Smoking and health: the association between smoking behaviour, total mortality, and cardiorespiratory disease in west central Scotland

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SUMMARY The relationship of smoking to total mortality and to the prevalence of cardiorespiratory symptoms has been studied in three prospective surveys in west central Scotland in which 18 786 people attended a multiphasic screening examination. The prevalence of respiratory symptoms, and to a lesser extent cardiovascular symptoms, increased with the number of cigarettes smoked, with inhalation, and with a younger age of starting to smoke. A lower prevalence of respiratory symptoms in both sexes was observed in smokers of filter cigarettes than in smokers of plain cigarettes, and in those who smoked cigarettes with lower tar levels, irrespective of whether these were filtered or plain. In general, the relationships found between smoking and mortality were similar to those reported by other workers. Current cigarette smokers had a death rate from all causes which was twice that of those who had never smoked. No difference was found between the mortality rates of smokers of plain and filter cigarettes.

Numerous prospective studies have investigated the relationship between smoking and mortality (Royal College of Physicians, 1977). However, most of them relate to special groups of the population, such as doctors (Doll and Peto, 1976) or life insurance policy holders (Kahn, 1966), and many relate to countries outside the United Kingdom. Indeed, so far as we are aware, apart from the 12.4 year follow-up of the British population random sample reported elsewhere in this issue (Todd *et al.*, 1978), no prospective mortality study of a 'typical' population has previously been reported in the United Kingdom. Information is also scarce on the relationship that recent marketing changes in the type of cigarette may have had with mortality from smoking-associated disease. Apart from the previously mentioned study and the retrospective study carried out in north east England (Dean *et al.*, 1977), no information based on United Kingdom data has previously been published on the relative associations of filter and plain smoking with mortality.

Methods

Since 1965, in collaboration with the late Professor

D. D. Reid, the Mass Health Examination Unit of the Greater Glasgow Health Board has been carrying out examinations of both general populations and occupational groups. The main objectives of this paper are, firstly, to analyse the relationship between various aspects of smoking behaviour and subsequent mortality, and, secondly, to study the relationship between smoking and cardiorespiratory symptoms.

Three separate surveys were undertaken in west central Scotland, where the prevalence of cardiorespiratory mortality has been recognised as the highest in western Europe (Fulton *et al.*, 1978). The first two studies, which took place between 1965 and 1968 (Survey 1), and between 1970 and 1972 (Survey 2), were predominantly of persons examined in occupational groups (Hawthorne *et al.*, 1972), but they included also the census-identified population of the Scottish island of Tiree (Hawthorne *et al.*, 1969). Together these studies included 5694 men and 815 women. The third study, between 1974 and 1975 (Survey 3), of 5601 men and 6676 women, was confined to the census-identified population of Paisley (Hawthorne *et al.*, 1975). The overall response rate averaged 77%.

The full examination procedure has been described before (Hawthorne *et al.*, 1969). For the purpose of this paper it is only necessary to know that the subject first completed a questionnaire on smoking and cardiorespiratory symptoms, which was then checked for missing information.

Information on subsequent mortality was obtained through the National Health Service Central Register at Edinburgh.

The present paper confines itself to those aged 45 to 64 at examination and restricts attention to the following variables:

SMOKING

Smokers were classified into three groups: current smokers, ex-smokers, or never smoked. The current smokers were classified by the number of cigarettes a day currently smoked, the type of cigarette normally smoked (filter, plain or hand-rolled), whether or not the smokers said that they inhaled, the age of starting to smoke, and (except in Survey 2) the brand of cigarette smoked. An individual was considered a smoker only if he smoked five or more cigarettes a day. The tar levels of the various brands were supplied by the Tobacco Research Council.

CARDIORESPIRATORY SYMPTOMS

The MRC bronchitis questionnaire (Medical Research Council, 1966) was used and the responses classified according to the presence of bronchitis syndrome, shortness of breath, wheezing, and persistent phlegm as defined in the questionnaire; the responses on angina and possible infarction were classified as defined by Rose and Blackburn (1968).

