THE RELATIONSHIP BETWEEN HUMAN SMOKING HABITS AND DEATH RATES

A FOLLOW-UP STUDY OF 187,766 MEN

E. Cuyler Hammond, Sc.D.
and
Daniel Horn, Ph.D., New York

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

From the Statistical Research Section, Medical and Scientific Department, American Cancer Society, New York.

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., Rosemary L. Percy, M.S., and Leonard Cohn, 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.
Page 3

CIGAR SMOKING

MORE THAN 3 TO 5 CIGARS SMOKED DURING YOUR LIFETIME? COMPLETE THIS PAGE ON CIGAR SMOKING HABIT)

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

   None
   Sables cigars once in a while but not every day
   Regularly smoke 1 to 5 cigars a day
   Regularly smoke 6 to 10 cigars a day
   Regularly smoke 1 to 5 cigars a day
   Regularly smoke 6 to 10 cigars a day
   Regularly smoke 11 or more cigars a day

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

   Enter Yes
   Enter Age
   Enter Years

3. How many years altogether have you, or did you, smoke cigars?

   No. of Years

4. Thinking back over the years you smoked, for how many of those years did you smoke cigars
   essentially, but not every day?

   Enter

5. For how many of those years did you regularly smoke 1 to 5 cigars a day?

   Enter

6. For how many of those years did you regularly smoke 6 to 10 cigars a day?

   Enter

7. For how many of those years did you regularly smoke 11 or more cigars a day?

   Enter

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

   Enter

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 do you do? (Check One)

   None
   Smoke a pipe once in a while but not every day
   Regularly smoke a pipe but less than 5 pipes a day
   Regularly smoke from 5 to 10 pipes a day
   Regularly smoke from 10 to 20 pipes a day
   Regularly smoke 20 or more pipes a day

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

   Enter

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

   Enter

4. For how many years altogether have you, or did you, smoke a pipe?

   No. of Years

5. Thinking back over the years you smoked, for how many of those years did you smoke a pipe
   essentially, but not every day?

   Enter

6. For how many of those years did you regularly smoke 1 to 5 pipes a day?

   Enter

7. For how many of those years did you regularly smoke 6 to 10 pipes a day?

   Enter

8. For how many of those years did you regularly smoke 11 to 20 pipes a day?

   Enter

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

   Enter

Total

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

PROCEDURES

The hundred ninety-four counties were selected as 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 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-
man, county chairman, and division office personnel made an attempt to trace all men who 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 anywhere on the death certificate, an attempt was made to obtain further details.

