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Mortality from tobacco in developed countries: indirect estimation from national vital statistics

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Prolonged cigarette smoking causes even more deaths from other diseases than from lung cancer. In developed countries, the absolute age-sex-specific lung cancer rates can be used to indicate the approximate proportions due to tobacco of deaths not only from lung cancer itself but also, indirectly, from vascular disease and from various other categories of disease. Even in the absence of direct information on smoking histories, therefore, national mortality from tobacco can be estimated approximately just from the disease mortality statistics that are available from all major developed countries for about 1985 (and for 1975 and so, by extrapolation, for 1995). The relation between the absolute excess of lung cancer and the proportional excess of other diseases can only be approximate, and so as not to overestimate the effects of tobacco it has been taken to be only half that suggested by a recent large prospective study of smoking and death among one million Americans.

Application of such methods indicates that, in developed countries alone, annual deaths from smoking number about 0·9 million in 1965, 1·3 million in 1975, 1·7 million in 1985, and 2·1 million in 1995 (and hence about 21 million in the decade 1990–99: 5–6 million European Community, 5–6 million USA, 5 million former USSR, 3 million Eastern and other Europe, and 2 million elsewhere, [ie, Australia, Canada, Japan, and New Zealand]). More than half these deaths will be at 35–69 years of age: during the 1990s tobacco will in developed countries cause about 30% of all deaths at 35–69 (making it the largest single cause of premature death) plus about 14% of all at older ages. Those killed at older ages are on average already almost 80 years old, however, and might have died soon anyway, but those killed by tobacco at 35–69 lose an average of about 23 years of life.

At present just under 20% of all deaths in developed countries are attributed to tobacco, but this percentage is still rising, suggesting that on current smoking patterns just over 20% of those now living in developed countries will eventually be killed by tobacco (ie, about a quarter of a billion, out of a current total population of just under one and a quarter billion).

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Introduction

In countries where cigarette smoking has been common for many decades, tobacco now accounts for a substantial proportion of premature deaths.[1,2] This paper provides estimates for early middle age (35–59), later middle age (60–69), and old age of mortality in developed countries from tobacco during the last few decades of the 20th century. For one particular country in one particular year, its main method is to take the national mortality rates from various categories of disease, and to attribute certain proportions of deaths from those disease categories to tobacco. These attributable proportions vary from one category to another, being largest for lung cancer, upper aerodigestive cancer and chronic obstructive pulmonary disease (COPD),

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intermediate for vascular disease, and zero for cirrhosis, accidents, and violence. They also vary with age, sex, and country, being largest in populations where lung cancer is common.

For most developed countries large, nationally representative studies of smoking and mortality are not yet available to provide tobacco-attributable proportions for the main causes of death. Here, these proportions are therefore estimated indirectly, based partly on a large recent prospective study by the American Cancer Society of smoking and mortality among more than a million US adults.[3] That study found that throughout middle age the death rates of current cigarette smokers (most of whom had smoked regularly throughout adult life) were more than twice the rates of non-smokers, who had never smoked regularly. Its results, combined with US smoking patterns, have been used by the US Surgeon-General to estimate that tobacco was responsible for about one-fifth of all US deaths in 1985:[4]

*1985 US deaths attributed to tobacco by US Surgeon-General**

Lung cancer from (active or passive) smoking	110 000
Cancers of other specified sites (eg, mouth, oesophagus, pharynx, larynx, pancreas, cervix, kidney, bladder)	31 000
Cancer of an unspecified site	Not estimated
Coronary artery or cerebral vascular disease	143 000
COPD	57 000
Other vascular or respiratory	45 000
Other medical causes (eg, peptic ulcer)	Not estimated
Fire or neonatal	4000
Total attributed by US Surgeon-General to tobacco (two-thirds male, one-third female)	390 000

*In 1985, there were 2·1 million US deaths.[5]

Only 28% of those tobacco-attributed US deaths involved lung cancer, however (see below).

The hazards of tobacco depend strongly not only on current but also on previous smoking patterns,[6,7] and on several co-factors[8-10] So, the US prospective study cannot be extrapolated directly to other populations, either in the present or, especially, in past decades. Even if the age-specific prevalence of smoking were known, there could be important differences between current smokers in the target population and in the US study. Other methods are therefore needed for other populations, and the chief novelty of the present report is that the *absolute* lung cancer rate in a particular population is used to indicate the *proportions* of the deaths from various other diseases to attribute to smoking. Thus, for example, the high lung cancer rate in the US indicates not only that a large proportion of all US lung cancer deaths are due to smoking (since the US rates are so much higher than would be expected among non-smokers) but also, indirectly, that a moderately large proportion of all other US deaths are due to smoking. Conversely, the low lung cancer rate among Spanish women (which differs hardly at all from what might be expected if none had ever smoked) suggests not only that few of their lung cancer deaths are yet due to smoking but also, indirectly, that few of their other deaths are yet due to the habit.

Such methods do require some form of age-sex-specific "calibration" of the approximate relation between absolute lung cancer rates and the proportions of other diseases attributable to smoking. The ideal might involve nationally representative prospective studies in several very different developed countries. Generally, however, such studies are not yet available so a cruder calibration has been adopted, based on the mortality experience during the 1980s of the current cigarette smokers and never-smokers in the US prospective study.[3] (Actually, the calibration involves attributing to causal effects of smoking none of the deaths from external causes, none of cirrhosis and only half the excesses of diseases other than lung cancer and cirrhosis indicated by that study: see below.)

Once some approximate calibration has been devised, the use of absolute lung cancer rates to estimate the proportions of deaths from other diseases attributable to smoking has the practical advantage that it requires only the national age-sex-specific mortality rates from various causes (which generally are available), and not national details of age-sex-specific past smoking histories (which generally are not). It has also the theoretical advantage that for diseases other than lung cancer it would not be materially biased by differences in other factors that increase by similar percentages the risk among smokers and the risk among non-smokers (for, such an increase will not change the proportion of such deaths that is attributable to smoking). Examples of such "multiplicative confounding" factors might include alcohol[10] for upper aerodigestive cancer or blood lipids[8] or blood pressure[9] for vascular disease.

TABLE I—CIGARETTE SMOKERS VERSUS "NON-SMOKERS" (NEVER SMOKED REGULARLY). SELECTED RISK RATIOS* FROM YEARS 3 TO 6 INCLUSIVE (APPROXIMATELY 1984–88) OF ACS CPS-II PROSPECTIVE STUDY OF ONE MILLION US ADULTS (SEE APPENDIX)

ICD-9	Male	Female
Lung cancer (ICD 162)	24·22	12·50
Upper aerodigestive cancer—mouth, pharynx, larynx or oesophagus (ICD 140–150 and 161)	7·87	6·95
Other cancer (rest of ICD 140–209)	1·69	1·20
Chronic obstructive pulmonary disease (ICD 490–2, 492–6)	13·82	14·21
Cirrhosis, accidents and violence (ICD 571 and 800–999)	—	—
Other medical causes (rest of ICD 000–799)†		
age 35–59	3·05	2·69
" 60–64	2·31	2·68
" 65–69	2·09	2·52
" 70–74	2·00	2·00
" 75+	1·54	1·44

*Risk ratios are standardised by the method of Mantel and Haenszel for whichever are relevant of the age groups 30–34, 35–39, 40–44, , 75–79, and 80+

Female risk ratios may rise in future years in the US, at least in the older age groups as women who have smoked for only part of their lives are replaced by lifelong smokers

†Except in extreme old age, the chief other medical causes were vascular disease, particularly coronary heart disease and stroke. For vascular diseases alone, those age-specific risk ratios were 3 45, 2 33, 2·01, 1 87 and 1 53 for males, and 2 96, 2 89, 2·53, 2 09 and 1 43 for females (and depended similarly on age for stroke and for CHD[4])