MORTALITY

All deaths reported between the time of examination and 31 October 1977 were classified into the following cause of death groups; ischaemic heart disease (ICD codes 410-414), cerebrovascular disease (430-438), lung cancer (162.1), chronic bronchitis (490-493), infectious and other respiratory diseases (460-486 and 510-519) (World Health Organisation, 1967) and all other causes.

Statistical Methods

The significance of an association between a *factor* (such as the age of starting to smoke) and the presence or absence of a *symptom* (such as angina), standardised for one or more *confounding variables* (such as age and number of cigarettes smoked), was evaluated using the following technique, based on that described by Peto and Pike (1973).

The data were first divided into strata according to combinations of the confounding variables;

then these strata were subdivided into levels according to a factor. Within a stratum, at the j^{th} level of a factor, O_j was the number observed with the symptom and S_j the number studied at that level. Assuming that the factor is independent of the prevalence of symptoms, the expected number, E_j , with the symptom within the stratum was calculated, and hence the deviation, D_j , from expectation.

$$\text{Where } D_j = O_j - E_j$$

These were then summed over all strata. The deviations were then tested for significant departure from the null hypothesis by assuming that

$$\chi^2 = d \cdot A^{-1} d$$

is asymptotically distributed as χ^2 with $m-1$ degrees of freedom. [Where m is the number of levels of the factor, d is the vector formed by the first $m-1$ total deviations and A is their covariance matrix (Peto and Pike, 1973).] Particular levels may be tested for deviation from the null hypothesis by using χ^2 with one degree of freedom (Armitage, 1966).

The methods used to evaluate the significance of an association between a *factor* and a *cause of death* were essentially the same, if time of death is taken to be an additional confounding variable and S_j represents the number at risk at the beginning of the time period for that stratum.

The ratio of the total observed to the total expected within each level of a factor which is analogous to the standardised mortality ratio is used as an indicator of the relative death rate or relative prevalence of symptoms at the various levels of the factor.

Results

The sex and age distribution of the three study populations is given in Table 1 and the distribution by smoking groups in Table 2.

Table 1 Sex and age distribution of study population

	Age group (years)			
	45-49	50-54	55-59	60-64
Men (%)	29.5	31.1	24.1	15.3
Women (%)	25.3	28.8	24.7	21.3

Table 2 Percentages of 'never smoked', ex-smokers, and current smokers

	Never smoked	Ex-smokers	Current smokers
Men	19.0	28.4	52.6
Women	47.3	8.5	44.2

Smoker defined as one smoking 5 or more cigarettes a day.

Table 3 demonstrates that, compared with men smokers, women smoked fewer cigarettes, started to smoke later in life, reported inhaling less often, and tended more often to smoke filter cigarettes. These

differences could not be explained by differences in the age distribution of the sexes. Table 4 reflects the fact that tar yields of cigarettes on the market in 1965-68 were much higher than in 1975-76.

Table 3 *Numbers and percentages of current smokers with various smoking characteristics*

		Men		Women	
		No.	%	No.	%
Number smoked per day	6-17	2348	39.5	1793	54.1
	18-22	2068	34.8	1172	35.4
	23+	1528	25.7	348	10.5
Type of cigarette	Filter	4117	69.3	3023	91.3
	Plain	1518	25.5	257	7.8
	Hand-rolled	309	5.2	32	1.0
Inhalation	Yes	5575	93.8	2854	86.2
	No	369	6.2	458	13.8
Age of starting to smoke	<15	1356	22.8	338	10.2
	15-19	3141	52.8	1538	46.4
	>20	1447	24.3	1436	43.4

Table 4 *Percentage of male current smokers smoking brands of different tar level for two study populations*

Tar level	Survey 1 (1965-68) %	Survey 3 (1974-76) %
Low tar and low to middle tar combined (<17 mg)	0.0	6.7
Middle tar (17-22 mg)	0.3	50.2
Middle to high tar (23-27 mg)	13.3	17.6
High tar (28+ mg)	86.4	25.6
TOTAL ALL TYPES	100.0	100.0
Base number of smokers	1000	2486

