4 shows the 4,854 deaths distributed by type-smoking categories and by age. Death rates were computed by dividing the number of deaths that occurred between the time of questioning and Oct. 31, 1953, by the number of men in the corresponding age-smoking-habit group, the median period of exposure to smoking being about 20 months. Throughout this report, age groups always refer to the age of the men at the time of questioning. Thus four cohorts, representing four age groups, are followed as consistent groups. The most striking finding of this study is that men with a history of regular cigarette smoking had a much higher death rate than men who had never smoked cigarettes regularly (fig. 1). This occurred in all four age groups. The death rate in the cigarette only category was 65% higher than in the never smoked category in age group 50 to 54; 60% higher in age group 55 to 59; 52% higher in age group 60 to 64; and 30% higher in age group 65 to 69. In each age group, the difference was statistically significant, with $P = 0.001$ or less.

The death rates among men with a history of having smoked cigarettes regularly and also some other type regularly were higher than in the never smoked cate-

tically significant in only one age group. The death rates for men who had smoked only pipes regularly were not appreciably different than for men who had never smoked.

Next, we wished to investigate the relative effect of various amounts of cigarette smoking. Men who were currently smoking cigarettes regularly at the time of questioning were classified by amount of cigarette smok-

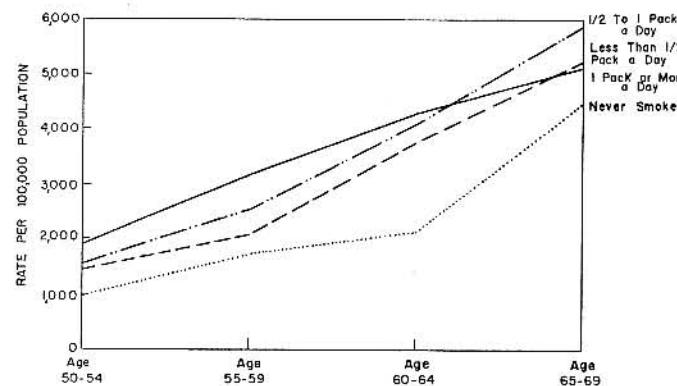


Fig. 2.—Graph showing total death rates by current amount of cigarette smoking at time of questioning and by age.

ing as indicated by answers to question 1 on page 2 of the questionnaire. The number of cases is shown in table 5, and the corresponding number of deaths and death rates are shown in table 6 and figure 2.

It was found that even men who regularly smoke less than half a pack of cigarettes a day had somewhat higher death rates than men who never smoked. This occurred in all four age groups. In the first and third age groups, this finding was statistically significant ($P = 0.03$ or less). Men who smoked half a pack of cigarettes or more a day had higher death rates than those who smoked less than this amount. Except in age group 65 to 69, the highest death rates were found in men who smoked a pack or more of cigarettes a day.

The large effect of heavy cigarette smoking is shown by the following comparisons: The death rate among men who smoked a pack or more of cigarettes a day was 102% higher than among men who never smoked in age group 50 to 54; 86% higher in age group 55 to 59; 108% higher in age group 60 to 64; and 21% higher in age group 65 to 69. The differences are statistically significant ($P = 0.0000001$ or less) in the first three age groups but not in the oldest age group.

A similar analysis was made after subdividing the men into two groups—those who smoked only cigarettes and those who smoked cigars or pipes as well as cigarettes. The results were about the same in these two subgroups as the results just given. However, the rates among men who had smoked only cigarettes were somewhat higher than among men who had smoked cigars and/or pipes as well as cigarettes.

Men who had never smoked cigarettes or pipes regularly but who were smoking cigars regularly at the time of questioning were classified by current amount of regular cigar smoking. The same type of analysis was made for current amount of pipe smoking. Unfortunately, the number of cases in each category of these classifications was too small to make valid comparisons at this time.

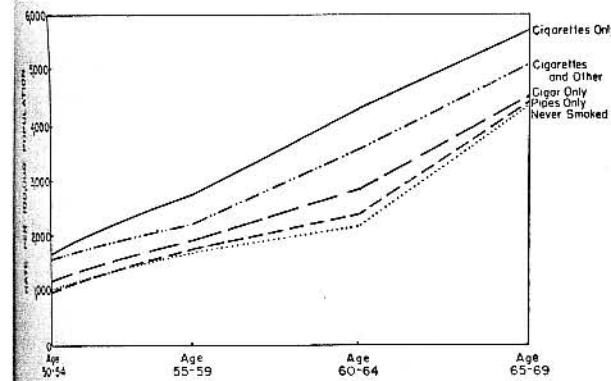


Fig. 1.—Graph showing total death rates by smoking history and by age.

category, although they were somewhat lower than in the cigarettes only category. The difference in rates between the cigarette and other category and the never smoked category was statistically significant in all except the oldest age group.

In all four age groups, the death rates of men who had smoked only cigars regularly were slightly higher than for men who had never smoked. The difference is statisti-

URBAN VERSUS RURAL

The Census Bureau defines as "urban" cities and towns with a population of 2,500 or more; other areas are defined as rural. For purposes of this analysis, we defined, as highly rural, counties with less than 40% of the population living in urban areas (as defined by the Census Bureau); less than 20% of the total labor force engaged in heavy industry or manufacturing; and no mining. At the other extreme, we defined, as highly

and 39,489 of the men were questioned in (and presumably lived in) highly urban counties. Up to Oct. 31, 1953, 613 deaths were reported from the highly rural counties and 1,013 deaths were reported from the highly urban counties. Table 7 shows the distribution of population in these two groups by type of smoking and by age. In every age group, a larger percentage of men in the rural counties had never smoked and a smaller percentage had a history of regular cigarette smoking than

TABLE 5.—Distribution of Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age*

Current Amount of Regular Cigarette Smoking at Time of Questioning	Age 50-54		Age 55-59		Age 60-64		Age 65-69	
	No.	%	No.	%	No.	%	No.	%
Less than $\frac{1}{2}$ pack a day.....	4,415	14.0	4,424	17.6	3,197	20.7	2,119	25.9
$\frac{1}{2}$ to 1 pack a day.....	15,655	49.7	12,771	50.8	8,051	52.0	4,167	51.0
1 pack or more a day.....	11,434	36.3	7,922	31.6	4,232	27.3	1,880	23.1
Total	31,524	100.0	25,117	100.0	15,480	100.0	8,175	100.0
Never smoked	9,170	9,138	7,786	6,287

* Men who were not currently smoking cigarettes regularly at time of questioning were omitted from these data.