### Table 3—Distribution of Population by Type of Smoking (Lifetime History) and by Age

<table>
<thead>
<tr>
<th>Type of Smoking</th>
<th>Age 50-59</th>
<th>Age 60-69</th>
<th>Age 70-79</th>
<th>Age 80-89</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never smoked</td>
<td>3,195</td>
<td>3,135</td>
<td>2,086</td>
<td>991</td>
<td>9,307</td>
</tr>
<tr>
<td>Occasionally only</td>
<td>2,241</td>
<td>3,476</td>
<td>1,441</td>
<td>444</td>
<td>7,662</td>
</tr>
<tr>
<td>Cigarette only</td>
<td>3,107</td>
<td>3,475</td>
<td>1,440</td>
<td>445</td>
<td>7,548</td>
</tr>
<tr>
<td>Pipe only</td>
<td>2,575</td>
<td>2,683</td>
<td>1,020</td>
<td>326</td>
<td>6,594</td>
</tr>
<tr>
<td>Cigarettes and pipes</td>
<td>2,474</td>
<td>2,578</td>
<td>1,009</td>
<td>320</td>
<td>6,481</td>
</tr>
<tr>
<td>Total</td>
<td>11,139</td>
<td>11,204</td>
<td>6,599</td>
<td>2,303</td>
<td>31,264</td>
</tr>
<tr>
<td>Subtotals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noncigarette smokers (never smoked cigarettes regularly)</td>
<td>3,290</td>
<td>3,753</td>
<td>2,067</td>
<td>967</td>
<td>9,277</td>
</tr>
<tr>
<td>Cigarette smokers</td>
<td>7,849</td>
<td>7,451</td>
<td>4,532</td>
<td>1,336</td>
<td>18,188</td>
</tr>
<tr>
<td>All regular cigarette smokers</td>
<td>11,139</td>
<td>11,204</td>
<td>6,599</td>
<td>2,303</td>
<td>31,264</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of Smoking</th>
<th>Age 50-59</th>
<th>Age 60-69</th>
<th>Age 70-79</th>
<th>Age 80-89</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never smoked</td>
<td>312</td>
<td>530</td>
<td>375</td>
<td>260</td>
<td>1,477</td>
</tr>
<tr>
<td>Occasionally only</td>
<td>372</td>
<td>532</td>
<td>428</td>
<td>265</td>
<td>1,697</td>
</tr>
<tr>
<td>Cigarette only</td>
<td>351</td>
<td>490</td>
<td>347</td>
<td>270</td>
<td>1,258</td>
</tr>
<tr>
<td>Pipe only</td>
<td>268</td>
<td>301</td>
<td>191</td>
<td>130</td>
<td>790</td>
</tr>
<tr>
<td>Cigarettes and pipes</td>
<td>249</td>
<td>307</td>
<td>202</td>
<td>130</td>
<td>788</td>
</tr>
<tr>
<td>Cigarettes and cigars</td>
<td>239</td>
<td>255</td>
<td>194</td>
<td>120</td>
<td>708</td>
</tr>
<tr>
<td>Total</td>
<td>1,431</td>
<td>1,855</td>
<td>1,256</td>
<td>820</td>
<td>5,552</td>
</tr>
<tr>
<td>Subtotals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noncigarette smokers (never smoked cigarettes regularly)</td>
<td>394</td>
<td>534</td>
<td>375</td>
<td>260</td>
<td>1,663</td>
</tr>
<tr>
<td>Cigarette smokers</td>
<td>1,037</td>
<td>1,321</td>
<td>1,001</td>
<td>660</td>
<td>4,019</td>
</tr>
<tr>
<td>All regular cigarette smokers</td>
<td>1,431</td>
<td>1,855</td>
<td>1,256</td>
<td>820</td>
<td>5,552</td>
</tr>
</tbody>
</table>

*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 28 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 192,174 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 (2.5%) 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 checked "yes" for the same question, but said that in their entire lives they had 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 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 type of smoking they had done regularly. If a man said that
I smoked one type regularly, occasional smoking of another type was disregarded. This classification was based on the lifetime history: "cigarette only"; "cigarette and pipe"; "cigarette, cigar, and pipe"; "cigarette 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 60 to 69 reported that they had never smoked as compared with only 15% of the men in the age group 50 to 54. Only 40.7% of the men in age group 65 to 69 had 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, 1933, by the number of men in the corresponding age-smoking-habit group, the median period of exposure to death 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 lower 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; 50% 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 only were higher than in the never smoked category, although they were somewhat lower than in the cigarettes only category. The difference in rates between 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 in men who had never smoked. The difference is statistically 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 smoking 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 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.
1320 SMOKING AND DEATH RATES—HAMMOND AND HORN
J.A.M.A., Aug. 7, 181

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

<table>
<thead>
<tr>
<th>Table 5.—Distribution of Population by Current Amount of Regular Cigarette Smoking at Time of Questioning and by Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Amount of Regular Cigarette Smoking at Time of Questioning</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Less than 1/2 pack a day</td>
</tr>
<tr>
<td>1/2 to 1 pack a day</td>
</tr>
<tr>
<td>1 pack or more a day</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Never smoked</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Table 6.—Total Deaths and Death Rates per 100,000 Population by Current Amount of Regular Cigarette Smoking and by Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Amount of Regular Cigarette Smoking at Time of Questioning</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Less than 1/2 pack a day</td>
</tr>
<tr>
<td>1/2 to 1 pack a day</td>
</tr>
<tr>
<td>1 pack or more a day</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Never smoked</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Table 7.—Percentage Distribution of Population by Type of Smoking (Lifetime History) and by Age in Highly Urban Counties Compared with Highly Rural Counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Smoking</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Never smoked</td>
</tr>
<tr>
<td>Occasional only</td>
</tr>
<tr>
<td>Cigarettes only</td>
</tr>
<tr>
<td>Cigarettes, cigars, and pipes</td>
</tr>
<tr>
<td>Cigarettes and cigars</td>
</tr>
<tr>
<td>Cigarettes and pipes</td>
</tr>
<tr>
<td>Cigarettes, cigars, and pipes</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Subtotals</td>
</tr>
<tr>
<td>All men with history of regular cigarette smoking</td>
</tr>
<tr>
<td>1 or more packs of cigarettes a day</td>
</tr>
</tbody>
</table>