PREVALENCE OF SYMPTOMS

Table 5 gives, for each of the six symptoms or syndromes studied, the prevalence by smoking group. For all four respiratory symptoms, current smokers had much higher rates than the never smoked group, and ex-smokers had intermediate rates, apart from shortness of breath in women. Men had higher rates for phlegm than women but lower rates for shortness of breath, while bronchitis

and wheezing rates were similar in the two sexes. The two cardiovascular symptoms were less clearly related to smoking. Men had higher possible infarction rates than women but slightly lower angina rates.

Table 6 (men) and Table 7 (women) show that for all four respiratory symptoms there was a highly significant positive association with the number of cigarettes smoked which was much stronger for women than for men. There was also a marked relationship in both sexes between the age of starting to smoke and the prevalence of symptoms; people who started to smoke before the age of 15, taking into account differences in age and number of cigarettes smoked, had prevalence rates almost twice as high as people who started to smoke at the age of 20 or over. Inhalation was less strongly related to prevalence of respiratory symptoms but, even so, inhalers tended to have rates about 30% higher than non-inhalers. This difference was not always statistically significant, perhaps because of the relatively small number of non-inhalers studied. For these three aspects of smoking behaviour, the trends for cardiovascular symptoms were always in the same direction as those for respiratory symptoms, although the associations were rather weaker and were not always statistically significant.

Smokers of plain cigarettes had a lower prevalence of respiratory symptoms than smokers of filter cigarettes, although in men the differences were fairly small and not always statistically significant; but in women they were always significant. No statistically significant difference in cardiovascular symptoms was seen for either sex, although women who smoked filter cigarettes had a lower prevalence than those who smoked plain ones. Male smokers of hand-rolled cigarettes had prevalence rates for all six symptoms higher than those of smokers of plain or filter tipped cigarettes.

No significant differences by tar level of brand smoked were seen in Survey 1, possibly because at

Table 5 *Prevalence of cardiorespiratory symptoms by broad smoking group*

	Bronchitis syndrome	Shortness of breath	Wheezing	Phlegm	Angina	Possible infarction
	%	%	%	%	%	%
MEN						
Never smoked	2.3	7.0	6.1	10.1	5.5	6.3
Ex-smokers	4.4	9.9	9.8	16.1	8.7	9.6
Current smokers	8.5	13.2	21.8	36.2	9.3	9.7
Total	6.2	11.1	15.4	25.5	8.4	9.0
WOMEN						
Never smoked	2.9	13.2	6.0	6.7	9.5	4.9
Ex-smokers	5.5	20.5	10.6	10.9	13.2	7.9
Current smokers	8.6	18.6	19.2	23.0	9.1	6.5
Total	5.6	16.2	12.2	14.3	9.6	5.9

Table 6 *Relative symptom prevalence (x 100) in male current cigarette smokers by number of cigarettes smoked (standardised for age), and by age of starting to smoke, inhalation, and type of cigarette smoked (standardised for age and number of cigarettes smoked)†*

	Bronchitis syndrome	Shortness of breath	Wheezing	Phlegm	Angina	Possible infarction
Number of cigarettes currently smoked						
6-17	86	91	80	83	90	93
18-22	93	90	103	102	96	95
23+	131	127	127	123	121	119
χ^2 (2 df)	19.4****	24.2****	60.4****	87.4****	10.3****	7.8**
Age of starting to smoke						
<15	148	136	131	121	131	111
15-19	91	95	96	101	97	98
20+	68	74	77	76	78	94
χ^2 (2 df)	50.8****	48.4****	67.3****	88.8****	22.6****	2.7
Inhalation						
Yes	102	101	102	103	102	102
No	70	80	71	62	77	77
χ^2 (1 df)	3.6*	2.7	9.8****	33.1****	2.3	2.5
Type of cigarette						
Filter	96	94	95	97	103	100
Plain	105	112	111	106	88	97
Hand-rolled	135	125	120	120	114	126
χ^2 (2 df)	3.8	8.4***	12.0***	11.7***	3.2	2.2
χ^2 (1 df filter v plain)	1.0	5.7**	9.3***	5.6**	2.5	0.1

