CIGARETTE SMOKING AND LIFE EXPECTANCY

BY

J. L. HAYBITTLE

From the Radiotherapeutic Centre, Addenbrooke's Hospital, Cambridge

Statistical relationships between smoking and death-rates may be expressed in a number of different ways, the two most common being either in terms of mortality ratios, *i.e.* the ratio of the death rate from any particular cause in smokers to the death rate from the same cause in non-smokers, or in terms of the differences between the numbers of deaths from various causes in smokers and non-smokers. The relative merits of these two approaches have been the subject of some controversy (Cornfield, Haenzel, Hammond, Lilienfeld, Shimkin, and Wynder, 1959; Berkson and Elveback, 1960), but it is probably true that the appropriateness of the method depends on the circumstances and purposes of the analysis.

One aspect of this question of presentation is the kind of index that is the most meaningful to the layman. If we consider that smoking has an adverse effect upon health and wish to discourage the general public from smoking, then the evidence must be presented to them in such a way that they can readily balance the possible disadvantages of smoking against the advantages which the confirmed smoker feels sure that he enjoys. The Report of the Royal College of Physicians (1962) set down the risks in a variety of ways, namely the fractional risks of dying from all causes of death and from lung cancer in a decade, and the percentage of men aged 35 who may expect to die before the age of 65, but these fractions and percentages are not immediately translatable into concrete loss for an individual.

Another possible method of presentation of the data is in terms of 'expectation of life', obtained from life tables of smokers and non-smokers. Such a method has not been widely used, although to the layman loss of years of life may seem a more concrete fact to face than a change in his mortality risk. It therefore seemed useful to calculate the life-expectancy of persons in different smoking categories using

the age-specific mortality rates obtained in the various prospective surveys that have been made. The results of these calculations are presented in this paper.

METHOD OF CALCULATION

The data on age-specific mortality rates from six prospective studies on male populations have been conveniently summarized by Ipsen and Pfaelzer (1963) in a report to the Surgeon General's Advisory Committee on Smoking and Health. Some of their findings are published in "Smoking and Health" (1964). They show that, if the logarithm of the age-specific death rate is plotted against age, the resulting points lie reasonably close to a straight line, and that, in general, the effect of smoking is not only to raise this line vertically on the graph above that for non-smokers, but also to cause the slope of the line to decrease slightly.

To calculate life expectancies in different categories of cigarette smokers, values of the age-specific death rates deduced from the equations to the straight lines fitted by Ipsen and Pfaelzer have been used to construct life tables by the method of Reed and Merrell (1939). The results are presented as life expectancies at age 40.

RESULTS

Table I (overleaf) shows the life expectancies (ϵ_{40}) for different cigarette smoking categories in the six prospective surveys listed in the column headings. It may be seen that four of the groups (Californian Legion, Californian Occupational, U.S. Veterans, and Men in 25 States) give a life expectancy for non-smokers of about 38 years, while the non-smokers in the other two groups (British Doctors and Men in 9 States) have life expectancies of about 3 years less.

TABLE I
LIFE EXPECTANCY IN YEARS AT AGE 40

Smoking Category (cigarettes per day)	Prospective Study					
	British Doctors (Doll and Hill, 1956)	Men in 9 States (Hammond and Horn, 1958)	U.S. Veterans (Dorn, 1958)	California Occupational (Dunn, Linden, and Breslow, 1960)	California Legion (Dunn, Buell, and Breslow, 1963)	Men in 25 States (Hammond, 1963)
Nil	34.3	35.2	37.7	38.1	37.6	37.9
1-9	33.6	32.6	37.0	36.4	35.1	34.3
10-20	32.4	30.5	32.9	33.0	33.1	32.7
21-39	31.0	29.3	31.2	30.9	32.0	32.2
40+	27.2	28.1	—	—	—	31.4

If, however, we look at Table II, which shows the loss of life expectancy associated with different amounts of cigarette smoking, then the results from the five American studies are very similar except for the light smokers (1-9 cigarettes per day). The life expectancy of heavy smokers (21-39 and 40+ cigarettes per day) is about 6 to 7 years less than that of non-smokers. The British doctors' study leads to smaller reductions in life expectancy for the lighter smoking categories, but for very heavy smokers (40+ cigarettes per day*) it agrees well with the two American studies in which this category was also analysed.

TABLE II
REDUCTION IN YEARS OF LIFE EXPECTANCY AT AGE 40
ASSOCIATED WITH CIGARETTE SMOKING

Smoking Category (cigarettes per day)	Prospective Study					
	British Doctors	Men in 9 States	U.S. Veterans	California Occupational	California Legion	Men in 25 States
1-9	0.7	2.6	0.7	1.7	2.5	3.6
10-20	1.9	4.7	4.1	5.1	4.5	5.2
21-39	3.3	5.9	6.5	7.2	5.6	5.7
40+	7.1	7.1	—	—	—	6.5

DISCUSSION

The above results show that, in spite of different life expectancies in the different groups, all the studies suggest that the reduction in life expectancy associated with heavy smoking is about 6 to 7 years. If all of the reduction is caused by smoking, it may be asked whether this average figure may be applied to the individual smoker, *i.e.* do *all* heavy smokers live from 6 to 7 years less than they would have done without smoking? If this were so we might at first sight expect the plot of the logarithm of the age-specific mortality rates against age for heavy smokers to have the same slope as that for non-smokers but

to be shifted about 7 years towards younger ages. As already mentioned above, this is not the case, Ipsen and Pfaelzer (1963) and Pike and Doll (1965) having shown that the slopes of the curves decrease as the amount of smoking increases. This is demonstrated in the Figure, where the plots for non-smokers and for smokers of 21-39 cigarettes per day are the average of the results for the four American studies which had very similar non-smoker life expectancy. The horizontal displacement is about 9 years at age 40 on the smoker curve and decreases to 5.5 years at age 80. This would be consistent with the assumption that the death of a heavy smoker at age 40 had been advanced about 9 years by smoking, but that a heavy smoker dying at 80 had suffered a smaller decrease of life-span.