urban, countries 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, Det-
troit, Syracuse, N. Y., Buffalo, Rochester, N. Y., etc.
The highly rural areas included places such as Bayfield
County, Wisconsin; Mille Lacs County, Minnesota;
Macomb 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 ques-
tioned in (and presumably lived in) highly rural counties,
and 39,489 of the men were questioned in (and pre-
sumably 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 high-
urban counties. Table 7 shows the distribution of pop-
ulation in these two groups by type of smoking and age.
In every age group, a larger percentage of men in the
rural counties had never smoked and a smaller per-
centage had a history of regular cigarette smoking but
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 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 coun-
ties the highest death rates occurred among men with a
history of regular cigarette smoking.
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 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 the 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 and figure 3 show the number of deaths and death rates from the disease 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 disease 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 somewhat more pronounced. For example, the death rates for men who smoked a pack or more of cigarettes a day were more than twice as high as the death rates of men who had never smoked in age groups 50 to 54 and 55 to 59.

![Graph showing death rates from coronary artery disease by current amount of cigarette smoking at time of questioning.](image)

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.
group 65 to 69 was smaller and not statistically
relevant.

CANCER

cancer was indicated as the primary cause of death in 44 death certificates. The relationships with smoking are shown on tables 11 and 12 and figures 5 and 6. In all four age groups, the cancer death rates among men with a history of regular cigarette smoking are higher than among men who never smoked. This can be said of men with a history of regular cigarette smoking who had also smoked cigars or pipes in the two older age groups, all four groups just mentioned are statistically significant (P = 0.002 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 subcategories 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

<table>
<thead>
<tr>
<th>Type of Smoking</th>
<th>Age 30-54</th>
<th>Age 55-69</th>
<th>Age 60-64</th>
<th>Age 65-69</th>
<th>Total No. of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarette only</td>
<td>14</td>
<td>168</td>
<td>93</td>
<td>50</td>
<td>258</td>
</tr>
<tr>
<td>Cigarette and pipe only</td>
<td>3</td>
<td>22</td>
<td>7</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>Cigarette and pipe and cigars</td>
<td>7</td>
<td>21</td>
<td>12</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Cigarette and pipe, and other</td>
<td>4</td>
<td>24</td>
<td>18</td>
<td>14</td>
<td>46</td>
</tr>
<tr>
<td>Cigarette smokers (never smoked cigarettes regularly)</td>
<td>8</td>
<td>17</td>
<td>6</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Cigar</td>
<td>16</td>
<td>13</td>
<td>12</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>Pipe</td>
<td>22</td>
<td>37</td>
<td>18</td>
<td>11</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>230</td>
<td>112</td>
<td>69</td>
<td>445</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Current Amount of Regular Cigarette Smoking at Time of Questioning</th>
<th>Age 30-54</th>
<th>Age 55-69</th>
<th>Age 60-64</th>
<th>Age 65-69</th>
<th>Total No. of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every day</td>
<td>12</td>
<td>205</td>
<td>93</td>
<td>50</td>
<td>258</td>
</tr>
<tr>
<td>Every other day</td>
<td>36</td>
<td>214</td>
<td>12</td>
<td>2</td>
<td>143</td>
</tr>
<tr>
<td>Every week</td>
<td>14</td>
<td>184</td>
<td>18</td>
<td>14</td>
<td>133</td>
</tr>
<tr>
<td>Curtains</td>
<td>12</td>
<td>205</td>
<td>93</td>
<td>50</td>
<td>258</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>230</td>
<td>112</td>
<td>69</td>
<td>445</td>
</tr>
</tbody>
</table>

The data for men who were current smoking cigarette regularly at time of questioning are omitted from this table.

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 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 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).

![Graph showing death rates from cancer (all sites) by current amount of cigarette smoking at time of questioning and by age.](image)

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

We are attempting to obtain information on the time 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 fatal 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 oldest age groups. There are, however, too few deaths and the borderline significance, except when all age groups 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 definite statements. There were 1,863 deaths not specifically indicated as being primarily due to either cancer or the cases of the coronary arteries. This includes 1,494 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 cigar 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 con-
cluded. However, at least a part of it is probably due
to diseases of coronary artery disease and cancer
been included.