*P<0.1 **P<0.05 ***P<0.01 ****P<0.001

†Each analysis is also standardised for study

Table 7 *Relative symptom prevalence (x 100) in female current cigarette smokers by number of cigarettes smoked (standardised for age), and by age of starting to smoke, inhalation, and type of cigarette smoked (standardised for age and number of cigarettes smoked)†*

	Bronchitis syndrome	Shortness of breath	Wheezing	Phlegm	Angina	Possible infarction
Number of cigarettes smoked						
6-17	71	76	77	77	88	94
18-22	104	110	111	114	102	103
23+	245	192	182	170	158	123
χ^2 (2 df)	83.9****	94.0****	81.5****	89.2****	14.3****	1.7
Age of starting to smoke						
<15	150	142	136	126	165	127
15-19	117	111	108	109	104	104
20+	68	77	82	83	81	90
χ^2 (2 df)	30.9****	42.1****	27.1****	25.9****	21.3****	3.0
Inhalation						
Yes	105	105	103	103	104	103
No	67	71	84	83	75	83
χ^2 (1 df)	5.7**	10.6***	3.6*	4.6**	3.6*	1.2
Type of cigarette††						
Filter	96	98	97	98	98	96
Plain	151	129	141	124	129	140
χ^2 (1 df)	7.7***	5.9**	11.8****	5.0**	2.4	3.3*

*P<0.1 **P<0.05 ***P<0.01 ****P<0.001

†Each analysis is also standardised for study

††Number of female hand-rolled cigarette smokers too small for reliable analysis

Table 8 *Relative symptom prevalence (x 100) in male current cigarette smokers by tar level of brand smoked within type of cigarette smoked (standardised for age and number of cigarettes smoked—Survey 3)*

	Bronchitis syndrome	Shortness of breath	Wheezing	Phlegm	Angina	Possible infarction
Filter smokers						
Low and low to middle tar	74	75	74	98	98	84
Middle tar	104	103	103	100	100	102
χ^2 (1 df)	2.2	3.1*	3.1**	0.1	0.1	0.8
Plain smokers						
Middle tar	96	81	65	82	69	87
Middle to high tar	105	97	102	103	102	93
High tar	(0)†	(208)	168	90	146	(281)
χ^2 (2 df)	2.7	6.8**	8.3**	2.0	1.1	11.1****

*P<0.1 **P<0.05 ***P<0.01 ****P<0.001

†Bracketed relative prevalences are unreliable as based on expected value of less than 5.

that time there was little difference in tar level of cigarettes on the market. Some differences were, however, seen in Survey 3 (Table 8). Although individual comparisons were often not statistically significant, there was a clear tendency in both filter and plain smokers for smokers of the lower tar cigarettes to have a lower prevalence of symptoms.

MORTALITY

Table 9 gives the relationship of smoking group to mortality. For men there was a highly significant association with total mortality: the percentage of current smokers who died was more than twice that for the never smoked group, with ex-smokers in an intermediate position. The most marked association for any cause of death was for lung cancer, where current smokers suffered 88 deaths out of 5944 at risk (148 per 10 000) with an estimated risk about 30 times higher than that of the never smokers with 1 death out of 2147 (4.6 per 10 000). Positive associations were also seen for a number of other causes of death, although, perhaps because of the small numbers, these were only clearly significant for ischaemic heart disease and for the 'other causes' group.

For women, there was a less clear but still significant excess ($P < 0.05$) of total mortality in current smokers, who suffered more than one and a half times the mortality of those who never smoked. Numbers of deaths in ex-smokers were too small to come to a reliable conclusion, but as for men, their death rate lay between that of 'never' and current smokers. By cause of death, the percentages dying in current smokers were higher than in 'never' smokers for ischaemic heart disease, and for the

group of diseases including lung cancer, although the excess was significant only in the latter case.