Materials

Prospective study of a million Americans

The American Cancer Society's second Cancer Prevention Study (ACS CPS-II) is a prospective study of smoking and death among more than one million Americans aged 30 or older when they completed a questionnaire in 1982.[3] In 1992, when the current 6-year results were abstracted, mortality follow-up was virtually complete for the first two years, and about 98–99% complete for the next four. Because some conditions that cause death in the first two years might have affected smoking habits at entry, analysis is restricted to years 3–6 inclusive, and relates deaths (subdivided by cause, sex and 5-year age group at the time of death) to person-years (multiplied by 0·985, to allow for the slight incompleteness in 1992 of the mortality follow-up) for those who in 1982 had never smoked regularly, and for those who were then current cigarette smokers (see Appendix). Most of the latter are lifelong cigarette smokers with a mean consumption of about 20 cigarettes per day.[13] In the US,[11] most male smokers under 80 and female smokers under 50 in 1980 had begun smoking in their teenage years, but many older

TABLE II—MORTALITY FROM SELECTED DISEASES IN VARIOUS MIDDLE-AGED POPULATIONS (DEATH CERTIFICATION RATES PER 100 000 AGED 55–64 IN 1985)

						USA (ACS prospective study)		
Cause of death	Sex	All "developed" countries	EC: 12 countries	Former USSR	USA	Current cigarette smoker	Never smoked regularly	67% current + 33% never
Lung cancer	M	205	199	265	221	296	12	202
	F	41	33	26	91	164	12	114
Oesophageal cancer	M	23	25	32	19	18	4	13
	F	5	4	8	5	7	0	5
Ischaemic heart disease	M	422	367	609	475	407	160	325
	F	142	95	234	163	117	40	92
Cerebral vascular disease	M	150	100	307	63	52	19	41
	F	106	59	216	47	37	11	28
Respiratory disease	M	112	91	180	102	70	12	51
	F	41	33	47	57	51	9	37
All causes	M	1771	1600	2320	1693	1464	502	1147
	F	866	750	1051	919	815	357	664

Sources: National mortality rates are from the *WHO Statistics Annuals*, and US smoker and non-smoker rates are from years 3–6 of a prospective study of smoking and mortality in a million US adults (American Cancer Society second cancer prevention study: ACS CPS-II).

female smokers had started several years later, so limiting their lung cancer risk.[10] The machine-measured tar levels per US cigarette were about 15 mg in the early 1980s, but had been double this 25 years earlier.[12]

For many diseases, the absolute death rates among the non-smokers and the smokers in the CPS-II study cannot be generalised even to the US, let alone to other populations. For example, the probability that a 35-year-old man will die before 70 is 34% at US 1985 death rates, but only 13% and 32% at the non-smoker and smoker death rates in years 3–6 of CPS-II. This discrepancy is partly because those who agree to join such a study may be of higher socioeconomic status or more interested in health than average (and therefore at lower than average risk of certain diseases). And partly because of the "healthy volunteer" effect: those who already had some evidence of life-threatening disease in 1982 might, as a result of it, have been less likely to join CPS-II, causing much lower death rates during the first year or two (and, unless the disease was something rapidly fatal such as lung cancer, somewhat lower death rates even in years 3–6). Hence, it is only for lung cancer that use will be made of the absolute risks in CPS-II. For all other diseases, it is just the relative risk that will be used (ie, the ratio of the rate among smokers to that among non-smokers), since this ratio may well be more widely generalisable, both to the USA and to some other developed countries, than the absolute risks are.

The relative risks in CPS-II below age 45 are based on only small numbers of deaths among smokers, and are therefore somewhat unreliable (as, for other reasons, are the death rates in extreme old age). The rates from ages 45 onwards are more reliable, and in each 5-year age group from 45 to 74 the death rates of the smokers are more than double those of non-smokers: see Appendix. (Even beyond age 75 they are almost double the non-smoker death rates.) If this approximately twofold difference was largely caused by tobacco, then it would suggest that in each age range about half the deaths of the smokers were caused by tobacco. A persistent twofold difference at each age due to tobacco would mean that about half of all regular cigarette smokers would eventually, either in middle or in old age, be killed by their habit. If, conservatively, it was assumed that "only" two-thirds of the observed more-than-twofold mortality excess is caused by tobacco then the CPS-II study would still suggest that about 40% of all regular cigarette smokers would eventually be killed by their habit.

The main purpose of obtaining the full data (see Appendix) was to match the absolute lung cancer rate in some mixture of CPS-II smokers and CPS-II non-smokers with the absolute lung cancer rate in a particular country, and then to use the proportional excess of various other causes of death in that mixture as a guide to the proportions of those other diseases in that country that might be due to tobacco. For this, the smoker and non-smoker lung cancer rates are needed (Appendix), along with the risk ratios (smoker versus non-smoker) for various groups of diseases (table I).

In table I all upper aerodigestive cancers (ICD-9 140-150, 161) are combined, for statistical stability and because the main such cancers have similarly extreme relative risks with respect to tobacco and with respect to alcohol. Likewise, all vascular diseases are combined because the relative risks for ischaemic heart disease and for stroke depend similarly on age in CPS-II[4] and because the vital statistics may, particularly in old age, interchange some vascular causes of death. Cirrhosis, accidents, and violence are excluded because it is almost impossible to get reliable evidence as to whether smoking can cause them. (Smokers are more likely to commit suicide and to die from cirrhosis, but in the present report no such deaths will be attributed to smoking.)

Routine population and mortality statistics

Age-sex-specific population estimates for each separate developed country are available for five-yearly time periods from 1965 to 2025.[15] For present purposes it is chiefly the populations aged over 35 that will be used, and since people aged over 35 in 2025 were born before 1990, these population estimtes are not affected by uncertainties in future birth rates.

Mortality statistics provided routinely by all major developed countries are published in the WHO's *World Health Statistics Annuals*.[5] Data for 1965, 1975, and 1985 are used here, subdivided by country, by sex, by 5-year age group, and by nine major cause-of-death categories: lung cancer, upper aerodigestive cancer (mouth, pharynx, larynx, oesophagus), other cancer, COPD, other respiratory disease, vascular disease, cirrhosis, other medical causes, and non-medical causes. From these, all-cause death rates for 1995 are estimated by proportional extrapolation of the 1975 and 1985 rates for each country, age, and sex category (subject to the restriction that there should be no more than a twofold difference between a 1985 and a 1995 rate), and the proportion of each such all-cause death rate to attribute to particular causes will be determined by similar extrapolatin of the nine cause-specific rates.

For East Germany, a similar procedure was used to estimate the unavailable 1965 rates by back-extrapolation from the 1975 and 1985 rates. A few other data deficiencies were filled in by applying adjacent rates to the UN population estimates[15] in the relevant years (Belgium, 1986 for 1985; Luxembourg, 1967 for 1965; Romania, 1984 for 1985), and Romanian 1965 cause-specific death numbers in 10-year age ranges (5–14, 15–24, . . ., 65–74, 75+) were subdivided into 5-year numbers (5–9, 10–14, . . ., 80–84, 85+) in the same proportions as Romanian 1969 all-cause mortality. The 1965 Israeli statistics used are those for Jewish deaths only. For secular comparability, subtotals for the twelve European Community (EC) countries in 1965, 1975, or 1985 include all 1992 EC territories. (East and West Germany, although analysed separately, count here as one.) In 1985, 99·8% (10·34 million) of the deaths over age 35 were in the twelve EC and eighteen largest other developed countries. So, in calculating the EC or developed world totals, 0·2% is added to the uncorrected totals and no separate analyses are presented for the 0·02 million deaths in smaller developed populations (0·01M Albania + 0·01M others: Andorra, Channel Is, Faeroes, Gibraltar, Greenland, Iceland, Isle of Man, Lichtenstein, Malta, Monaco, San Marino, Vatican City).

