

## PAPERS AND ORIGINALS

## Mortality in relation to smoking: 22 years' observations on female British doctors

RICHARD DOLL, RICHARD GRAY, BARBARA HAFNER, RICHARD PETO

### Summary and conclusions

A total of 6194 female doctors who in 1951 replied to a questionnaire about their smoking habits were followed up prospectively for 22 years. During that time 1094 died. Ischaemic heart disease, lung cancer, and chronic obstructive lung disease were all significantly ( $p < 0.001$ ) related to smoking, though the absolute excess risks were lower than in male doctors smoking equivalent amounts. Female smokers born before the first world war were less likely to describe themselves as inhalers or as having started to smoke while young than were female smokers who were born later. In these respects this younger group resembled male smokers, and as they move into their 60s and 70s their absolute risk of lung disease and relative risk of ischaemic heart disease will probably come to resemble the risks for men smoking the same numbers of cigarettes.

These findings show only that cigarette smoking causes lung cancer, chronic obstructive lung disease, and heart disease in women as in men. Whether the proportional increase in mortality from these diseases is as great in women as in men might be estimated directly from new case-control studies on men and women born since 1920.

### Introduction

Extensive data are available relating mortality to smoking habits in men, but much less information is available for women. Such data as there are suggest at first sight that women<sup>1-10</sup> are less

susceptible than men to the effects of smoking. This is not intrinsically implausible, because the effect of smoking is modified by the environment in which it occurs. We know, for example, that the risk of cancer attributable to cigarette smoking is greatly increased if men are also exposed to asbestos dust, radon, or alcohol,<sup>11-13</sup> while the risk of coronary thrombosis attributable to cigarette smoking is greatly increased if women are also taking oral contraceptives.<sup>14 15</sup>

For each smoking-related disease the *risk ratio* among people of a given age may be defined as the ratio of the death rate from the disease among smokers to that among non-smokers. It appears that the approximate effect of smoking on each smoking-related disease is to increase the effects of various other causes of that disease. If this is so the risk ratio for each disease may remain about the same, even though the absolute extent of the increase will depend on the presence or absence of other causative factors. If this general rule also applies to sex, we should expect that the risk ratios for each of the major diseases associated with smoking might be similar in women to those already observed in men. To date, however, most workers have reported considerably less extreme risk ratios in women. Nevertheless, if this is merely because on average women have not smoked effectively for as many years as men, the risk ratios may eventually be the same in both sexes, in which case the effects of smoking in women will be greater than is currently supposed. We must therefore continue to monitor the effects of smoking on female mortality.

In this paper we relate mortality to the smoking habits of 6194 women doctors who responded to a questionnaire sent to them by Doll and Hill in 1951.<sup>3</sup> We also compare the quantitative effects of smoking on the mortality rates in these women with those for the 34 440 male doctors who replied at the same time to the same questionnaire.

Imperial Cancer Research Fund Cancer Unit, Oxford OX1 3QG

SIR RICHARD DOLL, FRCP, FRS, honorary director

Nuffield Department of Clinical Medicine, Radcliffe Infirmary, Oxford OX2 6HE

RICHARD GRAY, MA, MSc, research officer

BARBARA HAFNER, research assistant

RICHARD PETO, MA, MSc, ICRF reader in cancer studies

### Method of study

The method of study and results in male doctors have been reported.<sup>3 4 16 17</sup> In brief, at the end of October 1951 a questionnaire was sent to all the men and women listed on the British Medical Register who were believed to be resident in the United Kingdom. In addition to name, address, and age they were asked a few simple questions about their smoking habits. As in other studies, a non-

smoker was defined as a person who had never smoked as much as one cigarette a day (or a quarter of an ounce (7 g) of tobacco a week) for as long as one year. Replies complete enough to be used were received from 6194 women—that is, about 60% of those who were alive when the questionnaire was sent. Observation of mortality in these women began on 1 November 1951 and was continued to 31 October 1973. Further inquiries about smoking were made in February 1961 (second questionnaire) and November 1973 (third questionnaire). In this report we relate mortality from November 1951 to October 1961 to the smoking habits described in 1951, and mortality from November 1961 to October 1973 to the smoking habits described in 1961.