TABLE 6.—Total Deaths and Death Rates per 100,000 Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age*

Current Amount of Regular Cigarette Smoking at Time of Questioning	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Less than $\frac{1}{2}$ pack a day.....	65	1,472	91	2,057	120	3,754	111	5,238	387
$\frac{1}{2}$ to 1 pack a day.....	247	1,578	322	2,521	328	4,074	244	5,850	1,341
1 pack or more a day.....	218	1,908	249	3,143	182	4,301	96	5,082	745
Total.....	530	1,681	602	2,680	630	4,070	451	5,517	2,339
Never smoked.....	91	992	158	1,729	167	2,145	281	4,170	607

* Data on men who were not currently smoking cigarettes regularly at time of questioning are omitted from this table.

TABLE 7.—Percentage Distribution of Population by Type of Smoking (Lifetime History) and by Age in Highly Urban Counties Compared with Highly Rural Counties

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Never smoked.....	12.7	19.4	13.8	22.3	15.7	24.0	18.2	27.5
Occasional only.....	4.5	6.8	4.4	7.9	5.4	9.6	6.0	10.2
Cigars only.....	7.0	4.2	8.7	5.9	9.5	7.1	11.4	0.8
Pipes only.....	3.3	4.4	4.4	6.4	5.6	9.9	9.0	18.7
Cigars and pipes.....	4.1	2.1	5.0	2.9	6.8	4.9	8.2	0.0
Cigarettes only.....	44.9	42.4	38.5	33.2	32.0	23.3	24.5	16.4
Cigarettes and cigars.....	5.3	3.4	6.0	4.0	5.9	3.7	6.0	2.8
Cigarettes and pipes.....	12.0	13.2	11.1	13.1	10.9	12.6	8.8	8.5
Cigarettes, cigars, and pipes.....	0.1	4.0	8.2	4.1	8.2	5.1	8.9	4.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Subtotals	—	—	—	—	—	—	—	—
All men with history of regular cigarette smoking.....	68.3	63.1	63.8	54.7	56.9	41.8	47.3	22.0
1 or more packs of cigarettes a day.....	20.7	15.1	16.6	10.7	12.5	6.7	8.6	4.3

urban, counties with 80% or more of the population living in urban areas and 30% or more of the total labor force engaged in heavy industry, manufacturing, or mining. By this definition, the highly urban areas in this study include Pittsburgh, Chicago, Los Angeles, Detroit, Syracuse, N. Y., Buffalo, Rochester, N. Y., etc. The highly rural areas included places such as Bayfield County, Wisconsin; Mille Lacs County, Minnesota; Mackinac County, Michigan; Cedar County, Iowa; and Ocean County, New Jersey. A total of 122 highly rural counties were included in the study area.

A total of 23,339 of the men in the study were questioned in (and presumably lived in) highly rural counties,

was found in urban counties. A further study of the population revealed that, among men with a history of regular cigarette smoking, a smaller percentage smoked a pack or more of cigarettes a day in the rural areas than in the urban areas.

The populations and numbers of deaths in these two groups are of insufficient size to undertake as detailed an analysis as was made for the total population of 187,766 men. Table 8 shows a summary of death rates by broad groupings according to smoking habits. In every age group in both the urban and the rural counties, the highest death rates occurred among men with a history of regular cigarette smoking.

death rates
Urban & rural smokers

The most that can be said of this urban-rural analysis, considering the statistical sampling variation to which these figures are subject, is that essentially the same basic relationships are found in these two subgroups as was found in the entire population of 187,766 men. It may be possible to make a more detailed analysis of this kind after the men have been followed for a longer period of time.

ANALYSIS BY AMERICAN CANCER SOCIETY DIVISIONS

As previously described, this study is being conducted in 10 divisions of the American Cancer Society located in different parts of the country. We wished to test the consistency with which the findings held up in each of the divisions. The analysis could not be made in as great detail as for the entire population of 187,766 men because of the small numbers in many of the subgroups in individual divisions. In spite of the statistical instability resulting from small numbers, the results were remarkably consistent as illustrated by the following figures.

TABLE 8.—*Death Rates per 100,000 Population in Highly Urban Counties as Compared with Highly Rural Counties by Smoking History and by Age*

Age Group	Smoking History	Highly Urban Counties			Highly Rural Counties		
		No. of Men	No. of Deaths	Death Rate	No. of Men	No. of Deaths	Death Rate
50-54	Never smoked regularly*	2,342	21	897	1,800	22	1,222
	Pipes and/or cigars only†	1,966	20	1,017	737	8	1,085
	Cigarettes ‡	9,290	140	1,507	4,334	69	1,592
	Total	13,598	181	1,331	6,871	99	1,141
55-59	Never smoked regularly	2,186	35	1,601	2,071	26	1,255
	Pipes and/or cigars only	2,174	38	1,518	1,040	21	2,019
	Cigarettes	7,679	199	2,592	3,760	101	2,686
	Total	12,030	267	2,218	6,871	148	2,154
60-64	Never smoked regularly	1,775	35	1,972	1,836	44	2,397
	Pipes and/or cigars only	1,847	50	2,707	1,194	29	2,429
	Cigarettes	4,788	181	3,780	2,442	100	4,095
	Total	8,410	266	3,163	5,472	173	3,162
65-69	Never smoked regularly	1,315	79	6,008	1,590	68	4,277
	Pipes and/or cigars only	1,558	64	4,121	1,216	52	4,276
	Cigarettes	2,574	156	6,061	1,319	73	5,535
	Total	5,442	299	5,494	4,125	193	4,079

* Never smoked "combined with "occasional only."

† History of regular cigar or pipe smoking but no regular cigarette smoking.

‡ History of regular cigarette smoking with or without history of cigar or pipe smoking.

In all 10 divisions in age group 50 to 54, the death rate was lower among men who had never smoked than among men who were currently smoking a pack or more cigarettes a day. The same was true in all 10 divisions for age group 55 to 59.