Methods

In estimating the overall scale of the epidemic of death from tobacco in developed countries, there is a range of uncertainty between the lower limits and the upper limits of what is scientifically plausible, and the present report tends to base its calculations chiefly on the lower limits. The uncertainty derives not so much from the million deaths each year from lung cancer, upper aerodigestive cancer, and COPD (the great majority of which can, with only a narrow range of uncertainty, be attributed to tobacco), but from the nine or ten million other deaths each year in developed countries (another million of which may, albeit with a wider range or uncertainty, also be attributed to tobacco). Vascular diseases—chiefly coronary heart disease (CHD) and stroke—account for more than half these other deaths, and the CPS-II study suggests that, at least in North America, tobacco is associated with more deaths from vascular disease than from lung cancer. But, whereas virtually all the excess risk of lung cancer that is associated with smoking in the US (Appendix) is actually caused[10] by the habit, this may not be true for vascular disease: part of the association (table I) may well be due to other differences between US smokers and US non-smokers. Alternatively, if some cardioprotective factor (alcohol use, perhaps) is more common among smokers than among non-smokers then the real cardiotoxicity of tobacco might be underestimated by table I. Hence, even within the CPS-II prospective study itself there is some uncertainty as to what fraction of the vascular mortality among smokers is actually caused by smoking.

Further uncertainties are added when extrapolating from CPS-II to other populations, since even though for lung cancer mortality the absolute rates attributable to smoking in two populations may be equally high, that does not guarantee that for vascular mortality the porportions attributable to smoking in the two populations must be exactly equal to each other. For example (table II), lung cancer mortality just among the middle-aged male smokers in CPS-II is about the same as among all middle-aged males in the USSR, and vascular mortality among the middle-aged male smokers in CPS-II is about 200% higher than in the corresponding non-smokers. Possibly, therefore, vascular mortality among middle-aged USSR males as a whole is also about 200% higher than if none had ever smoked. Perhaps, however, once due allowance has been made for confounding and for the problems of extrapolation from one population to another, this excess percentage in the USSR might be only 100%, not 200% (ie, perhaps only about half, not two-thirds, of the male vascular deaths in middle age are attributable to tobacco).

Conservative underestimation of tobacco hazards

The present report subdivides the diseases that cause death into a few broad categories, and is then conservative in determining what proportions to attribute to tobacco. Conservatively, deaths from external causes (including fires, suicides, and accidents), neonatal deaths (including stillbirths), all other deaths under 35 years, and all deaths from cirrhosis of the liver will not be attributed to tobacco, even though some of these deaths are due to smoking. Lung cancer is dealt with by comparison of the absolute rates in each country with those among US non-smokers. The remaining six disease categories (upper aerodigestive cancer, other cancer, COPD, other pulmonary disease, vascular disease and other medical causes) are dealt with by calculating (on an age-specific basis) the excess percentages suggested indirectly by the national lung cancer rates, and then simply halving each excess percentage, in the hope of obtaining a conservative estimate of the proportions of such deaths to attribute to tobacco (see Discussion).

In populations with high tobacco-attributable mortality from upper aerodigestive cancer or from COPD, halving the large percentage excess makes little difference. For example, whether the excess is 400% or whether it is 800%, the large majority (either 4/5 or 8/9, in this example) of all such deaths will still be attributed to tobacco. But where only a minority of the deaths are attributable to tobacco, halving the percentage excess will almost halve the number attributed to tobacco.

Halving the percentage excess is crude and arbitrary, and although it provides a reasonable degree of protection against overestimation of the epidemic, it does so at the risk of somewhat underestimating the hazards. The degree of underestimation will not be great, however (since the possibility of confounding does have to be allowed for, particularly in diseases where the excess among smokers is only moderate—and the halving has a substantial effect only in these circumstances). Indeed, for the United States itself in 1985 the "conservative" procedures of the present report (by analyses only of national mortality rates) will be found to attribute to tobacco almost exactly the same number of deaths as the US Surgeon-General did by combination of national mortality rates with additional data on the prevalence of smoking in the US. Details of the conservative procedure are summarised below.

Ignore deaths under age 35—Most deaths from tobacco are in middle or old age and, conservatively, attention will be restricted to these. Neonatal deaths, and all other deaths from tobacco before age 35, will therefore be ignored.

Ignore cirrhosis and non-medical causes—Cirrhosis is commoner among smokers than among non-smokers, as is suicide, but it is difficult to assess how much, if any, of these excesses to attribute to smoking. Deaths from cirrhosis (ICD-9 571) will therefore be ignored, along with deaths from suicide, fires and all other external causes (ICD 800-999).

Lung cancer at ages 35–79: compare with US non-smokers—In developed countries, lung cancer is so rare among non-smokers that big studies are needed to describe reliably their age-specific death rates from the disease. The two largest prospective studies of smoking, each of which involved over a million people, both took place in the US, one (CPS-I) in the 1960s and one (CPS-II) in the 1980s. Comparing the lung cancer mortality among the non-smokers (never smoked regularly) in these two studies, there was no significant trend over the 20-year period that separated them[4] (and no significant difference between these studies and the smaller study of British doctors[10]). So, the US non-smoker lung cancer rates in CPS-II (Appendix) may approximately describe non-smokers in other developed countries. Among Spanish women, for example, where smoking cannot yet be causing much lung cancer (since only a few per cent of those in later middle age are smokers) the lung cancer rates are still like those of the US female non-smokers. (Among young Spanish women, however, about half now smoke, and if they continue to do so then when they eventually reach later middle age high death rates must be expected.)

The similarity of non-smoker lung cancer death certification rates in different developed countries is only approximate, for there will be differences not only in the extent to which other diseases are mis-certified as primary lung cancer, or vice versa, but also in the effects on non-smokers of other causative factors such as general air pollution or occupation (or, perhaps, some infective, nutritional or hormonal factors).[10] Among non-smokers, however, the disease is rare even in polluted areas—indeed, even radon and asbestos may cause only a small absolute risk among those who have never smoked. So for each sex the tobacco-attributable lung cancer in each country is estimated by subtracting the smoothed US non-smoker rates in the Appendix from the national rates (with no lung cancer deaths attributed to tobacco in any of the age groups 35–59, 60–64, 65–69, 70–74 or 75–79 in which the national rate was less than the US non-smoker rate or, conservatively, in any subsequent age group): also, because the rates at older ages may be unreliable or unstable, in each population the fraction of lung cancer attributed to smoking was taken to be the same at 80+ as at 75–79.

Other diseases at ages 35–79: conservative halving of apparent excess attributed to tobacco—For the other diseases, a more complicated procedure is needed to estimate the fractions attributable to tobacco, since it cannot be assumed that the absolute rates among non-smokers will be comparable in different populations. First, using the 5-yearly lung cancer rates from the Appendix, a mixture of CPS-II smokers and CPS-II non-smokers aged 35 to 79 is constructed, with the proportions of smokers at ages 35-59, 60–64, 65–69, 70–74 and 75–79 chosen to make the lung cancer rates in each of these age groups in the mixed population equal to those in the country to be analysed. (The ratio of the non-smoker lung cancer rates to the national rates in these five

TABLE III—ALL DEVELOPED COUNTRIES, 1985 MORTALITY: SMOKING-ATTRIBUTED DEATHS/TOTAL DEATHS, IN THOUSANDS

Ages	Sex	Lung cancer	Upper aerodig. cancer	Other cancer	COPD	Other respiratory	Vascular disease	Cirrhosis	Other medical	Non-medical eg, fire, suicide	All fatal conditions
35–69	M	203/217	47/69	64/362	71/87	14/45	297/876	*/90	78/227	*/242	774/2216 (35%)
	F	37/56	4/13	7/399	19/41	3/22	54/496	*/42	18/156	*/84	141/1307 (11%)
70+	M	134/148	19/34	48/383	126/179	15/136	180/1567	*/32	37/321	*/75	561/2876 (20%)
	F	29/48	4/16	6/455	42/120	6/155	72/2462	*/30	16/472	*/91	175/3850 (5%)
All ages†	M	338/367	66/103	112/772	197/270	30/229	477/2470	*/128	115/726	*/536	1335/5601 (24%)
	F	65/104	8/29	13/878	61/163	9/216	126/2972	*/76	34/758	*/236	316/5433 (6%)