## Data

### SMOKING HABITS

Table I shows the numbers of responses to the second and third questionnaires. Of the possible survivors in 1961 and 1973—that is, including the women who were not traced—106 (1.8%) and 209 (4.1%) respectively failed to supply further information on smoking.

TABLE I—Completeness of follow-up in 1961 and 1973 (n=6194)

	No of women
<b>1961 survey</b>	
Known to have died before 1 November 1960	319
Known to have died during 1 November 1960 to 31 October 1961	46
Without replying	13
After replying	33
Presumed to be alive on 1 November 1961	5818
Replied before 1 November 1961	5723
Contacted but did not reply before 1 November 1961	95
Too ill	5
Refused	10
Reason unknown	80
Not traced (presumed to be alive)	11
<b>1973 survey</b>	
Known to have died before 1 November 1973	1094
Known to be alive on 1 November 1973	5039
Replied before 1 November 1974	4891
Contacted but did not reply before 1 November 1974	148
Too ill	10
Refused	7
Reason unknown	89
Died during 1 November 1973 to 1 November 1974 without replying	42
Not traced (presumed to be alive)	61

The questions that the women were asked in 1951, 1961, and 1973 were the same as those that the men were asked in 1951, 1957, and 1972 respectively.<sup>16</sup> In 1951 they included the age when smoking began, and in 1961 they included inhaling. Table II shows the proportions of lifelong non-smokers and the average numbers of cigarettes smoked daily by women of various ages at the beginning of the study. Table II also shows the average numbers smoked 10 and

20 years later by the survivors who replied to the 1961 and 1973 questionnaires respectively, and these numbers expressed as percentages of the numbers smoked by British women of the same age.

The trends observed were the result of two opposite tendencies. The first and strongest of these was for smokers to give up smoking and consequently for the mean consumption by women who were smoking in 1951 to decrease. The second tendency, which was substantial only in the first 10 years, was for young non-smokers to take up smoking. This caused some irregularities in the general downward trend in the numbers of cigarettes smoked daily, though not in the downward trend in consumption relative to that in other British women. At the beginning of the period women doctors under 35 smoked somewhat less than the national average for all women of the same ages,<sup>18</sup> but older women smoked more. By 1971, however, British women in general were smoking more than they had been 20 years before, so that although the women doctors as a whole originally smoked 28% more than the national average, by 1971 they smoked 36% less.

### DEATHS

Information on deaths was obtained as for men.<sup>16</sup> Of the 6194 women, 1094 were known to have died before 1 November 1973, 5039 were known to have been alive at that date, and 61 (1.0%) were not traced (table I).

In most cases the underlying cause of death was obtained from the official death certificates. Except for deaths in which lung cancer was mentioned we accepted without further inquiry the certified cause and (unless otherwise stated) classified the deaths according to the underlying cause. In only one case were we unable to obtain any evidence of the cause. The underlying causes were classified according to the seventh revision of the International Classification of Diseases,<sup>18</sup> except that we created a separate category of "pulmonary heart disease."<sup>16</sup>

Cancer of the lung, trachea, or pleura was given as the underlying cause of 29 deaths and as a contributory cause in one. In each of these 30 deaths we sought confirmation of the diagnosis from the doctors who had certified the death and, when necessary, from the consultant to whom the patient had been referred. As a result we accepted carcinoma of the lung as the underlying cause of 27 deaths. Two deaths were considered to have been due to causes not mentioned in the certificates—namely, malignant fibroma of the pleura and adenocarcinoma of the ovary—and were treated as such in our analysis. The diagnosis of lung cancer referred to as a contributory cause of death of one woman was apparently correct.