In age group 60 to 64, the same was true in 9 of the 10 divisions. In the oldest age group, the usual relationship held in 7 of the 10 divisions.

ANALYSIS BY DATE OF DEATH

Death rates computed from these data are not directly comparable to death rates for the general population as reported by the National Office of Vital Statistics. There are several reasons for this.

The 187,766 men were questioned (and entered the study) over a period of five months, although the majority were questioned within a span of six weeks. This must be considered in any attempt to compare our findings with official mortality statistics.

Although the men were not screened by medical examination (as is given to life insurance applicants), the study group was to some degree a "preferred risk" population at the start of the study. The reason for this is that the volunteers ordinarily did not enroll men in the study who were seriously ill or dying at the time; therefore, the death rates were relatively low during the first few months.

Death rates in the United States are higher in winter than in summer. The entire group of 187,766 men studied were exposed to risk for at least 17 months (June 1, 1952, through Oct. 31, 1953), and the great majority of them were exposed to risk for at least 18 months (May 1, 1952, through Oct. 31, 1953). As a generalization, May through October might be called a low death rate period, while November through April might be called a high death rate period.

The fact that the majority of the men were exposed to risk during 12 low death rate months and only 6 high

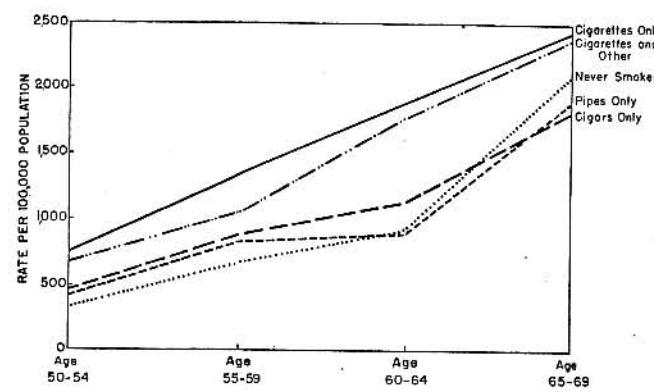


Fig. 3.—Graph showing death rates from coronary artery disease by smoking history and by age.

death rate months tended to make the over-all death rate lower than comparable figures based on exposure to risk during a single, complete calendar year.

In planning the study, we had anticipated that deaths that occurred during the first few months would have to be excluded from the analysis in order to avoid the theoretical possibility of a bias influencing the relationship between death rates and smoking habits. In order to test for this, we have made an analysis separately for deaths that occurred in each of three six month periods (May 1 through Oct. 31, 1952; Nov. 1, 1952, through April 30, 1953; and May 1 through Oct. 31, 1953), as well as the 387 deaths that occurred prior to May, 1952. In all four periods, regular cigarette smokers had higher death rates than men who had never smoked.

TABLE 9.—Deaths from Diseases of the Coronary Arteries and Death Rates per 100,000 Population by Type of Smoking (Lifetime History) and by Age at Time of Questioning

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Never smoked.....	32	349	63	689	69	886	131	2,084	246
Occasional only	14	429	18	399	33	1,139	44	1,923	104
Cigars only	17	483	37	801	41	1,117	56	1,802	151
Pipes only	10	431	25	811	29	868	63	1,884	127
Cigars and pipes.....	5	243	24	986	28	1,084	27	1,206	84
Cigarettes only	202	766	264	1,331	218	1,870	144	2,438	923
Cigarettes and cigars.....	15	529	32	1,121	37	1,873	33	2,450	117
Cigarettes and pipes.....	62	766	74	1,020	87	1,735	66	2,492	289
Cigarettes, cigars, and pipes.....	20	598	39	1,023	52	1,766	41	2,116	153
Total	377	618	571	1,023	594	1,419	606	2,079	2,147
Subtotals									
Noncigarette smokers (never smoked cigarettes regularly).....	78	384	162	784	200	986	321	1,859	761
Cigarettes and other.....	97	680	145	1,042	176	1,772	140	2,360	668
All regular cigarette smokers.....	299	736	409	1,212	394	1,825	284	2,399	1,588

TABLE 10.—Deaths from Diseases of the Coronary Arteries and Death Rates per 100,000 Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age*

Current Amount of Regular Cigarette Smoking at Time of Questioning	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Less than $\frac{1}{2}$ pack a day.....	26	589	34	769	43	1,345	46	2,171	149
$\frac{1}{2}$ to 1 pack a day.....	116	741	164	1,284	157	1,950	113	2,712	550
1 pack or more a day.....	98	856	117	1,477	75	1,772	44	2,329	334
Total	240	761	315	1,254	275	1,776	208	2,483	1,033
Never smoked.....	32	349	63	689	69	886	131	2,084	246

* Data on men who were not currently smoking cigarettes regularly at time of questioning are omitted from this table.

Because of this finding, it was decided to base the present report on all deaths that occurred through Oct. 31, 1953, instead of excluding deaths that occurred in the first few months. As a matter of fact, the relationships between cigarette smoking and death rates were greater in the last two six month periods than in the earlier periods. Had we excluded deaths that occurred before Nov. 1, 1952, the relationships between smoking habits and death rates would have been slightly greater than those shown in the figures and charts in this report.

DISEASES OF THE CORONARY ARTERIES

Photostatic copies or abstracts of the death certificates have so far been obtained for 4,710 (97%) of the 4,854 deaths reported. Disease of the coronary arteries was the primary cause of death as recorded on 2,147 (45.6%) of the death certificates. In this category, we included deaths reported by the physician as being due to coronary occlusion, coronary thrombosis, myocardial infarction, or arteriosclerotic heart disease.

Table 9 and figure 3 show the number of deaths and death rates from diseases of the coronary arteries by type of smoking and by age. Table 10 and figure 4 show the number of deaths and death rates from diseases of the coronary arteries by current amount of regular cigarette smoking at the time of questioning.