*Any relationship of these deaths with smoking is ignored
†Includes 784 (000) deaths at ages 0–34

separate age groups determines the proportions not attributed to tobacco.) Second, using for other diseases relative risks from table I (which are taken as if they were independent of age for cancer and for chronic obstructive pulmonary disease), determine the excess in each age group as a percentage of the non-smoker rates. Finally, for a particular disease category in a particular age group, the method of extrapolation from this mixed population to the target country is to assume that the proportion of deaths due to smoking is similar in the target population and in the mixed population. But, it cannot be assumed that all the excess mortality among smokers in the CPS-II study was actually caused by tobacco. Upper aerodigestive cancers, for example, are caused both by tobacco and by alcohol, and smokers may drink more than non-smokers. Likewise, even among non-smokers many diseases are inversely related to social class, and so too is smoking. Hence, in CPS-II part of the excess mortality among smokers may be due to factors other than tobacco. To ensure that the hazards of tobacco are not exaggerated, the excess mortality in the mixed population will be halved before estimating the fraction of deaths attributable to tobacco. For example, if the mixture had 7 times the COPD mortality of non-smokers (ie, a 6-fold excess) then instead of 6/7 of the COPD deaths being attributed to tobacco, only 3/4 would be, a 3-fold excess. In countries where lung cancer is common this does not greatly reduce the fractions of COPD or upper aerodigestive cancer deaths attributed to tobacco, but it does substantially reduce the fractions of other deaths attributed to the habit. This simple halving of the excess risk is obviously not a satisfactory procedure, for it is crude and arbitrary and may seriously under-estimate some of the true hazards of tobacco. Prospective studies in a number of countries of smoking, mortality and various possible confounding factors should eventually clarify the local hazards that are actually caused by tobacco, but in most countries these are not yet available.

Ages 80+: use 75–79 proportions—Because lung cancer rates are particularly unreliable in extreme old age, the proportions of each disease category attributed to smoking will simply be taken to be the same at 80+ as at 75–79.

Results

Does the method produce any obviously anomalous results? Only if its results are generally plausible can their implications be explored. Although brief results will be given for 1965 and 1975, chief emphasis will be on the results for 1985 (the last year for which the results are based on actual mortality rates), on approximate extrapolations to 1995 (the first year for which the results might be directly relevant to current planning of preventive strategies), and on the longer-term trends.

1985 mortality by disease category

Table III gives for 1985 the numbers of tobacco-attributed deaths from various categories of disease. The results are subdivided into middle age (35–69) and old age (70+). Scrutiny of table III does not reveal any obvious implausibilities in particular causes of death, except perhaps for some uncertainty about the large number of "other medical" deaths attributed to smoking. This is such a minor category of death in North America that the excess seen in the CPS-II study cannot reliably be extrapolated to populations where such deaths are common. (Note, however, that some of these "other medical" deaths in national mortality statistics include tobacco-related conditions such as peptic ulcer, tuberculosis, or even some misclassified deaths from a respiratory, neoplastic or vascular cause.)

1985 mortality by age, loss of life expectancy.

Table IV gives, for the same 1985 deaths, a more detailed breakdown by age. The estimates are not reliable below age 45, where the CPS-II study provides only limited data, but the number of deaths attributed to tobacco at these early ages is small. For other reasons,[10] the estimates are also less reliable in old age (particularly above age 80) than in middle age.

From table IV it is possible to estimate the loss of 1985 life expectancy from death at various ages from smoking, since subtraction of the tobacco-attributed deaths leaves the 1985

TABLE IV—AGE DISTRIBUTION OF TOBACCO-ATTRIBUTED DEATHS, ALL DEVELOPED COUNTRIES, 1985, AND YEARS LOSS OF LIFE EXPECTANCY PER DEATH FROM SMOKING (AT THE DEATH RATES REMAINING WITHOUT THE DEATHS ATTRIBUTED TO TOBACCO*)

	Males			Females		
Ages	Deaths (1000) Attrib/Total	Popn. (mill.)	Years lost	Deaths (1000) Attrib/Total	Popn. (mill.)	Years lost
35–39	23/102	42·0	39·1	3/46	42·1	42.4
40–44	34/122	33·6	34·5	4/58	34·3	37·7
45–49	72/215	35·2	30·1	8/101	36·8	33·0
50–54	109/292	31·3	25·7	13/143	33·2	28·5
55–59	184/448	30·5	21·6	24/236	34·6	24·2
60–64	187/512	23·7	17·6	44/335	31·4	20·0
65–69	166/525	16·4	14·0	45/387	23·0	16·1
70–74	210/785	15·2	10·8	59/699	23·8	12·5
75–79	155/836	10 3	8·1	37/914	18·2	9·5
80–84	112/674	5·5	6·0	35/972	11·4	7·1
85+	84/580	2·8	4·0	45/1264	7·4	4·0
0–34	–/509	321·3	**	–/276	311·1	**
35–69	775/2216	212·8	21·5†	141/1306	235·4	22·0†
70+	561/2875	33·8	8·1	176/3849	60·8	8·6
All	1336/5600	567·9	15·9	317/5431	607·3	14·6

Note: Estimates in old age (especially above age 80) may not be reliable.
*Non-smoker life expectancy in a 5-year age range is taken as the mean of that at the start and end of it. At age 85 non-smoker life expectancy is taken as 5 years (male) or 6 years (female), at ages 85+ 4 years (male or female), and at ages 80, 75, .., 40, 35 as 2·5+(2·5+life expectancy 5 years later) × (probability of surviving 5 more years). If R is the death rate in a particular 5-year period then the probability of surviving that period is exp(−5R), which would, for example, be exp(−5(0·512−0 187)/23·7) for men aged 60 without the deaths attributed to tobacco.
**Since the age distribution from 0 to 34 is fairly uniform, the crude death rates can be used to estimate survival (95% male, 97% female) from birth to 35. But, among those now aged 0–34 most have already escaped the risks of infancy and childhood, so at current death rates larger proportions (98% and 99%) will survive to 35, and so to risk of death at 35–69
†22 1 and 22·5 at projected 1995 rates (with no change at older ages).

TABLE V—TRENDS IN MORTALITY ATTRIBUTED TO TOBACCO, AND IN ALL MORTALITY, IN DEVELOPED COUNTRIES (NO.=THOUSANDS OF DEATHS, RATE=RATE PER HUNDRED THOUSAND, STANDARDISED FOR AGE*)

		(a) All mortality, irrespective of tobacco							b) Mortality attributed to tobacco					Mortality not attributed to tobacco: (a)–(b)	
		0–34		35–69		70–79		80+	35–69		70–79		80+	35–69	70–79
		No.	Rate	No	Rate	No.	Rate	No	No.	Rate	No	Rate	No.	Rate	Rate
Male: Lung cancer	1965	1	0	134	100	43	256	8	123	91	36	215	7	(9)	(41)
	1975	1	0	175	115	79	380	18	162	107	70	338	15	(8)	(42)
	1985	1	0	217	130	113	446	36	203	121	102	404	32	(9)	(42)
	1995	**1**	**0**	**292**	**145**	**140**	**535**	**66**	**275**	**137**	**129**	**493**	**61**	**(8)**	**(42)**
Male: Any cancer	1965	31	11	483	357	213	1324	82	189	139	54	323	13	218	1001
	1975	31	10	564	367	297	1472	114	247	161	103	498	28	206	974
	1985	29	9	647	383	386	1548	180	314	184	148	586	54	199	962
	1995	**24**	**8**	**802**	**394**	**419**	**1614**	**259**	**424**	**208**	**181**	**695**	**95**	**186**	**919**
Male: Any fatal condition	1965	665	220	2079	1512	1187	7561	833	573	415	163	969	62	1097	6592
	1975	607	199	2308	1457	1449	7380	991	703	450	294	1412	125	1007	5968
	1985	509	159	2216	1282	1621	6625	1255	774	444	365	1440	196	838	5185
	1995	**392**	**124**	**2429**	**1171**	**1493**	**5864**	**1478**	**941**	**452**	**392**	**1487**	**285**	**719**	**4377**
Female: Lung cancer	1965	1	0	24	14	10	38	3	9	5	2	7	0	(9)	(31)
	1975	1	0	38	19	17	51	7	20	10	7	20	2	(9)	(31)
	1985	1	0	56	27	33	79	15	37	18	20	48	8	(9)	(31)
	1995	**1**	**0**	**84**	**36**	**54**	**126**	**28**	**63**	**27**	**41**	**95**	**19**	**(9)**	**(31)**
Female: Any cancer	1965	27	10	419	235	190	766	95	12	7	3	11	1	228	755
	1975	25	9	452	225	241	738	135	27	14	9	27	4	211	711
	1985	25	8	467	221	310	747	209	47	23	26	63	12	198	684
	1995	**22**	7	**505**	**213**	**321**	**751**	**280**	**78**	**34**	**51**	**118**	**28**	**179**	**633**
Female: Any fatal condition	1965	427	141	1382	798	1235	5122	1263	50	28	16	57	6	770	5065
	1975	342	116	1426	718	1457	4596	1682	97	49	43	124	28	669	4472
	1985	276	90	1307	631	1614	3976	2236	141	69	96	224	79	562	3752
	1995	**208**	**70**	**1342**	**571**	**1406**	**3385**	**2690**	**198**	**86**	**150**	**343**	**160**	**485**	**3042**