During the follow-up period, 536 men and 72 women died who were current cigarette smokers at the time of examination. In Table 10, therefore, we looked in detail at the relationship of various aspects of smoking behaviour to total mortality, and, in men, to some of the principal causes of death. Although there was evidence of an increasing total mortality with amount smoked in women smokers (trend on 1 df significant at the 90% confidence level) this was not so in male smokers, in whom the rates were only 10% higher for smokers of 23 or more cigarettes a day than for smokers of 6-17 cigarettes a day. There was, however, a significant association with amount smoked for male lung cancer rates.

The age of starting to smoke was not found to be significantly associated with total mortality in either sex or, in men, with any individual cause, although there was a higher mortality in those who started to smoke at younger ages. Combining the results for both sexes gives a trend in mortality which is significant at the 90% confidence level.

The strongest association seen in Table 10 was between male mortality and inhalation; those who reported inhaling had total death rates almost twice as high as those who did not. This excess, mainly due to an excess ischaemic heart disease mortality rate, was not seen at all in women.

Although the total numbers of male deaths among smokers of filter and plain cigarettes were not insubstantial (323 and 184 respectively), there was not the slightest indication of any difference in overall death rates between smokers of the two different types of cigarette. Nor was any significant

Table 9 *Mortality by smoking habits*

	Never smoked		Ex-smokers		Current smokers		All	
	No.	%	No.	%	No.	%	No.	%
MEN								
Number at risk	2147	100.00	3204	100.00	5944	100.00	11 295	100.00
Ischaemic heart disease	42	1.96	81	2.53	237	3.99	360	3.19
Cerebrovascular disease	8	0.37	15	0.47	33	0.56	56	0.50
Other vascular disease	0	0.00	4	0.13	12	0.20	16	0.14
Lung cancer	1	0.05	15	0.47	88	1.48	104	0.92
Chronic bronchitis	2	0.09	3	0.09	23	0.39	28	0.25
Respiratory infection	2	0.09	4	0.13	5	0.08	11	0.10
Other causes	26	1.21	54	1.69	138	2.32	218	1.93
All causes	81	3.77	176	5.49	536	9.02	793	7.02
WOMEN								
Number at risk	3544	100.00	634	100.00	3313	100.00	7491	100.00
Ischaemic heart disease	15	0.42	2	0.79	23	0.69	43	0.57
Cerebrovascular and other vascular disease, lung cancer, chronic bronchitis, and respiratory infection	4	0.11	4	0.63	20	0.60	28	0.37
Other causes	30	0.85	2	0.32	29	0.88	61	0.81
All causes	49	1.38	11	1.74	72	2.17	132	2.17

Table 10 Relative mortality ($\times 100$) in current cigarette smokers by number of cigarettes smoked (standardised for age), and by age of starting to smoke, inhalation, and type of cigarette smoked (standardised for age and number smoked)[†]

	Men					Women
	Ischaemic heart disease	Cerebrovascular disease	Lung cancer	Chronic bronchitis	All causes	All causes
Number of cigarettes smoked						
6-17	102	77	70	127	94	83
18-22	94	119	134	80	107	116
23+	105	121	118	(67) ^{††}	103	149
χ^2 (2 df)	0.46	1.60	7.90**	1.73	1.88	3.65
Age of starting to smoke						
<15	92	94	113	123	106	159
15-19	103	119	100	120	104	85
20+	102	67	88	36	87	103
χ^2 (2 df)	0.50	1.69	0.62	3.13	3.30	2.95
Inhalation						
Yes	104	101	101	98	103	96
No	48	(83)	82	(125)	55	124
χ^2 (1 df)	5.06**	0.06	0.24	0.08	9.10***	0.65
Type of cigarette						
Filter	104	121	89	81	101	102
Plain	99	70	107	113	99	79
Hand-rolled	65	(59)	(182)	(200)	95	—
χ^2 (2 df)	2.14	2.45	3.92	2.20	0.18	—
χ^2 (1 df filter v plain)	0.17	2.02	0.64	0.84	0.08	0.29