The findings for diseases of the coronary arteries in respect to regular cigarette smoking were essentially the same as for the deaths regardless of cause as previously described, except that the relationships are very much more pronounced. For example, the death rates for men who smoked a pack or more of cigarettes a day were

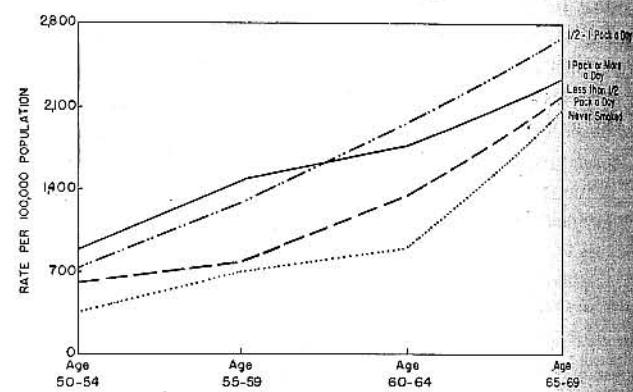


Fig. 4.—Graph showing death rates from coronary artery disease by current amount of cigarette smoking at time of questioning and by age.

and exactly twice as high in age group 60 to 64. These differences were statistically significant in each of the three age groups ($P = 0.00002$ or less). The difference

The group 65 to 69 was smaller and not statistically significant.

CANCER

Cancer was indicated as the primary cause of death on 844 death certificates. The relationships with smoking habits are shown on tables 11 and 12 and figures 5 and 6. In all four age groups, the cancer death rates were higher among men with a history of only regular cigarette smoking than among men who never smoked. The same can be said of men with a history of regular cigarette smoking who had also smoked cigars or pipes regularly. In the two older age groups, all four comparisons just mentioned are statistically significant ($P = 0.02$ or less). In the two younger age groups, one of the

cigarettes daily have significantly higher death rates from lung cancer than those who have never smoked regularly ($P = 0.03$ or less). The best estimate that can be made at the present time (at the 5% level of confidence) is that lung cancer deaths are from 3 to 9 times as common among men with a history of cigarette smoking as among men who have never smoked regularly and that lung cancer deaths are from 5 to 16 times as common among men who smoke one pack or more per day. Another year or two of follow-up must precede estimation of the degree of the effect with more precision.

An analysis has been made of death rates for cancer of each specific site. The number of deaths in these sub-categories is too small for the rates to be statistically

TABLE 11.—Deaths from Cancer (All Sites) and Death Rates per 100,000 Population by Type of Smoking (Lifetime History) and by Age at Time of Questioning

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Never smoked	14	158	25	274	22	283	37	589	98
Tobacco only	3	92	10	307	6	207	22	963	41
Cigars only	7	190	11	263	23	627	22	708	63
Pipes only	5	215	12	389	18	380	21	628	51
Cigars and pipes	4	195	7	288	14	542	14	626	39
Cigarettes only	66	250	101	509	99	849	68	1,161	334
Cigarettes and cigars	5	177	8	280	12	608	9	668	34
Cigarettes and pipes	22	272	34	469	31	618	25	914	112
Cigarettes, cigars, and pipes	8	239	15	394	27	917	22	1,135	72
Total	134	220	223	400	247	599	240	826	844
Subtotals									
Non-cigarette smokers (never smoked cigarettes regularly)	33	102	65	295	78	385	116	672	292
Cigarettes and other	35	245	67	470	70	706	56	944	218
All regular cigarette smokers	101	249	158	468	109	783	121	1,047	552

TABLE 12.—Deaths from Cancer (All Sites) and Death Rates per 100,000 Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age*

Current Amount of Regular Cigarette Smoking at Time of Questioning	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Less than $\frac{1}{2}$ pack a day	13	295	25	565	28	876	22	1,088	88
1 to 1 pack a day	35	224	52	407	62	770	40	960	189
1 pack or more a day	40	349	61	644	46	1,087	24	1,271	161
Total	88	279	128	510	130	879	86	1,052	438
Never smoked	14	158	25	274	22	283	37	589	98

*Data on men who were not currently smoking cigarettes regularly at time of questioning are omitted from this table.

Comparisons is statistically significant, and the other are approach borderline significance.

Of the 844 cancer deaths, 167 were indicated on the certificate as being due to primary cancer of the lung. We are attempting to obtain more information on basis of diagnosis for each of these cases, but this work has not yet been completed. So far, we have information that 57 were based on microscopic evidence, and of these 5 were specified as adenocarcinoma. The evidence presently at hand does not warrant presenting the findings in any greater detail than is shown in table 13.

The lung cancer death rate was higher among men with a history of regular cigarette smoking than among men who had never smoked regularly and even higher among men who currently smoked one pack or more of cigarettes a day at the time of questioning. The differences are statistically significant ($P = 0.002$ or less). In fact, even the men smoking less than one pack of

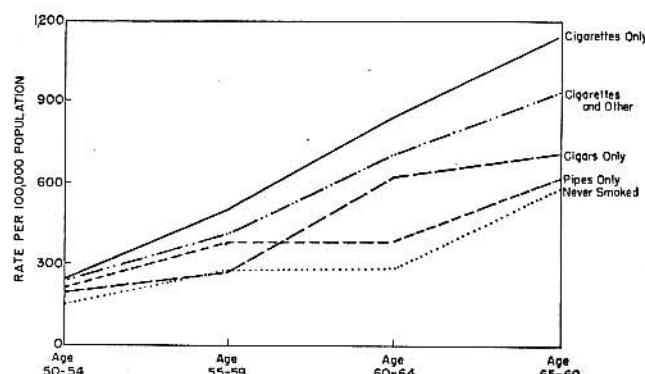


Fig. 5.—Graph showing death rates from cancer (all sites) by smoking history and by age.

stable. Nevertheless, the findings give the impression that, for most of the commoner sites of cancer among men, regular cigarette smokers have higher death rates than those who never smoked.