*Standardised rates are means of seven 5-yearly rates, or of the two rates for 70–74 and 75–79.

Notes: 1995 estimates (in bold type) use national age-specific projections of rates, plus published populations [15]

The lung cancer death rates (in brackets) that are not attributed to tobacco have been forced to be approximately constant

death rates that would have been expected in the absence of smoking. Both for males and for females, the average loss of 1985 life expectancy from smoking for those killed by the habit in middle age (35–69) is about 22 years. Indeed, even for those killed in later middle age (60–69) the mean loss is about 16 years, while for those killed by the habit in early middle age (35–59) it is about 27 years. But, many of those killed by the habit in old age (70+) might have have died soon anyway, since their average age at death was about 80. At present, therefore, deaths in early middle age (35–59) account for about half of the loss of life expectancy attributed to smoking, deaths in later middle age (60–69) account for about half of the remainder of it, and deaths in old age (70+) account for under a quarter of the total.

The actual loss of life expectancy of those now being killed by tobacco should, however, be calculated not at 1985 or 1995 non-smoker death rates, but at the progressively lower non-smoker death rates of future years. This will hardly alter the 8-year loss of life expectancy of those killed by tobacco in old age, but will increase the loss of life expectancy of those killed by tobacco in middle age by one or two additional years beyond the 22 years in table IV. Those now being killed by tobacco in middle age are therefore losing about 23 years of non-smoker life expectancy.

Trends in the mortality that is not due to tobacco (table V).

For 1965, 1975, 1985 and (by projection) 1995, table V gives a more detailed breakdown not only of the crude numbers of deaths (which are affected by the size of the population) but also of the standardised death rates (which are not). The analyses are subdivided by age and sex, and are presented separately for lung cancer, for any cancer and for any fatal condition. For each such category of disease, table V gives: *(a)* all mortality, irrespective of tobacco; *(b)* the mortality that is attributed to tobacco; and then, by subtraction, *(c)* the remaining mortality that is not attributed to tobacco. It is the age-standardised rates in table V that are of particular interest, and these are calculated from 0–34, 35–69 and 70–79. Deaths above 80 are not included in these rates, for no sufficiently accurate assessment of the effects of tobacco is possible.

At ages 0–34 the overall mortality is low, the proportion caused by tobacco is small, and the age-standardised death rate is decreasing rapidly. (Both in males and in females it decreased by about one-third over the 20-year period from 1965 to 1985, from an average for both sexes of 181 per 100 000, corresponding to a 6% risk of death by age 35, down to 125, corresponding to a 4% risk.)

At ages 35–69 and at ages 70–79 the male and the female lung cancer mortality rates are both increasing, but the male and female all-cause mortality rates are both decreasing. This suggests that tobacco is responsible for a growing proportion of a decreasing total. In males these opposite effects result in approximately constant overall death rates being attributed to tobacco, but in females the overall death rates attributed to tobacco are beginning to grow rapidly, though they are still far smaller than the male rates.

Cancer—In the present decade, about one-third of all cancer deaths in developed countries are attributed to tobacco (in table V for 1995 the numbers of thousands of cancer deaths attributed to tobacco are: males 700/1504 [47%]; females 157/1128 [14%]; both sexes 857/2632=33%). During the 1960s this proportion was much smaller (table V for 1965: 272/1540=18%). These changes in the proportions of cancer deaths that are attributed to tobacco are so large that the effects of tobacco have

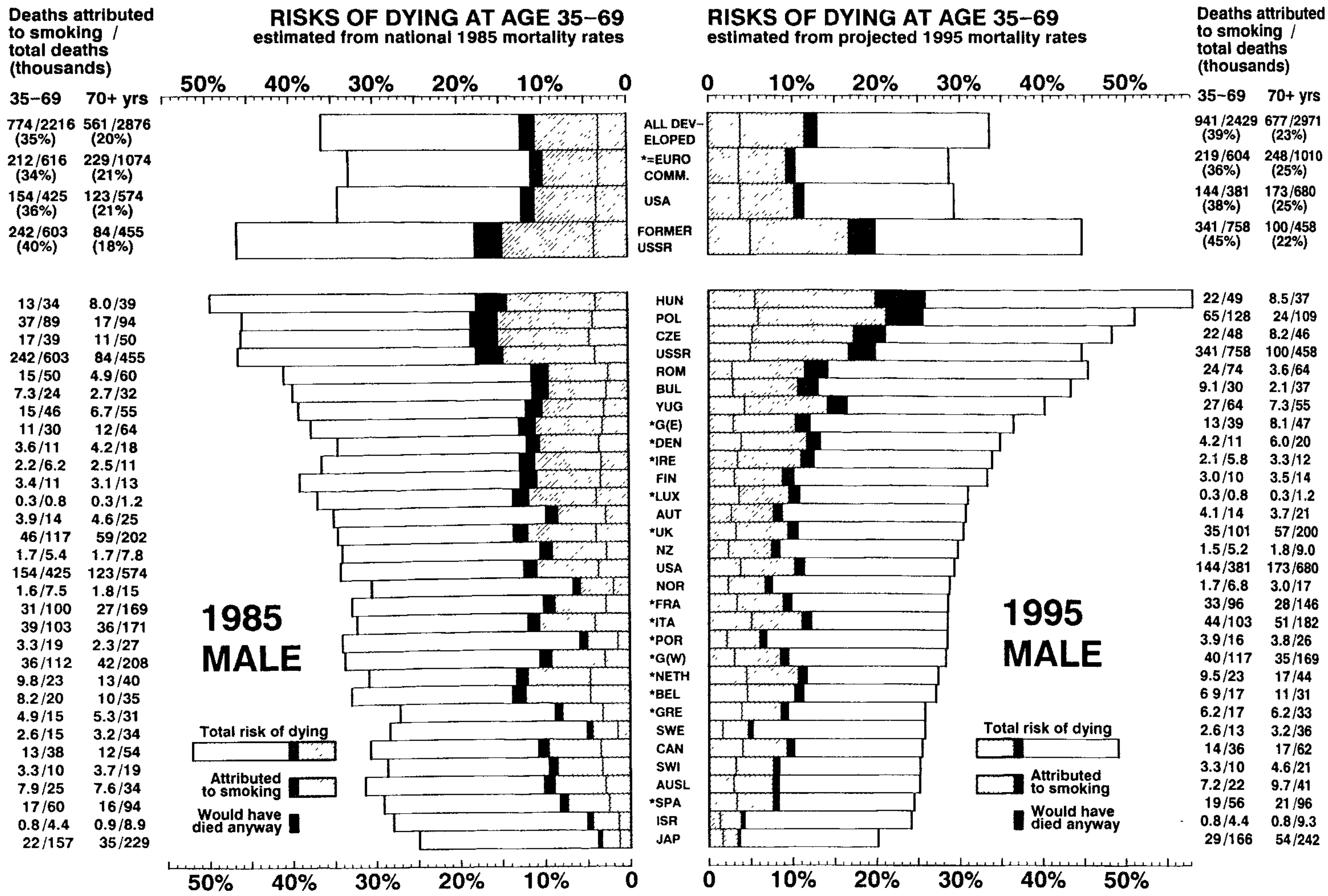

Fig 1—Males, 1985 and 1995: numbers of deaths and risks of death attributed to tobacco and not attributed to tobacco, in various developed populations.