### Statistical analysis

Deaths during 1 November 1951 to 31 October 1961 were related to the information received in reply to the 1951 questionnaire irrespective of any information received in 1961. Deaths during 1 November 1961 to 31 October 1973 were related to the information

TABLE II—Cigarette consumption by women doctors compared with national average

Age group (years)			No of women in 1951	% Non-smokers in 1951	Cigarettes smoked by all women doctors responding					
					Mean No daily			No as % of No smoked by UK women of same age†		
1951	1961	1971			1951	1961*	1971†	1951	1961	1971
20-4	30-4	40-4	292	66	3.0	3.1	3.0	85	51	34
25-9	35-9	45-9	1254	54	4.1	4.4	3.0	89	72	38
30-4	40-4	50-4	917	48	4.6	4.8	3.3	94	69	46
35-9	45-9	55-9	724	44	5.1	4.9	3.9	138	76	67
40-4	50-4	60-4	451	42	6.2	5.7	3.9	148	113	94
45-9	55-9	65-9	573	44	6.0	5.2	4.0	153	122	134
50-4	60-4	70-4	999	45	5.7	4.5	3.1	196	153	168
55-9	65-9	75-9	413	48	4.1	3.4	1.6	163	168	143
60-4	70-4	80-4	208	56	3.5	2.4	1.4	179	163	165
65-9	75-9		143	59	3.6	3.2		260	471	
70-4	80-4		112	65	1.8	1.2		196	220	
75-9			64	81	1.4			305		
80-4			27	70	2.2			684		
≥85			17	94	0.0					
All ages			6194	50	4.7§	4.4§	3.2§	128	90	64

\* To avoid antemortem changes in habit, numbers estimated from women who replied in 1961 and survived to 1 November 1961.

† Numbers estimated from women who replied to questionnaire two years later by ignoring reported changes in interim.

‡ UK data averaged for 1950-2, 1960-2, and 1970-2; 80 years and over used for 80-84 years.

§ When standardised to age distribution of male doctors means for all ages were respectively 4.7, 4.3, and 2.6.

TABLE III—Female death rates by cause of death and smoking habits when last asked

Cause of death	No of deaths	Yearly death rate per 100 000 women standardised directly to age distribution of male doctors					$\chi^2$ test on one degree of freedom for:		
		Non-smokers	Ex-smokers of cigarettes only	Daily cigarette consumption (current smokers only)			Non-smokers v others	Trend, ignoring ex-smokers	
				1-14	15-24	$\geq 25$			
(1) Diseases "closely associated" with smoking among male doctors:									
Cancer of lung .. .. .	27	7	23	9	45	208	13.47***	61.59***	
Cancer of oesophagus .. .. .	2	0	8	4	0	0	—	—	
Cancer of other respiratory sites .. .. .	4	2	3	0	8	13	—	4.51*	
Respiratory tuberculosis .. .. .	2	3	0	0	0	0	—	—	
Chronic bronchitis and emphysema .. .. .	13	2	10	21	57	64	12.34***	26.64***	
Pulmonary heart disease .. .. .	2	2	5	0	0	0	—	—	
Aortic aneurysm .. .. .	11	7	21	9	9	0	—	—	
Hernia .. .. .	2	2	0	9	0	0	—	—	
(2) Ischaemic heart disease .. .. .	179	138	126	132	304	292	—	21.14***	
(3) Other diseases classified as associated with smoking in discussion of male doctors:									
Cancer of rectum .. .. .	7	5	0	4	15	48	—	—	
Cancer of pancreas .. .. .	14	9	11	4	24	16	—	—	
Cancer of bladder .. .. .	5	7	0	4	0	0	—	—	
Pneumonia .. .. .	44	34	40	64	132	14	3.27	5.45*	
Myocardial degeneration .. .. .	72	86	50	38	114	206	—	—	
Hypertension .. .. .	19	18	4	11	63	29	—	—	
Arteriosclerosis .. .. .	7	7	9	18	0	0	—	—	
Cerebral thrombosis .. .. .	68	73	86	68	33	14	—	—	
Cirrhosis of liver, alcoholism .. .. .	8	2	11	0	22	15	4.31*	8.66**	
Peptic ulcer .. .. .	2	2	5	0	0	0	—	—	
Suicide .. .. .	25	19	19	9	37	55	—	3.10	
Poisoning .. .. .	13	13	0	13	7	14	—	—	
(4) Diseases other than (1), (2), and (3):									
Parkinsonism .. .. .	5	5	3	9	0	0	—	—	
Cancer of breast .. .. .	84	77	59	50	73	40	—	—	
Cancer of ovary .. .. .	24	10	17	29	61	13	5.13*	5.37*	
Cancer of other sites .. .. .	126	96	130	111	99	110	—	—	
Other diseases .. .. .	325	299	256	251	324	379	—	—	
All diseases .. .. .		921	898	866	1426	1529	4.39*	33.48***	
(No of deaths excluding 4 among pipe or cigar smokers) .. .. .	(1090)	(554)	(184)	(152)	(135)	(65)			