Tables 14 and 15 show the findings for cancer of all sites combined, after excluding lung cancer (fig. 7 and 8). In all four age groups, regular cigarette smokers had

TABLE 13.—*Lung Cancer Death Rates by Type of Smoking and by Amount of Cigarette Smoking at Time of Questioning*

Type of Smoking	Population	All Cases Reported as Primary Lung Cancer		Microscopically Proved Lung Cancer (Excluding Adeno-carcinoma)	
		No. of Deaths	Death Rate	No. of Deaths	Death Rate
Never smoked or occasional only	44,091	12	27.2	4	9.1
Cigar and/or pipe smoking but never smoked cigarettes regularly	35,853	12	33.5	3	8.4
History of regular cigarette smoking	107,822	148	132.6	45	41.7
Total	187,766	167	88.9	62	27.7
Regular cigarette smoking; less than 1 pack a day at time of questioning	54,799	62	113.1	17	31.0
Regular cigarette smoking; 1 pack or more a day at time of questioning	25,497	61	289.2	24	94.1

TABLE 14.—*Deaths from Cancer (Exclusive of Lung) and Death Rates per 100,000 Population by Type of Smoking (Lifetime History) and by Age at Time of Questioning*

Type of Smoking	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Never smoked	12	181	24	263	22	283	31	493	33
Occasional only	3	92	9	276	6	207	20	874	26
Cigars only	7	199	10	241	21	572	20	644	43
Pipes only	5	215	9	292	13	389	19	568	45
Cigars and pipes	4	195	6	247	14	542	13	581	57
Cigarettes only	44	167	68	343	75	643	50	847	227
Cigarettes and cigars	3	108	7	245	9	456	8	694	37
Cigarettes and pipes	17	210	23	317	26	519	21	793	57
Cigarettes, cigars, and pipes	6	179	10	262	22	747	20	1,082	63
Total	101	166	166	297	208	497	202	694	67
Subtotals									
Noneigarette smokers (never smoked cigarettes regularly)	31	152	58	263	76	375	103	597	28
Cigarettes and other	26	182	40	287	57	574	49	826	172
All regular cigarette smokers	70	172	108	320	132	611	99	886	49

a higher death rate than men who had never smoked. This difference is statistically significant in the two oldest age groups ($P = 0.0005$ and 0.01, respectively). In the age groups 60 to 64 and 65 to 69, the death rate among

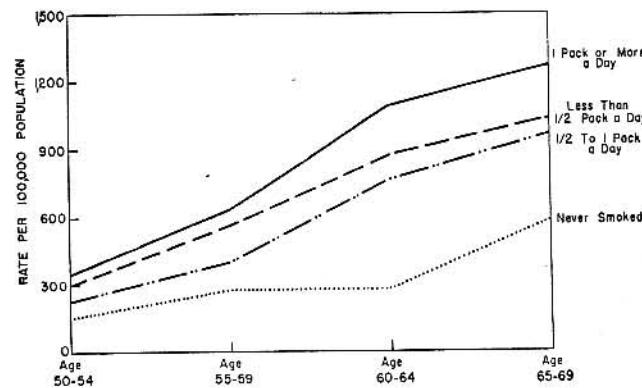


Fig. 6.—Graph showing death rates from cancer (all sites) by current amount of cigarette smoking at time of questioning and by age.

men who smoked a pack or more of cigarettes a day was more than twice as high as among men who had never smoked; both of these differences are statistically significant ($P = 0.001$ and 0.008, respectively).

We are attempting to obtain information on the basis of diagnosis of all deaths in which cancer was mentioned on the death certificate. This process has not yet been completed. However, we have made a preliminary analysis on cancer deaths known to us to have been verified

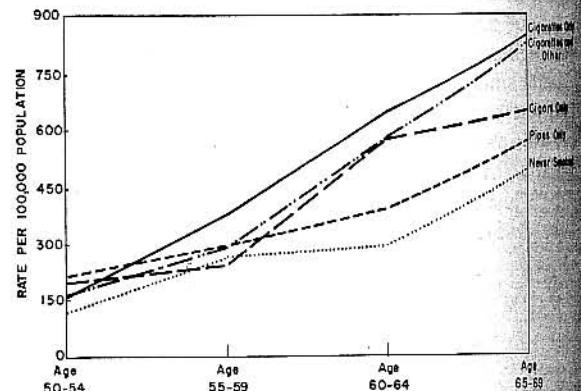


Fig. 7.—Graph showing death rates from cancer (exclusive of lung) and death rates per 100,000 population by type of smoking (lifetime history) and by age at time of questioning.

microscopically. In this group, the findings were essentially the same as those described above.

At the present time it is impossible to be sure of the relationship between regular cigar or pipe smoking and cancer death rates. The rates tend to be higher than those for men who have never smoked, especially in the older age groups. There are, however, too few deaths for even borderline significance, except when all ages are combined among cigar smokers and among heavy pipe smokers (10 pipefuls or more per day). It will require at least one more year of follow-up to evaluate this relationship properly.

OTHER CAUSES OF DEATH

There are no other specific causes of death for which we have enough data at this time to warrant making any statements. There were 1,863 deaths not specifically indicated as being primarily due to either cancer or diseases of the coronary arteries. This includes 144 deaths with no death certificate information available at the present time, as well as some with the cause of death stated as being uncertain.

In this group, death rates among regular cigarette smokers were appreciably higher than among men who never smoked. This may be due to an effect of smoking

specific diseases other than those already considered. However, at least a part of it is probably due to cases of coronary artery disease and cancer which have been included.

OBSERVED VERSUS EXPECTED DEATHS

In finding a high association between death rates and regular cigarette smoking, we were interested to know the degree to which various diseases were involved. Table 16 shows the figures that were computed for this purpose. The method of computation may be illustrated by the following example.

Interpreted as follows: 431 men with a history of regular cigarette smoking only in age group 50 to 54 actually died. Only 262 would have died had the death rate in this group been exactly the same as for men in age group 50 to 54 who never smoked.

The same procedure was carried out to obtain each pair of "observed" and "expected" figures in the body of table 16. The figures in the total column at the right of the table were obtained by summing the corresponding figures for each of the four age groups.

As has been previously described, many of the comparisons varied from one age group to another. How-

TABLE 15.—Deaths from Cancer (Exclusive of Lung) and Death Rates per 100,000 Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age*

Current Amount of Regular Cigarette Smoking at Time of Questioning	Age 50-54		Age 55-59		Age 60-64		Age 65-69		Total No. of Deaths
	No. of Deaths	Death Rate							
Less than $\frac{1}{2}$ pack a day	8	181	20	452	21	657	16	765	65
1 pack a day	29	185	38	298	52	646	31	744	150
1 pack or more a day	23	201	28	353	29	685	20	1,059	100
Total	60	190	86	342	102	659	67	820	315
Never smoked	12	131	24	263	22	283	31	493	89

Data on men who were not currently smoking cigarettes regularly at time of questioning are omitted from this table.