Columns of numbers give deaths (in thousands) attributed to smoking/total deaths, for ages 35–69 and for ages 70+. Bar lengths give risks at age 35 of dying before age 70, at the national death rates of 1985 (left) and at the projected death rates of 1995 (right): total bar length = total risk of dying at 35–69, and solid-plus-shaded bar length = risk of dying from tobacco at 35–69 (solid = would have died before 70 of some other causes; shaded = would have survived to 70 or more; and, within the shaded area, the part between zero and the thin vertical line = probability of dying of lung cancer at age 35–69).

dominated the male trends in overall cancer mortality over the past few decades, causing increases where decreases would otherwise have existed, and are likely to dominate the female trends over the next few decades. Subtraction of the estimated effects of tobacco from the overall trends in cancer mortality (table V, right-hand columns) suggests that, among people who have never smoked, overall cancer death certification rates in developed countries have been decreasing fairly steadily over the past few decades in old age (70–79), in middle age (35–69) and at earlier ages (0–34). The interpretation of such trends has been discussed elsewhere.[10]

All-cause mortality—If, again, the effects of smoking are allowed for by subtraction of the tobacco-attributed deaths, then for the all-cause mortality rates in developed countries that are not attributed to tobacco the decrease is even more striking than for the cancer mortality rates (table V, right-hand columns). Thus, over the past few decades in developed countries non-smokers appear to have experienced decreasing overall cancer mortality rates, together with even more rapidly decreasing mortality from other diseases. (In the particular case of the United States the non-smoker trends can be confirmed directly, since the CPS-I study in the 1960s included many non-smokers, whose experience has been compared[4] with the non-smokers in CPS-II in the 1980s.)

Mortality by country (figs 1 and 2)

Fig 1 (males) and fig 2 (females) describe, for various developed countries or groups of countries, the mortality attributed to tobacco in middle age (35–69) and at older ages. The overall bar lengths (shaded plus white) describe the probabilities of death in middle age, and the shaded parts (hatched plus black) describe the probabilities of death in middle age that are attributed to tobacco. In each figure, the left half describes the analyses of actual 1985 mortality rates, while the right half describes the analyses of projected 1995 mortality rates. Both in 1985 and in 1995, the risks of death in middle age are almost twice as great for males as for females, partly because the male risks currently attributed to smoking (shaded areas) are higher and partly because the other male risks (white areas) are also higher.

Among males (top of fig 1), the lengths of the bars for "all developed countries" indicate that the overall risk of death at ages 35–69 was 36% at the 1985 death rates and 34% at the 1995 rates. In both cases, the risk of death attributed to tobacco was 13%. If this figure of 13% were to continue to be approximately constant for a few decades, it would suggest that about 13% of all men aged 35 in developed countries would be killed by tobacco before 70.

Among females (top of fig 2), the bars for "all developed countries" indicate that the overall risk of death at ages 35–69 was also decreasing (20% at 1985 rates, 18% at 1995 rates). But the risk of death from tobacco at ages 35–69 was increasing (from 2% to 3%) and until, perhaps a few decades hence, it stabilises it cannot be used directly to estimate probabilities of female death in middle age.

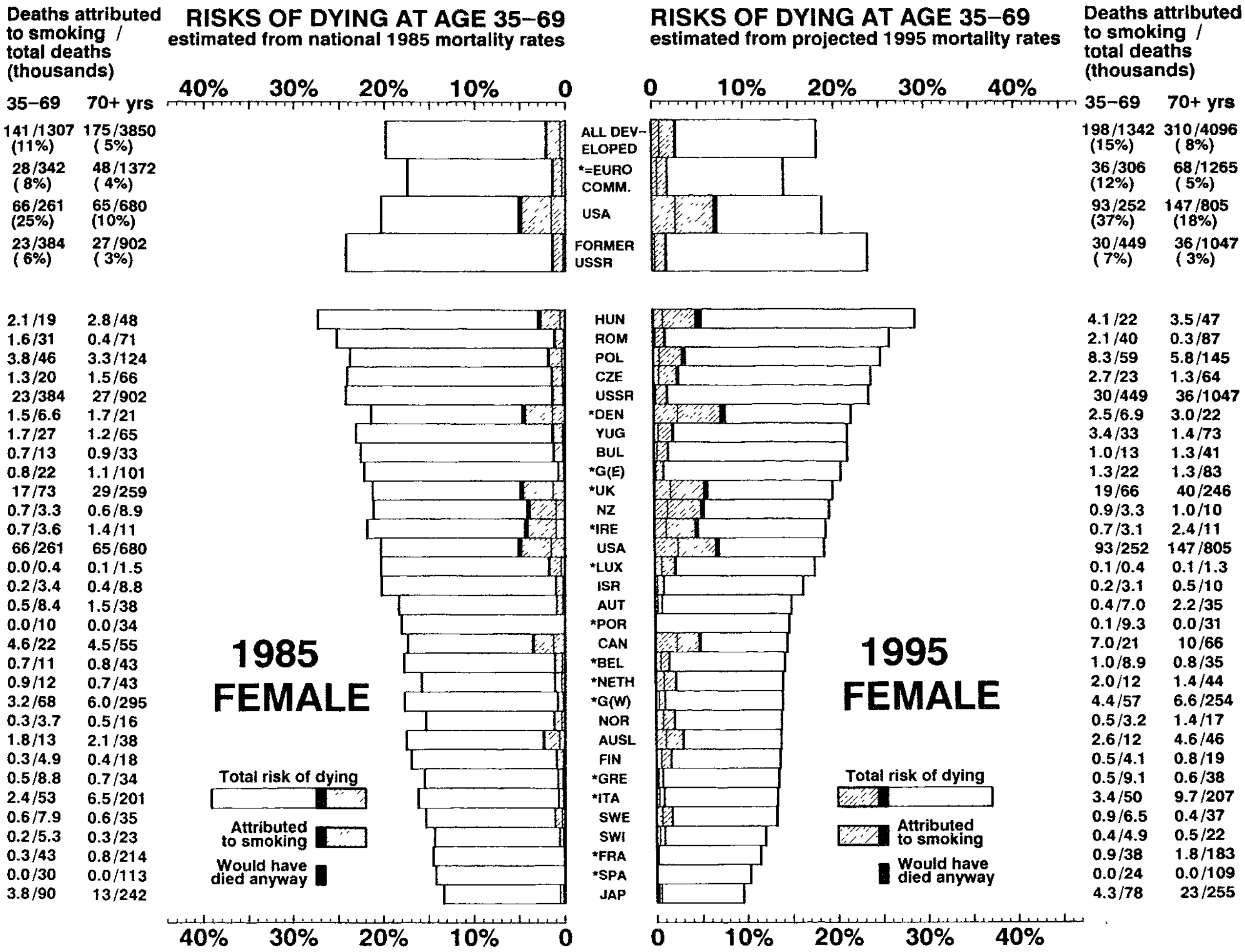

Fig 2—Females, 1985 and 1995: numbers of deaths and risks of death attributed to tobacco and not attributed to tobacco in various developed populations (format as in fig 1).

The overall numbers of deaths (in thousands, male plus female) attributed to tobacco in 1995 were 1139/3771 (30% of all deaths) in middle age and 987/7067 (14% of all deaths) at older ages, the years lost being about 23 each for the former and 8 each for the latter. This predicts a grand total of 2·1 million tobacco-attributed deaths in 1995, of which about 590 000 involve lung cancer. (The vertical lines inside the shaded areas in figs 1 and 2 indicate the lung cancer rates: since the lung cancer prediction is the most reliable, a crude check on the plausibility of this total of about 2 million can be provided by noting that it is 3 or 4 times larger than the lung cancer prediction, this ratio being similar to that in the Surgeon-General's estimate[4] that in 1985 there were about 400 000 tobacco-attributed deaths in the US, of which 110 000 involve lung cancer: see Introduction).