\*  $p < 0.05$ . \*\*  $p < 0.01$ . \*\*\*  $p < 0.001$ .

received in reply to the 1961 questionnaire (or, for the 106 women who did not reply to the 1961 questionnaire, to the information they had provided in 1951) irrespective of information received later.

Only six women in 1951 and a further nine in 1961 reported ever having smoked pipes or cigars (four of whom died during the study), so that we could make no useful estimate of the hazards associated with these habits. Our analysis therefore relates only to the remaining 1090 deaths among the women who, when last asked, were lifelong non-smokers or current or past smokers of cigarettes only. As in our analysis of male doctors<sup>16</sup> all tests of the statistical significance of differences between non-smokers and other people, and tests of the statistical significance of trends with respect to dose, are indirectly standardised for age and do not use continuity corrections.

To facilitate simple comparison of the female rates with those reported for men some have been standardised directly to the person-years age distribution of male doctors. (Percentages in successive five-year age groups from 20-24 to 85 and over for men were 0.1, 2.5, 6.5, 10.7, 14.1, 14.6, 13.6, 11.3, 9.0, 6.9, 4.7, 3.1, 1.9, and 1.0, while for female smokers the percentages were 0.2, 3.6, 8.4, 11.5, 13.6, 14.0, 13.1, 12.0, 9.5, 7.1, 4.3, 1.7, 0.7, and 0.3.) Owing to the paucity of women smokers in the older age groups, however, such rates are much less accurate than were the corresponding rates for men. To minimise the effects of random error some of the female rates are therefore also presented standardised directly to the age distribution of the person-years observed for current women smokers. Where this has been done we have, for comparison, also cited male rates standardised in the same way.

## Results and comments

### MORTALITY BY CAUSE AND CIGARETTE SMOKING

Table III shows the number of deaths attributed to 26 different causes (or groups of causes) together with the corresponding mortality rates standardised directly to the age distribution of male doctors. Causes of death are shown separately if they were associated with smoking in the data for men (20 causes positively associated and one negatively associated) or in most other published series (cancer of the bladder). Figures are also given for cancers of the breast and ovary because they were responsible for many deaths. In assessing the data it should be noted that few women were current heavy smokers.

Rates of 13, 14, 15, or 16 per 100 000 in this top smoking group were each derived from one single death (the variation being due to differences in the age distribution of deaths from each cause).

Of the eight causes of death that we found to be "closely associated" with smoking in men, only two (cancer of the lung and chronic bronchitis or emphysema) satisfied among women the strict criteria for "close association" (in terms of proportionally increased risks and statistical significance) which we devised for our analysis of mortality among the male doctors.<sup>16</sup> The remaining six causes accounted for only 23 deaths in women and showed no clear relation with smoking. This may, however, simply represent an artefact of chance owing to random irregularities in small numbers.