TABLE 16.—Expected* Versus Observed Number of Deaths by Cause Among Men with a History of Regular Smoking

History of Regular Smoking	Primary Cause of Death	Observed Versus Expected No. of Deaths								Total	
		Age 50-54		Age 55-59		Age 60-64		Age 65-69			
		Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected		
Cigarette only	Total	431	262	550	343	564	250	342	264	1,827	
	Coronary †	202	92	264	137	218	103	144	123	828	
	Cancer	66	40	101	54	99	33	68	35	334	
	Other ‡	103	130	185	152	187	114	130	106	665	
Cigarette plus cigar and/or pipe	Total	216	142	307	211	351	213	301	265	1,175	
	Coronary	97	50	145	90	176	88	140	124	558	
	Cancer	35	22	57	38	70	28	56	35	218	
	Other	84	70	105	107	105	97	105	106	399	
Cigar and/or pipe (never cigarette)	Total	81	78	185	167	249	206	371	388	886	
	Coronary	32	28	86	67	98	85	146	181	302	
	Cancer	16	12	30	26	50	27	57	51	153	
	Other	33	38	60	74	101	94	168	156	371	
Total with history of regular smoking of any type	Total	728	482	1,042	751	1,104	609	1,014	917	3,888	
	Coronary	331	170	495	300	492	276	430	428	1,748	
	Cancer	117	74	188	118	219	88	181	121	705	
	Other	280	238	350	333	398	305	403	368	1,435	
Cigarettes, 1 pack or more a day	Total	218	114	249	187	182	91	90	84	745	
	Coronary	98	40	117	55	75	37	44	39	384	
	Cancer	40	18	51	22	46	12	24	11	161	
	Other	80	56	81	60	61	42	28	34	250	

*Calculated by applying death rate of men who had never smoked to number of regular smokers exposed to risk.

†Diseases of the coronary arteries.

‡Cases in which the cause of death is unknown to us at the present time are also included in this category.

In age group 50 to 54, there were 26,365 men with a history of regular cigarette smoking only, of whom 431 were "observed" to have died (tables 3 and 4). This "observed" number of 431 deaths is entered in the box in the upper left hand corner of table 16 under "observed." In the same age group, there were 9,170 men who had never smoked, and of these 91 died, giving a death rate of 992 per 100,000 population (or 0.992%). Applying the death rate of the group that never smoked to the number of men with a history of regular cigarette smoking only gives an "expected" number of 262 deaths ($9,170 \times 0.992 = 262$). This expected number is entered in the box just to the right of the "observed" number of 431 in table 16. These figures may be in-

ever, for the sake of simplicity, the following discussion of these figures will be limited to a consideration of the combined totals for the four age groups.

Consider first the men who were currently smoking one pack of cigarettes or more a day at the time of questioning (fig. 9). The expected total number of deaths in this group was 426, whereas 745 deaths actually occurred. The difference is $745 - 426 = 319$ deaths, or an excess of 75% above the expected number ($P < 0.000000001$). For diseases of the coronary arteries, the difference was $334 - 171 = 163$ deaths, or 95% above expected. ($P < 0.000000001$). For cancer, the difference was $161 - 63 = 98$ deaths, or 156% above expected ($P < 0.000000001$). For all other and

unknown causes of death, the difference was 250 — 192 = 58 deaths, or 30% above expected ($P = 0.01$).

The total excess of 319 deaths is distributed by causes as follows: diseases of the coronary arteries 163 (51%); cancer 98 (31%); other and unspecified causes 58 (18%). Some of the deaths for which we have no death certificate at the present time were undoubtedly due to cancer or diseases of the coronary arteries, and one or

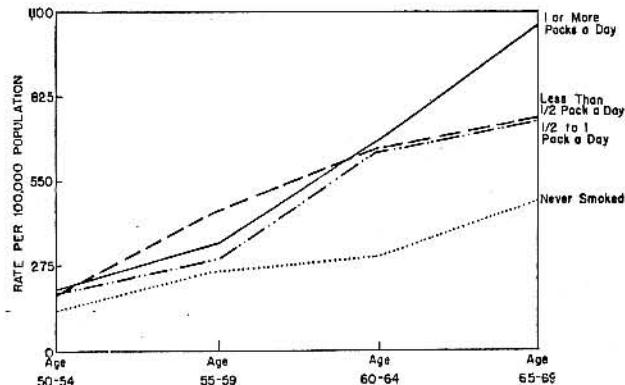


Fig. 8.—Graph showing death rates from cancer (exclusive of lung) by current amount of cigarette smoking at time of questioning and by age.

the other of these two diseases was a contributing factor in some deaths that were ascribed as being primarily due to other causes.

Among all men with a history of regular cigarette smoking only, the expected number of deaths was 1,119, the observed number was 1,827, and the excess was 1,827 — 1,119 = 708 deaths. The 708 excess deaths were distributed by cause as follows: diseases of the coronary arteries 375 (53%); cancer 172 (24%); and other and unspecified 163 (23%). Among men with a history of having smoked cigarettes regularly and also having smoked cigars and/or pipes regularly, the excess in expected over observed deaths was 1,175 — 861 = 314 deaths. The distribution by cause was diseases of the coronary arteries 200 (64%); cancer 95 (30%); and other and unspecified 19 (6%).

Clearly, over half of the excess in observed over expected deaths for regular cigarette smokers is attributable to diseases of the coronary arteries and a very large part of the remainder is attributable to cancer. From the data at present available, it is impossible to say for certain whether any other specific diseases are involved.

Next consider men with a history of regular cigar and/or pipe smoking who never smoked cigarettes regularly. The observed number of deaths was 886 compared with an expected number of 839, or an excess of only 47 deaths (6%). Of these 47 excess deaths, 37 are attributable to cancer for which the observed number of deaths was 32% higher than the expected number. This excess is statistically significant at the 0.04 level of significance.