* $P < 0.1$ ** $P < 0.05$ *** $P < 0.001$ **** $P < 0.001$ [†]Each analysis is also standardised for study^{††}Bracketed figures unreliable as based on expected value of less than 5 deaths.

difference found for any of the causes of death considered in men, or for total mortality in women. We also investigated the possibility of a relationship between mortality and the tar yield of the cigarette. As there was little difference in mortality between filter and plain smokers, and as a relatively small variation in tar yields was observed between brands smoked in Survey 1, which produced the majority of the deaths observed, it was perhaps not to be expected that this analysis would show any significant results. And so it proved.

Discussion

Our findings on symptom prevalence are in many ways similar to those of Dean *et al.* (1978) in a representative study of the United Kingdom in 1972. Like us, they found that respiratory symptoms, and to a lesser extent cardiovascular symptoms, were far more prevalent in current smokers and that, among the different groups of smokers, symptom levels were higher in those who smoked heavily and in those who inhaled. They also observed, as we did, that while men had higher phlegm rates than women, the reverse was true for shortness of breath. There were, however, a number of differences between the studies. Firstly, Dean *et al.* tended to record rather higher rates of wheezing and shortness of breath and lower rates of angina. Secondly, they did not report findings on the age of starting to smoke, with which we were able to demonstrate a marked negative association. Thirdly, and most importantly, while Dean *et al.* found, with the exception of morning cough, which we did not

study, that smokers of filter cigarettes had only slightly and non-significantly lower symptom prevalence rates than smokers of plain cigarettes, we did find a number of substantial differences, especially in women, where smokers of filter cigarettes had, on average, about 30% lower prevalence rates. We were also able to demonstrate, for some symptoms, that smokers of lower tar cigarettes tended to have lower prevalence rates than smokers of higher tar cigarettes of the same type (filter or plain).

Comparison of our mortality findings with other studies is less straightforward, partly because of the relatively small numbers of deaths observed and partly because of differing definitions of smoking groups. However, there appear to be a number of similarities. For example, our finding that male current cigarette smokers have a death rate from all causes twice that in the never smoked group is broadly comparable with the findings by Doll and Peto (1976), Hammond (1966), Kahn (1966), and Godley (1974). So, too, is our finding of a very large excess risk of lung cancer in current cigarette smokers. The fact that we found no significant association of 'all causes' mortality with the number of cigarettes smoked or the age of starting to smoke, although surprising at first sight, probably reflects the fact that these associations are relatively weak and the number of deaths relatively small. Indeed, the associations we found are not significantly different from those found, where they are available, in the above mentioned four studies. Similarly, though the association between inhalation and total

male mortality was rather more marked in our study than it was in the studies of either Doll and Peto or Hammond, close examination shows that our finding is within the range of that expected from these larger studies.

Our finding, however, that men smoking filter and plain cigarette have an estimated relative risk of total mortality of 1.02, with approximate 95% confidence limits of 0.86–1.23, probably does differ significantly from that to be expected from the findings of Dean *et al.* (1977), who reported relative risks of 0.54, 0.66, 0.75, and 0.68 for lung cancer, chronic bronchitis, ischaemic heart disease, and cerebrovascular disease respectively. It is, however, not significantly different from the much smaller difference between filter and plain cigarette smokers' death rates found by Todd *et al.* (1978), or from that expected from Hammond *et al.* (1976) in their comparison of death rates in smokers of low, medium and high tar-nicotine cigarettes.

Our study, in general, confirms the associations of smoking with both mortality and prevalence of symptoms that have been found by other workers. However, in regard to the comparison of smokers of filter and plain cigarettes, we have found, compared with previous evidence, a rather greater advantage for filter smokers in terms of symptom prevalence and no advantage in terms of mortality. In view of these discrepancies, and the importance of obtaining reliable information on this comparison and on that between smokers of lower and higher tar cigarettes, more data seem urgently needed.

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