As expected, ischaemic heart disease was less preponderant as a cause of death in women than in men (accounting for 16% of all deaths against 32% in men) and the relation with smoking less definite, except for women smoking 15 or more cigarettes a day. Women smokers as a whole had a mortality of 174 per 100 000 a year, which was only 26% higher than the rate for non-smokers ( $p=0.15$ ); but among women who smoked 15 or more cigarettes a day the rate was over twice that among non-smokers, and so the trend in mortality with amount smoked was statistically highly significant ( $p < 0.001$ ).

Among men we listed 10 other causes of death which, although not by definition closely associated, nevertheless exhibited a statistically significant trend of mortality with amount smoked. Only two of these 10 causes (pneumonia and alcoholism) were statistically significantly associated with smoking in women. The numbers of female deaths attributed to the other eight causes were for the most part small. There was a trend for increasing female mortality from suicide with amount smoked ( $p < 0.1$ ), but female mortality from cerebral thrombosis tended (if anything) to decrease with amount smoked.

Of the six remaining causes of death examined, one—namely, cancer of the ovary—showed a positive relation with smoking (based on 24 deaths). We know of only one other study in which inquiries were made about the smoking habits of women with this disease.<sup>19</sup> Histories were taken from 300 women with cancer of the ovary and a similar number of control patients and no association with smoking was observed (M L Newhouse, personal communication). The one cause that was significantly negatively associated with smoking in men (Parkinsonism) was represented by only five deaths in women, which is too few to provide any useful information.

Table IV compares the male and female rates for the four broad

TABLE IV—Death rates for four broad categories of disease according to smoking habits: male and female doctors

Cause of death	No of deaths				Yearly death rates/100 000 persons standardised directly to age structure of all female smokers of cigarettes only											
	Non-smokers		Current smokers of cigarettes only		Non-smokers			Daily cigarette consumption (current smokers only)								
								1-14			15-24			≥25		
	M	F	M	F	M	F	M:F	M	F	M:F	M	F	M:F	M	F	M:F
(1) Closely associated with smoking among male doctors .. .. .	17	14	488	34	20	15	1.3	136	30	4.5	236	97	2.4	461	243	1.9
(2) Ischaemic heart disease:																
Age < 65* .. .. .	107	14	566	23	163	31	5.3	257	44	5.8	338	79	4.3	402	85	4.7
Age ≥ 65* .. .. .	182	71	528	45	1466	511	2.9	2027	402	5.0	1724	1117	1.5	2127	1411	1.5
(3) Other causes classified by Doll and Peto <sup>16</sup> as associated with smoking .. .. .	241	163	777	79	202	154	1.3	269	121	2.2	359	272	1.3	537	244	2.2
(4) Other causes .. .. .	393	292	984	171	392	377	1.0	462	352	1.3	449	475	0.9	522†	396	1.3
All causes .. .. .	940	554	3343	352	961	643	1.5	1372	599	2.3	1577	1069	1.5	2164	1154	1.9

\* Rates standardised to population of women smokers under and over 65 years of age respectively.

† Causes of male excess included "ill-defined cardiovascular disease" (7th ICD 782; non-smoker, light, medium, and heavy male rates 1, 5, 5, and 10); "other unspecified diseases of the heart" (ICD 434, excluding specified cor pulmonale; male rates 8, 7, 13, and 21); subarachnoid haemorrhage (ICD 330; male rates 3, 6, 10, and 12); "other" cerebral haemorrhage" (ICD 331; male rates 54, 74, 68, and 87); renal disease (ICD 590-603; male rates 11, 23, 18, and 31); and "poisoning by other agents with mention of alcohol" (male rates 0, 2, 6, and 4). Each association is plausible, but in each case the association with total tobacco consumption, which was the criterion for separate examination by Doll and Peto,<sup>16</sup> was less pronounced than the associations reported here with cigarette consumption.