One other fact, not shown in table 16, is worthy of mention at this point. Among all men with a history of regular cigarette smoking, the observed number of can-

cer deaths was 552 as compared with an expected number of 285 giving an excess of 267 deaths. For lung cancer the excess was 143 observed — 24 expected = 119 deaths. Thus, of the total excess attributable to cancer, 45% was attributable to lung cancer and 55% was attributable to cancer of other sites.

COMMENT

The following statements can be made about white men who were between the ages of 50 and 69 in the first half of 1952. Death rates from diseases of the coronary arteries and from cancer are much higher among men with a history of regular cigarette smoking than among men who never smoked. Death rates from these two causes are also much higher among men with a history of regular cigarette smoking than among men with a history of having smoked cigars and/or pipes regularly but of never having smoked cigarettes regularly. This proves that an association exists. The question now arises as to whether the association is due to a cause and effect relationship between regular cigarette smoking and death rates from these two diseases. For this, it is pertinent to examine other independent evidence relating to the subject. At the start we should say that no single piece of this other evidence is conclusive in itself. Therefore, we must consider the separate pieces in relationship to each other. If they form a reasonable pattern that is consistent with the hypothesis that the relationship is one of cause and effect, then this hypothesis should be accepted unless and until even better proof is presented in support of some alternative hypothesis that is consistent with all of the known facts. In 1928, Lombard and Doering¹ made an analysis of records collected by the Visiting Nurse Association and found heavy smoking to be commoner among cancer patients than among persons in the control group.

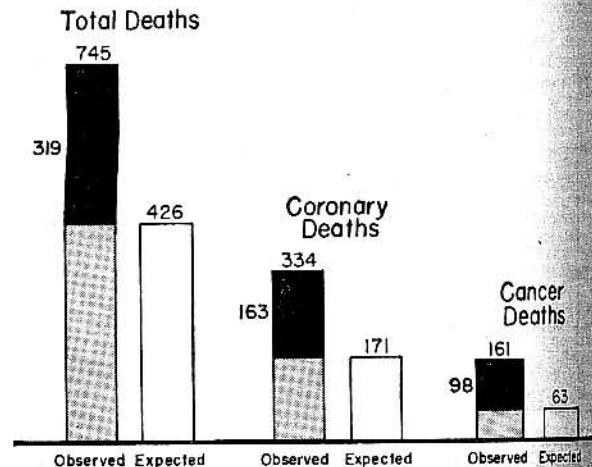


Fig. 9.—Graph showing effect of smoking one pack of cigarettes or more a day.

1938, Pearl² reported that, among men in the middle age groups, the life expectancy was greater among non-users of tobacco than among heavy smokers. The closing paragraph of his paper is worth quoting here: "However envisaged, the net conclusion is clear. In this sizable material the smoking of tobacco was statistically associated with an impairment of life duration, and the amount or degree of this impairment increased as the

1. Lombard, H. L., and Doering, C. R.: Cancer Studies in Massachusetts: 2. Habits, Characteristics and Environment of Individuals With and Without Cancer, *New England J. Med.* 295: 481-487, 1928.

2. Pearl, R.: Tobacco Smoking and Longevity, *Science* 87: 216-217, 1938.

actual amount of smoking increased. Here, just as is usually the case in our experience in studies of this sort, the differences between the usage groups in specific mortality rates, as indicated by q_x , practically disappear from about age 70 on. This is presumably an expression of the residual effect of the heavily selective character of mortality in the earlier years in the groups damaged by the agent (in this case tobacco). On this view those individuals in the damaged groups who survive to 70 or thereabouts are such tough and resistant specimens that thereafter tobacco does them no further measurable harm as a group."

Acting on the lead provided by the findings of Lombard and Doering, the Massachusetts State Health Department obtained information on the use of tobacco among 2,927 men over 40 who visited a cancer clinic.³ They found a definite association between the use of tobacco and cancer of the buccal cavity as well as cancer of the lung. The report of their findings was published in 1945.

In 1950, four independent groups of investigators reported finding a higher percentage of heavy cigarette smokers among lung cancer patients than among control groups. Since that time, a number of other investigators have reported similar findings. The results of these studies, which were conducted by the so-called "historic method," were recently summarized by Wynder.⁴ Elsewhere⁵ we have discussed the advantages and disadvantages of the historic method as compared with the follow-up method used in this investigation.

Now let us consider trends in the use of tobacco. The consumption of cigarettes⁶ in the United States rose from 630 per person 15 years of age and over in 1920 to 1,500 in 1953. This was a 456% increase in 33 years. In terms of weight, 1.89 lb. (857.28 gm.) of tobacco per person 15 years of age and over were smoked in cigarettes in 1920 as compared with 10.5 lb. (4,762.7 gm.) in 1953. During the same period of time, the consumption of smoking, chewing, and snuff tobacco declined from 133 lb. (1,954.04 gm.) to 1.19 lb. (539.77 gm.) per adult per year, and the consumption of cigar tobacco declined from 2.45 lb. (1,111.29 gm.) to 1.25 lb. (566.99 gm.).

Next let us consider trends in age standardized death rates among white men living in the United States. The overall rate, as well as the death rate from most diseases, declined from 1930 to 1948. Very few diseases showed an increase during this period of time.⁷ The only two that showed a very great increase were lung cancer and diseases of the coronary arteries. Rates for lung cancer rose from 5.3 per 100,000 in 1930 to 27.1 per 100,000 in 1948, an increase of 411%. Death rates from diseases of the coronary arteries among white men in the United States rose from 61.1 per 100,000 in 1930 to 235.6 in 1948, an increase of 286%. Because of changing definitions and methods of classifying causes of death, it is difficult to ascertain the exact extent of the increase in death rates from diseases of the coronary arteries. A full discussion of this problem is given in another paper.⁸ In spite of indications that improvements have been made in cancer cure rates, the standardized death rates for cancer, other than lung cancer, among white men rose from 152.1 in 1930 to 165.2 in 1948.

Several years ago, some persons contended that the apparent rise in lung cancer death rates was merely the result of improvements in diagnosis and reporting. It is now generally accepted that the increase actually occurred.⁹ The National Cancer Institute¹⁰ has presented evidence that suggests that there has been a real rise in incidence rates from a number of sites of cancer. One of us¹¹ has recently written a more detailed discussion of some of the implications in changing death rates from various causes in relation to the problem at hand.