For males (fig 1), the pattern of international differences shows that the epidemic of premature death from tobacco has already become substantial in all developed countries. The all-cause death rates in middle age are especially high in Eastern Europe, one major reason for this being tobacco (shaded areas), and East European death rates are in many cases still increasing. For instance, at the projected 1995 death rates, about half of all Polish males aged 35 could expect to die before 70, with about half these Polish deaths attributed to tobacco. By contrast with this, however, only about a quarter of all Swedish males aged 35 could expect to die before 70, with only about one-fifth of these Swedish deaths attributed to tobacco. However, tobacco is not the only reason for the high male death rates in Eastern Europe because female death rates there are also high.

For females (fig 2), the absolute risks of death in middle age are smaller than for males, and the proportions attributed to tobacco of those deaths are also smaller than for males—indeed, in countries such as France, Spain, and Portugal, the female lung cancer rates are about the same as in US non-smokers, suggesting very small numbers of deaths from tobacco. But, in a few countries the female lung cancer rates are rising rapidly: for example, the proportion of US female deaths attributed to tobacco has risen from 25% at the 1985 death rates to 37% at the 1995 rates, a proportion that is higher in the US than in any other country. At the projected 1995 death rates, about half a million female deaths are atrributed to the habit, including 240 000 in the US and 60 000 in the UK. The low rates in France, Spain, and Portugal are plausible, as are the high rates in the US and UK. What is less plausible in fig 2, however, is that in countries such as the former USSR, a few percent of the female deaths are attributed, perhaps mistakenly, to tobacco. (Even though the female USSR lung cancer death certification rates in 1985 were consistently slightly higher than in US non-smokers, they were, at least in middle age, not yet rising, which suggests that the female epidemic had scarcely begun in the USSR.) But, both in middle and in old age, most of the female deaths attributed to tobacco in fig 2 are from countries such as the Uk or US where the lung cancer epidemic was already well advanced in 1985, so the overall estimates for females remain plausible.

Taking all developed countries together, the European Community (EC), the US and the former USSR each account for about a quarter of the population. Totals for these groupings are shown separately (thick bars) at the top of figs 1 and 2, and longer term trends for the numbers of deaths attributed to tobacco in these groupings are shown in fig 3. For males (or for males and females together), the largest absolute number of tobacco-attributed deaths is in the EC, but for females, the largest number is in the US, and

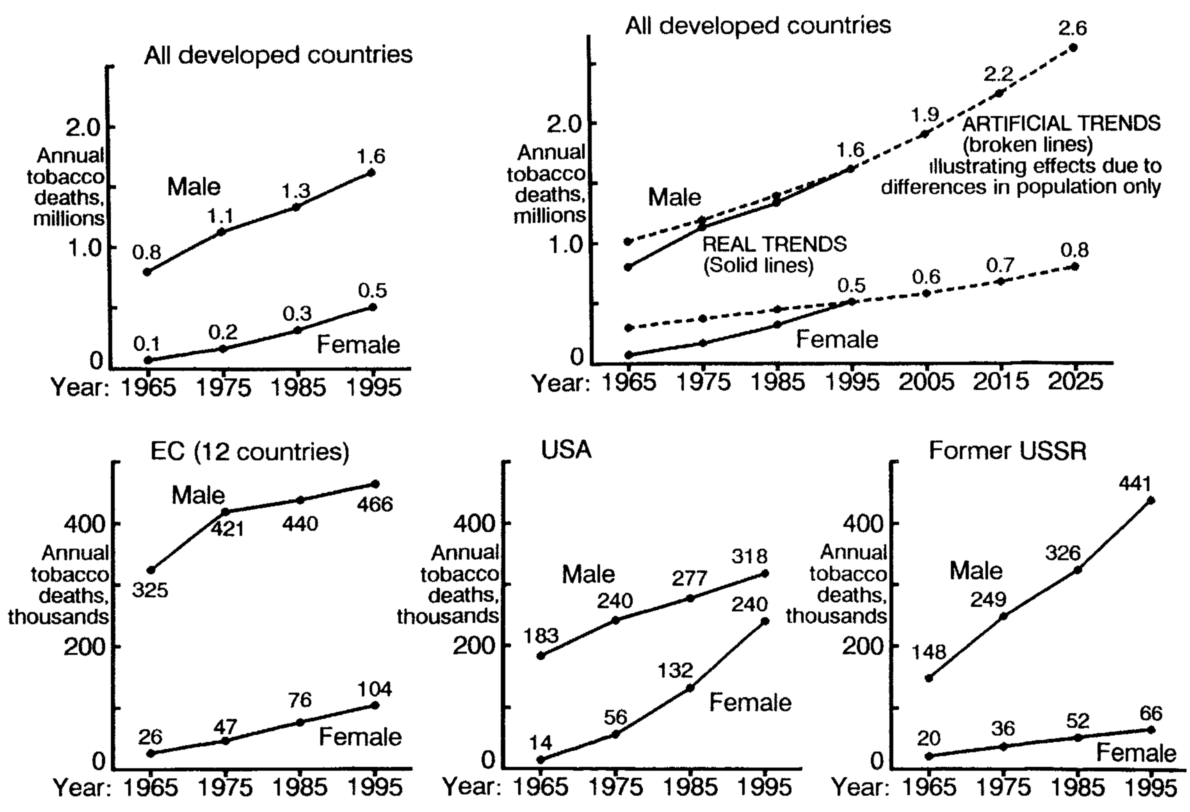

Fig 3—Smoking—attributed deaths in 1965, 1975, 1985, and 1995.

Together with artificial calculations, applying the 1995 tobacco-attributed death rates for all developed countries to the pouplations in other years, 1965–2025, at ages 35–39, 40–44, ..., 80+.

the trends in US tobacco-attributed mortality in fig 3 suggest that the epidemic will, in a decade or two, be killing about as many women as men in the US. (The age-specific rates are lower for women than for men not only for tobacco-attributed deaths but also for other deaths, so the proportion who die of tobacco may eventually be similar for both sexes.)

The trends in fig 3 in the absolute numbers of tobacco-attributed deaths are affected not only by changes in death rates from tobacco but also by changes in the sizes of the populations. For all developed countries together, the effects of population changes alone (broken lines in fig 3) are compared with the real trends. For males, the similarity of the slopes of the broken and the solid lines indicates that the increase in the annual number of deaths is due chiefly to population growth, whereas for females the difference between the slopes shows that the increase is due not just to population growth but, still more, to increasing death rates.

If these constant male death rates from tobacco were to persist for a few more decades, then the annual numbers of male deaths from tobacco would grow from about 1·6 million in 1995 to about 2·6 million by 2025. But the increase in the female rates suggests that the annual numbers of female deaths from tobacco over the next few decades will, on present smoking patterns, become progressively larger than is indicated by the broken line in fig 3. By 2025, therefore, there could well be substantially more than a million female deaths a year in developed countries from tobacco.

Discussion

The strengths and weaknesses of the present method of assessing mortality from tobacco in developed countries were discussed as it was introduced and used. The general conclusion was that in such countries it is likely to be reasonably reliable in middle age but somewhat less reliable at older ages. One simple check on its plausibility is provided by its findings for the United States. Based only on US national mortality data, without the use of any data on smoking habits in the US, it attributes 408 000 US deaths to tobacco in 1985, and 52% fewer in 1965. The US Surgeon-General, by a completely different method that does make use of data on smoking prevalence rates and contemporary relative risks in the US (which might not be available elsewhere) attributes about 390 000 US deaths to tobacco in 1985, and 47% fewer in 1965.[4] This similarity reinforces the plausibility of the present method, at least for populations that are not too different from the US over the past few decades. But, the more different the population or the epoch, the more uncertain the results of the method must be. The plausibility of its overall conclusions will therefore be assessed by discussion not only of the few largest populations that make the largest contributions to the overall total, but also of the populations with the most extreme risks attributed to tobacco.