groups of diseases, standardised directly to the age distribution of the current women smokers in 1961. Deaths from ischaemic heart disease were divided into two subgroups according to the age at which death occurred. Three points emerged. Firstly, the male:female ratio in non-smokers was substantially greater than unity for ischaemic heart disease—and grossly so for men and women aged under 65—but not for any of the other three groups of diseases examined. Secondly, the sex ratio for diseases closely associated with smoking was higher for all groups of smokers than for non-smokers but diminished with increasing amounts smoked. Thirdly, for each group of diseases the sex ratio was highest for smokers of fewer than 15 cigarettes a day.

TABLE V—Daily cigarette consumption by men and women of various ages as ascertained from second questionnaires (sent in 1957 and 1961 respectively). Figures are numbers of smokers\*

Age (years) in 1957 or 1961	Daily cigarette consumption					
	1-14		15-24		≥25	
	M	F	M	F	M	F
< 55	2242	493	2894	346	1651	142
55-64	602	229	651	128	571	73
65-74	293	61	254	37	172	9
≥ 75	212	11	76	11	27	1

\* Doctors who did not answer the second questionnaire, who did not survive to 31 October after it, or who did not give an unequivocal Yes/No answer about their inhaling habits are omitted from tables V and VI, as are doctors who failed to specify the age at which they began smoking.

## DIFFERENCES BETWEEN MALE AND FEMALE SMOKING HABITS

The last two of these observations could be explained if men and women who apparently fell into the same broad categories of light, moderate, and heavy cigarette smoking differed substantially in other aspects of their smoking histories that affect the incidence of disease. Table V shows the numbers of men and women who said they were smoking only cigarettes in response to the second questionnaire, in which a question about inhaling was asked. In table V the shortage of women smokers in our study is painfully apparent, especially in the older age groups, where the probability of death is appreciable. There were so few continuing cigarette smokers among women aged 75 and over that useful comparison can be made only at younger ages.

Table VI shows three features of the smoking habits of men and women who were light, moderate, and heavy cigarette smokers in three age groups under 75. Within each of these three broad smoking categories, women reported smoking slightly less than men, but the differences were small and inconsistent. Subdivision of the numbers of cigarettes reported to have been smoked into these three categories should therefore suffice to take account of differences between the sexes in the numbers of cigarettes reported to have been smoked daily. The same was not true, however, with regard to the two other available features of the smoking history. Firstly, women of all ages began smoking later than men. The differences were small under 55 years of age, but at older ages, when the male death rates from smoking were greatest, they averaged between four and seven years. Secondly, much smaller proportions of women said they inhaled. Substantial differences in inhalation were recorded in each age group and were greatest between 65 and 74 years of age, when 54% of men in all smoking categories combined said they inhaled compared with only 18% of women. Evidently, therefore, over the period of our

TABLE VI—Characteristics of light, moderate, and heavy cigarette smokers by age and sex\*

	Daily cigarette consumption					
	1-14		15-24		≥25	
	M	F	M	F	M	F
Age < 55 years						
Mean consumption of cigarettes daily .. .. .	8.0	7.4	18.6	18.5	31.2	31.4
Mean age at starting to smoke (years) .. .. .	19.6	20.6	18.8	20.3	18.6	19.9
Percentage inhaling .. .. .	72.7	53.3	85.1	67.9	85.3	66.9
Age 55-64 years						
Mean consumption of cigarettes daily .. .. .	8.0	7.0	18.9	18.6	32.0	31.1
Mean age at starting to smoke (years) .. .. .	19.8	24.8	19.1	23.2	18.3	23.8
Percentage inhaling .. .. .	51.0	19.7	65.7	28.1	71.8	42.5
Age 65-74 years						
Mean consumption of cigarettes daily .. .. .	8.0	7.4	18.6	18.9	31.1	28.9
Mean age at starting to smoke (years) .. .. .	20.1	27.1	19.3	25.8	19.5	23.8
Percentage inhaling .. .. .	44.0	16.4	62.2	18.9	58.1	22.2

\* In 1957 for men and 1961 for women. For exclusions see footnote to table V.

study men and women who had reached ages at which death was likely to occur had had smoking histories that differed in ways that would not be allowed for adequately by simple standardisation according to the amount stated to have been smoked daily.