A number of investigators¹² have presented evidence that cigarette smoking causes vasoconstriction as well as an increase in the heart rate and an increase in blood pressure. Wynder, Graham, and Croninger¹³ have produced skin cancer in mice by the application of material condensed from cigarette smoke.

In Norway, it was difficult to obtain cigarettes during the time of the German occupation. No accurate data is available on cigarette consumption in Norway during the war years, but some idea of the trends is given by the following figures. The per capita consumption of cigarettes was 310 in 1939, 180 in 1945 (the year the war ended), 410 in 1946, and 470 in 1948.¹⁴ Strøm and Jensen¹⁴ have reported death rates from circulatory diseases in Norway during 1943-1945 (the latter part of the war period) and 1946-1948 (the early postwar years) as compared with the prewar period 1938-1940. They included in the general category of "arteriosclerosis" most of those deaths that we would have classified as caused by diseases of the coronary arteries. The death rates started to decrease soon after the beginning of the war and by the latter part of the war years they had dropped to 57% of the prewar figure in age group 40 to 59 and to 52% of the prewar figure in age group 60 to 79. After the war, the death rates started to increase. Within a few years (1946-1948), the rates had risen to 71% of the prewar figure in age group 40 to 59 and to 57% of the prewar figure in age group 60 to 79. It should be noted that the hypothesis has been advanced that the changes in death rates in Norway were due to changes in dietary factors.

Official figures based on death certificates (as reported by the National Office of Vital Statistics) seem to indicate that death rates from both cancer and heart diseases are higher in urban areas than rural areas in the United

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States. Some doubt has been expressed as to whether this finding can be taken at face value. Be that as it may, in this study we found a higher percentage of regular cigarette smokers and a lower percentage of men who had never smoked in urban counties than in rural counties.

If the same factor tends to increase death rates from two different diseases, then one should not be surprised to find associations of various sorts between the two diseases or symptoms related to the diseases. For example, a study conducted by the Society of Actuaries¹⁵ revealed that, among persons with a high pulse rate, the number of deaths from cancer (all sites) was about 60% above expected and the number of deaths from lung cancer was about 150% above expected. There were similar findings among persons with significant heart murmurs.

Death rates from lung cancer and from diseases of the coronary arteries are higher among males than among females. Furthermore, death rates from both of these diseases have been increasing more rapidly among males than among females. The reasons for this are not clear. It may be that it is due to a constitutional difference of some sort between the two sexes. There is evidence¹⁶ that cigarette smoking started as an almost universal habit among men many years before the women took up the habit to the same degree. There is also evidence that fewer women than men are heavy smokers in the older age groups in which the majority of deaths from these two diseases occur.

The theory has been advanced that the increase in air pollution may account for both the rise in lung cancer death rates and the urban-rural difference in rates. One of us¹⁷ has pointed out that there may be some merit in this hypothesis. It may well be that air pollution is a contributing factor. If so, the full effect may not be apparent for another decade or two. However, it does not explain the observed association between smoking habits and death rates from cancer in rural as well as in urban areas.

All of the evidence we have seen seems to be consistent with the hypothesis that the association between smoking habits and death rates from lung cancer and diseases of the coronary arteries results from a cause and effect relationship. We know of no alternative hypothesis that is consistent with all of the known facts. It is our opinion, therefore, that regular cigarette smoking causes an increase in death rates from these two diseases. More information is needed before we can make the same statement regarding other specific sites of cancer with the same degree of confidence.

The question arises as to what agent or agents in cigarette smoke produce these effects. Probably nicotine is at least partially responsible for the findings in relation to diseases of the coronary arteries. Other than this, we would not hazard a guess on the subject at present.

SUMMARY AND CONCLUSIONS

It was found that men with a history of regular cigarette smoking have a considerably higher death rate than men who have never smoked or men who have smoked

only cigars or pipes. A total of 3,002 deaths occurred among men with a history of regular cigarette smoking. If they had died at the same rate as men who never smoked, only 1,980 would have died. In other words 1,022 additional deaths (52% more than expected) occurred among men with a history of regular cigarette smoking. This finding was based on a study of 187,766 white men between the ages of 50 and 69. Death rates increase with amount of cigarette smoking. A total of 745 deaths occurred among men who were currently smoking a pack or more of cigarettes a day at the time they were questioned. Only 426 of them would have died if their death rates had been the same as for men who never smoked. That is to say, an additional 319 deaths (75% more than expected) occurred among men who were smoking a pack or more of cigarettes a day at the start of the study.

Disease of the coronary arteries was indicated as the primary cause of death of 2,147 men, 45.6% of those for whom death certificate information was available. The findings in respect to cigarette smoking were about the same as for the over-all death rate, except that the relationship was much more pronounced. Approximately 56% of the total effect of regular cigarette smoking on the over-all death rate may be attributed to the effect of cigarette smoking on deaths primarily caused by disease of the coronary arteries.

Cancer was indicated as the primary cause of death of 844 men, 18% of those for whom death certificate information was available. Deaths from cancer were definitely associated with regular cigarette smoking, the effect being particularly marked in the older age groups. Approximately 26% of the total effect of cigarette smoking on the over-all death rate may be attributed to the effect of cigarette smoking on deaths from cancer. The findings suggest that there may also be a relationship between cigar and pipe smoking and cancer death rates. At least another year of follow-up will be required before this relationship can be properly evaluated.

Of the 844 deaths from cancer, 167 were indicated on the death certificates as being due to lung cancer. The death rate from lung cancer was much higher among men with a history of regular cigarette smoking than among men who never smoked regularly. Regular cigarette smokers had a higher death rate from cancer of sites other than lung cancer than did men who never smoked.

These findings prove that there is a definite association between smoking habits and death rates, at least in white men between the ages of 50 and 69. Most of the over-all association is accounted for by an association between regular cigarette smoking and death rates from cancer and from diseases of the coronary arteries, although it is possible that some other diseases may also be involved. For reasons discussed, we are of the opinion that the associations found between regular cigarette smoking and death rates from diseases of the coronary arteries and between regular cigarette smoking and death rates from lung cancer reflect cause and effect relationships. More information is needed before we can make the same statement regarding other specific sites of cancer with the same degree of confidence.

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