FIGURE.—Age-specific mortality rates plotted against age. Data for smokers and non-smokers were derived from the American prospective studies listed in the last four columns of Table I. For explanation of dotted curve, see text.

* I am informed by Dr Doll that the data for his study are slightly misrepresented in "Smoking and Health" (1964), and that his two heaviest smoking categories were in fact 20-34 a day and 35 or more cigarettes a day.

On the other hand, it is possible that the difference in slopes of the two lines could be a cohort effect, *i.e.* that the effect of smoking is increasing with succeeding generations, in which case a heavy smoker at present in his forties will have his life expectancy reduced by about 8.2 years irrespective of when his death occurs. (This figure is calculated on the assumption that heavy smoker mortality in the future could be represented by a straight line coinciding at 35 years with the heavy smoker line in the Figure but parallel to the non-smoker line).

A third possibility is that the observed mortality in heavy smokers differs from that in non-smokers because a susceptible fraction of the heavy smokers is affected by smoking, while the remainder has the same life expectancy as non-smokers. Column (2) of Table III shows the l_x values for the smokers of 21–39 cigarettes per day whose age-specific mortality rates are shown in the Figure. Let us suppose that in fact half the smokers had the same mortality as non-smokers with the resulting l_x values shown in column (3). Then the differences shown in column (4) will be the l_x values of the remaining heavy smokers whose life expectancy was actually affected by smoking. We may note first that by age 80 practically all the heavy smokers left alive would be accounted for by the survivors of the fraction with non-smoker mortality. It is unlikely therefore that this fraction could initially at age 40 have been much more than a half. As it is, the survivors at ages of 85+ are higher in column (3) than in column (2), but as the basic information is less reliable in these very old age groups, we should probably not pay too much attention to this discrepancy. If the life expectancy of the susceptible fraction is computed from the l_x values in column (4) assuming the life-table terminates with the 80– age group, then the figure obtained is 26.0 years, representing a loss of

life of 11.8 years as compared with the non-smoker expectancy. The dotted curve in the Figure shows the age-specific mortality rates for this susceptible group. If the fraction with non-smoker mortality is less than a half, then the loss of life expectancy in the susceptible group will be correspondingly less, and approach nearer the value of 6.3 years obtained for the heavy smoker group taken as a whole.

In the above discussion no account has been taken of the possibility that some of the differences in life expectancy between smokers and non-smokers may be due to causes other than smoking, *e.g.* constitutional and genetic differences between non-smokers and smokers. The question is dealt with at some length in "Smoking and Health" (1964), and the authors conclude that differences in death rates due to constitutional or genetic factors "may be moderate or small rather than large". It is of interest that, in the study by Hammond (1963) on men in 25 states, cigarette smokers and non-smokers were divided according as they had long- or short-lived parents and grandparents, and the mortality ratio was found to be higher for men with short-lived ancestors. On the assumption that a person with long-lived ancestors inherits a tendency to have a longer life-span than does one with short-lived ancestors, this observation could fit in with the suggestion made above that the reduction in life expectancy of a heavy smoker dying at 40 has been more than that of a heavy smoker dying at 80.

It is also conceivable that personality traits may influence life expectancy, since Kissen (1966) has found that, within any one smoking category, the lung cancer mortality rate is increased in men who have a diminished outlet for emotional discharge. A prospective mortality study in which personality traits were tested would be of great value in confirming the strength of this association and also of any association between personality traits and overall life expectancy. If such associations exist, then they may prove to be the basis for selection of a particularly susceptible group of smokers as discussed above. However, we must note that whereas above the non-susceptible group of smokers were assumed to have the same mortality as non-smokers, Kissen's data suggests that heavy smokers with good emotional outlet have a lung cancer mortality rate which is still 2.6 times that for non-smokers with poor emotional outlet, and nearly six times that for all non-smokers.

We may summarize therefore by saying that, unless smokers, quite irrespective of their smoking, are shorter-lived than non-smokers, the loss of life expectancy beyond age 40 due to smoking 21 cigarettes or more per day is likely to be about 6

TABLE III

ILLUSTRATIVE EXAMPLE OF A GROUP OF HEAVY SMOKERS HALF OF WHOM HAVE THE SAME MORTALITY AS NON-SMOKERS

Age Group (yrs) (1)	10,000 Heavy Smokers l_x (2)	5,000 Non-smokers l_x (3)	Difference $l_x - l_x$ (4)
40–	10,000	5,000	5,000
45–	9,787	4,960	4,827
50–	9,466	4,885	4,581
55–	8,981	4,760	4,221
60–	8,267	4,580	3,687
65–	7,256	4,290	2,966
70–	5,904	3,850	2,054
75–	4,271	3,225	1,046
80–	2,564	2,420	144
85–	1,123	1,500	–377
90–	302	682	–380
95–	37	181	–144

years. But for an individual with a constitutional tendency to be short-lived, or who is particularly susceptible to the deleterious effect of smoking, the loss of life expectancy may be greater, and could be as high as 12 years.

SUMMARY

Life expectancies at age 40 have been calculated for men in various smoking categories using data from six prospective studies. It is shown that the life expectancy of non-smokers is about 6 years greater than that of heavy cigarette smokers (more than 21 cigarettes per day). The implications of this finding are discussed in the light of a number of possible hypotheses about the effect of smoking on the life expectancy of the individual smoker.

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