Further standardisation to allow for age at starting and inhalation is impracticable with our limited data. Inhaling was first ascertained only in 1961, so that only 12 years' observations can be related to inhaling. Moreover, the proportion of women who in the 1961 questionnaire said that they were current smokers, started smoking under 25 years of age, and inhaled was so small that we recorded among them only 11 deaths from diseases defined as closely related to smoking.

#### RELATIVE EFFECT OF SMOKING IN MEN AND WOMEN

Despite the limitations our data suggest that the three principal diseases produced by smoking in men (cancer of the lung, chronic bronchitis and emphysema, and ischaemic heart disease) are also produced by smoking in women. The mortality from the first two diseases in non-smokers is roughly the same in both sexes, and smoking may have the same quantitative effect when account is taken of all the relevant aspects of the smoking history. In contrast, the mortality from ischaemic heart disease in non-smokers is much greater in men than in women and the absolute effect of smoking by women is certainly less. The relative effect, however, may be much the same. The data are too few for any useful conclusions to be drawn about the effect of smoking by women in producing other diseases that are less closely related to the habit.

#### Discussion

If we divide the women doctors in this study into two groups, depending on whether or not they were born before the first world war, it is clear that the smokers in the two groups differed in the way they smoked cigarettes. Thus a woman who in 1961 reported smoking (say) 10 cigarettes a day was more likely to have started young and to have described herself as an inhaler if she was born after the first world war than if she was born before, and she may also have differed in other and more important measures of exposure. The younger group, with male-like smoking methods, had not, at the time of our study (or at the time of any of the other prospective studies), attained an age when the risk of death was substantial. When the younger group progress into their 60s and 70s the absolute effects of smoking a given number of cigarettes on the mortality from those diseases that are closely related to smoking in men, and the relative effects on mortality from ischaemic heart disease, may turn out to be about the same as have been observed in men.

If that is indeed the case it would be unwise to estimate the likely effects of smoking by women from this or, if British women doctors are typical of other women, any of the other current prospective studies,<sup>8-20</sup> for the true risks may be much higher than these suggest. Our study shows only that cigarette smoking does indeed cause lung cancer, chronic obstructive lung disease, and heart disease in women as in men. Whether the proportional increase in mortality from these diseases is as great in women as in men might now be estimated directly from new case-control studies organised in the 1980s on British men and women born since 1920. Such studies are also needed to monitor what benefits, if any, are associated with the change during the past decade or two to what, it is hoped, are less hazardous cigarettes. Unless beneficial effects of the change to less hazardous cigarettes exist that are sufficient to counter-balance the effects of the progressive replacement of the older generation of women by a newer generation with altogether different smoking habits, the maximum effects of smoking on female mortality have yet to be seen.

This study is a continuation of that originally conceived and initiated by Sir Austin Bradford Hill.

#### Addendum

After this article was submitted for publication an extensive work, *Report on the Health Consequences of Smoking for Women*, was published by the Surgeon General, US Department of Health, Education and Welfare, Public Health Service, Washington DC.

While re-examining the male data we noticed certain errors in the report by Doll and Peto.<sup>16</sup> Firstly, pipe smokers beware: the "all-causes" death rate of 1000 in table VI was a misprint for 1600. Also, there were minor errors throughout table V, although the general picture is unchanged in the corrected version, which is available on request. Finally, the pitiable image conjured up by "cancer of the prostrate" in table III is perhaps best left unaltered.