OBSERVED VERSUS EXPECTED DEATHS

Finding a high association between death rates
and cigarette smoking, we were interested in the
to the degree to which various diseases were involved.
It shows the figures that were computed for this
The method of computation may be illustrated following example.

5.- 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^2

<table>
<thead>
<tr>
<th>Age Group</th>
<th>No. of Deaths</th>
<th>Death Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-54</td>
<td>30</td>
<td>110</td>
</tr>
<tr>
<td>55-64</td>
<td>45</td>
<td>152</td>
</tr>
<tr>
<td>65-74</td>
<td>60</td>
<td>220</td>
</tr>
</tbody>
</table>

Interpreted as follows: 431 men with a history of regular
male 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 com-
parisons varied from one age group to another. How-

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 ques-
tioning (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 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 cigarette smoke 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 cancer 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 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 cause and effect relationship between regular cigarette smoking and death rates from these two diseases. In this, it is pertinent to examine other independent evidence relating to the subject. At the start we shall say that no single piece of this other evidence is exclusive in itself. Therefore, we must consider the several 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 the hypothesis should be accepted unless and until better proof is presented in support of some alternate hypothesis that is consistent with all of the known facts. In 1928, Lombard and Doering 2 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.


1938, Pearl 2 reported that, among men in the highest age groups, the life expectancy was greater among users of tobacco than among heavy smokers. The following paragraph of his paper is worth quoting here: "However envisaged, the net conclusion is clear. In this mass material the smoking of tobacco was statistically associated with an impairment of life duration, and the amount or degree of this impairment increased with..."
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. The National Cancer Institute has presented evidence that suggests that there has been a real rise in incidence rates from a number of sites of cancer. One of us 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 investigators 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 Croninger 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. Strom and Jensen 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 “arteriosclerotic” 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 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 States. 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. Elsewhere, we have discussed the advantages and disadvantages of the historic method as compared with the method used in this investigation.

We let consider trends in the use of tobacco. The consumption of cigarettes in the United States rose from 450 per person 15 years of age and over in 1920 to 650 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 chewing, snuff tobacco declined from 1 lb. (1,954.04 gm.) to 1.19 lb. (539.77 gm.) per person per year, and the consumption of cigar tobacco declined from 2.45 lb. (1,112.29 gm.) to 1.25 lb. (558.99 gm.) per year.

We let consider trends in age standardized death rates among white men living in the United States. The age at death, as well as the death rate from most diseases, rose from 1930 to 1948. Very few diseases showed a decrease during this period of time. The only two that showed a very great increase were lung cancer and disease of the coronary arteries. Rates for lung cancer rose from 53 per 100,000 in 1930 to 271 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 diagnostic methods of classifying causes of death, it is difficult to ascertain the extent of the increase in deaths from diseases of the coronary arteries. A discussion of this problem is given in another paper. Indications that improvements have been made in cancer cure rates, the standardized death rates of cancer other than lung cancer, among white men were 152.1 in 1930 to 165.2 in 1948.

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 Actuaries 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 evidence 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.

4. 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 us has pointed out that this is a significant factor in this hypothesis. It may be that air pollution is a contributing factor. If so, the full extent of the 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 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 only cigars or pipes. A total of 3,002 deaths occurred among men with a history of regular cigarette smoking. Of these, 1,980 died at the same age as men who had never smoked, only 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 by the time they were questioned. Only 426 of them had died if their death rates had been the same as in 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 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 whom death certificate information was available. The findings in respect to cigarette smoking were about the same as for the overall death rate, except that the relationship was much more pronounced. Approximately 56% of the total effect of regular cigarette smoking on the overall 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, this being particularly marked in the older age group. Approximately 26% of the total effect of cigarette smoking on the overall death rate may be attributed to the effect of cigarette smoking on deaths from cancer. The failure to suggest that there may also be a relationship between cigar and pipe smoking and cancer death rates after another year of follow-up was required before the relationship can be properly evaluated.

Of the 844 deaths from cancer, 167 were indicated by 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 the larynx 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 men between the ages of 50 and 69. Most of the overall 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.

47 Beaver St. (Dr. Hammond).