#### References

- Cederlof R, Friberg L, Hrubec Z, Lorch U. *The relationship of smoking and some social covariables to mortality and cancer morbidity*. Stockholm: Department of Environmental Hygiene, Karolinska Institute, 1975.
- Department of National Health and Welfare. *A Canadian study of smoking and health*. Ottawa: Department of National Health and Welfare, 1966.
- Doll R, Hill AB. A study of the aetiology of carcinoma of the lung. *Br Med J* 1952;ii:1271-86.
- Doll R, Hill AB. Mortality of British doctors in relation to smoking: observations on coronary thrombosis. *Natl Cancer Inst Monogr* 1966; No 19:205-68.
- Hammond EC. Smoking in relation to the death rates of one million men and women: epidemiological study of cancer and other chronic diseases. *Natl Cancer Inst Monogr* 1966;No19:127-204.
- Hammond EC, Garfinkel L, Seidman H, Lew EA. Tar and nicotine content of cigarette smoke in relation to death rates. *Environ Res* 1976; 12:263-74.
- Hirayama T. Smoking in relation to death rates of 265 118 men and women in Japan. A report of five years' follow-up. American Cancer Society's Fourteenth Science Writers' Seminar, Clearwater Beach, Florida, 27 March 1972.
- National Heart, Lung and Blood Institute. Some characteristics related to the incidence of cardiovascular disease and death. Framingham study, 18-year follow-up. In: Kanal WB, Gordon T, eds. *An epidemiological investigation of cardiovascular disease*. Washington: Department of Health, Education and Welfare, 1974: publication No (NIH) 74-599.
- Rogot E. Cardiorespiratory disease mortality among British and Norwegian migrants to the United States. *Am J Epidemiol* 1978;108:181-91.
- Wynder EL, Bross IJ, Cornfield J, O'Donnell WE. Lung cancer in women. *N Engl J Med* 1956;255:1111-21.
- Selikoff IJ, Hammond EC. Asbestos-associated disease in United States shipyards. *CA* 1978;28:87-99.
- Archer VE, Gillam JD, Wagoner JK. Respiratory disease mortality among uranium miners. *Ann NY Acad Sci* 1976;271:280-93.
- Tuyns AJ, Pequignot G, Jensen OM. Les cancers de l'oesophage en ile-et-vilaine en fonction des niveaux de consommation d'alcool et de tabac. Des risques qui se multiplient. *Bull Cancer (Paris)* 1977;64:45-60.
- Doll R. Contraception and cardiovascular accidents. *Bulletin de l'Institut National de la Santé et de la Recherche Médicale* 1979;83:17-30.
- Shapiro S, Slone D, Rosenberg L, Kaufman DW, Stolley PD, Miettinen OS. Oral contraceptive use in relation to myocardial infarction. *Lancet* 1979;ii:743-6.
- Doll R, Peto R. Mortality in relation to smoking: 20 years' observations on male British doctors. *Br Med J* 1976;iii:1525-36.
- Doll R, Peto R. Cigarette smoking and bronchial carcinoma: dose and time relationships among regular smokers and lifelong non-smokers. *Journal of Epidemiology and Community Health* 1978;32:303-13.
- World Health Organisation. *Manual of the international statistical classification of diseases, injuries and causes of death. Seventh revision*. Geneva: World Health Organisation, 1957.
- Newhouse ML, Pearson RM, Fullerton JM, Boesen EAM, Shannon HS. A case-control study of carcinoma of the ovary. *Br J Prev Soc Med* 1977;31:148-53.
- Hirayama T. Smoking and cancer: a prospective study on cancer epidemiology based on census populations in Japan. In: *Health consequences, education, cessation activities, and governmental action. Smoking and health II. Proceedings of third world conference on smoking and health*. Washington: Department of Health, Education and Welfare, 1977: publication No (NIH) 77-1413:65-72.

(Accepted 12 February 1980)