Populations with low risks, with high risks, or with large absolute numbers of deaths attributed to tobacco

For males, the populations with the lowest and the highest proportions of deaths in middle age now attributed to tobacco are, respectively, Japan (17%) and Poland (50%), and the absolute hazards are even more extremely different than these proportions would suggest (fig 1). A large census-based prospective study of the effects of tobacco already exists in Japan,[16] with results for Japanese males that are reasonably compatible with fig 1. At the projected 1995 Polish death rates about half the males aged 35 would expect to die before 70, with about half of these deaths attributed to tobacco. Direct evidence, preferably from a large, reasonably representative prospective study in a country such as Poland, is needed to test this prediction, to monitor future trends in tobacco-attributable mortality and to seek co-factors that might explain why smoking appears to be even more dangerous in Eastern Europe than elsewhere. Occupational factors and general air pollution must be contributing to differing extents to the lung cancer rates in various countries, and may be particularly important in Eastern Europe. But, they are not likely to be major determinants of the international mortality patterns,[10] and the present approximate methods therefore remain appropriate.

For females, the populations with the lowest and with the highest proportions of deaths in middle age attributed to tobacco are, respectively, Spain (0%) and the USA (37%). In Spain a very low risk is reasonable, as female smoking is rare in middle age and is common only among young women (whose tobacco-attributable death rates will eventually become high if they continue to smoke as they age). In the US a high female death rate from tobacco is well documented for 1985, and a steep trend is well documented from 1965 to 1985.[4] The prediction that there will, during the current decade, be particularly high female death rates from tobacco in the United States is therefore securely based on reliable data from large prospective studies in the same country,[4] and in view of the steep increase in US female mortality from tobacco that is now in progress even larger numbers of deaths from tobacco must be expected among US females during the first few years of the next century.

The validity of the overall estimates for all developed populations in the current decade depends chiefly on the validity of the larger contributions. For females, much the largest contribution involves the reliable estimates from the United States. On average during the 1990s, tobacco is expected to cause about a quarter of a million female deaths a year in the US plus about a quarter of a million female deaths a year in other developed countries. (The second largest contribution is from UK females.) Because the US hazards are well documented, the grand total of half a million female deaths a year (ie, about 5 million female deaths from tobacco in developed countries during the whole decade 1990–1999) can be accepted as reliable.

In each population most of the deaths attributed to tobacco are male, so male mortality is closely correlated with overall (male plus female) mortality from the habit. Either for males alone or for males and females together, the greatest annual number of deaths currently attributed to tobacco in any developed population is in the European Community (fig 3). It is estimated that in the EC there will be about 570 000 deaths per year from tobacco during the current decade, of which about a quarter of a million will still be in middle age (35–69). Within the EC, the countries with the greatest numbers of deaths currently attributed to tobacco are the UK (150 000 per year) and Germany (111 000 per year), although the highest risk of death in middle age from tobacco in the EC (and the most rapid increase in this risk) appears to be in Denmark. A large collaborative European prospective study is currently being organised through the International Agency for Research on Cancer that will monitor the evolution of this epidemic throughout the EC, as well as seeking particularly reliable evidence on possible co-factors for the hazards of tobacco. Within the EC, the UK is the country with much the largest number of deaths attributed to tobacco, and a number of studies of the habit have been conducted there. None, however, has been on a representative sample of the population. All estimates of UK mortality from tobacco have therefore used indirect arguments. A recent estimate of 110 000 deaths a year by the UK Health Education Authority[17] is lower than the present estimate of 150 000 (perhaps because it failed to allow appropriately for the delay between the decrease in male smoking prevalence and the decrease in male death), but is not grossly different.

Extrapolation to future decades

Extrapolation to 1995 is reasonably secure, but the further into the next century the risks are extrapolated (fig 3) the more uncertainty there must be about the age-specific death rates from tobacco. Substantial uncertainty about the age-specific death rates in future decades need not, however, imply similarly large uncertainties about the absolute annual numbers of deaths, for even large changes in death rates (such as, for example, the decreases in causes other than tobacco of vascular mortality) may not have much effect on the proportion of deaths attributable to tobacco. Hence, the age-specific death rates of the future from current smoking patterns cannot be predicted reliably, as they depend on other factors, but the approximate annual number of deaths in the future from tobacco can be.

At the 1995 tobacco-attributed mortality rates among people of a given age there would be about 3·4 million deaths from tobacco in 2025 (2·6 million male plus 0·8 million female: these numbers are larger than the 1·6 million male and 0·5 million female in 1995 only because of population growth). But, although the male tobacco-attributed death rates may, on current smoking patterns, be approximately stable (as they have been for the past few years), the female rates are rising rapidly—indeed, although the age-specific risks are lower for females than for males, if women smoke like men then the US example shows that the absolute number of female deaths from tobacco may eventually be about as great as the male number. The uncertainties in the future predictions are greater than those in the current estimates, but even though the decreasing male death rates from tobacco that have been achieved in a few developed countries may be extended to more developed countries over the next few decades, the female death rates from tobacco are now increasing rapidly and, taking men and women together, of all deaths the proportion attributed to tobacco will for several years continue to increase. Hence, on current smoking patterns in developed countries, at least 3 million deaths a year from tobacco must be expected in 2025, and the actual number could well be considerably higher than this. The UK was the first country to experience high male lung cancer rates, but even in the UK the disease was rare until the second quarter of this century, so worldwide extrapolation of the numbers in fig 3 backwards to low numbers a few decades before 1965 (and taking the number in each decade to be ten times the annual number) indicates that deaths in developed countries from tobacco probably numbered in total "only" a few million from 1930 to 1959, followed by about 9 million in the 1960s, 13 million in the 1970s, 17 million in the 1980s, 21 million in the 1990s and, at the 1995 tobacco-attributed death rates (which will not, of course, really remain constant), 25 million, 29 million and 34 million over the next 3 decades. These numbers total about 150 million from 1930 to 2029, including about 50 million in the 60-year period from 1930 to 1989 and about 100 million in the 40-year period from 1990–2029. Although crude, such estimates suffice to provide a useful guide to the approximate scale of tobacco-related mortality that must be expected in the next century.

An alternative approach to the assessment of these future hazards is to note that in the mid-1990s about one-fifth (2·1 million/10·8 million: figs 1 and 2) of all deaths in developed countries were already attributed to tobacco, and that on current smoking patterns (especially among females) this proportion may well increase a little over the next few decades but is not likely to decrease. This suggests that about one-fifth of the people now living in developed countries (ie, about a quarter of a billion out of one-and-a-quarter billion) will, on current smoking patterns, eventually be killed by tobacco, losing an average of about 15 years of life expectancy per death.

The present methods are obviously crude, and the presentation of a mass of apparently precise figures should not be taken to suggest otherwise. Hence, because the growing worldwide epidemic of premature death from tobacco is so great, its detailed evolution needs to be monitored accurately by large, reliable prospective studies in a number of developed countries (and, particularly importantly,[18] in a number of less developed countries). Such studies could assess not only the effects of tobacco but also some of the factors that importantly modify those effects. The large pattern is, however, now clear: in developed countries tobacco is already causing about two million deaths a year this number is still increasing, and about half those killed by the habit are still only in middle age, making tobacco much the most important cause of premature death. Elsewhere, the epidemic is generally at an earlier stage but recent large increases in cigarette use in countries such as China means that tobacco will, in a few decades, also become one of the most important causes of premature death in less developed countries.[18]

This report originated from the WHO Consultative Group on Statistical Aspects of Tobacco-related Mortality: R. Peto (chairman), A. D. Lopez (scientific secretary), T. Novotny (rapporteur), C. Chollat-Traquet, P. C. Gupta, K. Kuulaasma, M. Parkin, K. D. Stanley. L. Garfinkel first provided CPS-II data, Sir Richard Doll provided helpful criticism, and Gale Mead provided secretarial support (and harrassment).

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Appendix: Annual mortality rates per 100,000 in years 3-6 inclusive (approximately 1984-1988) of ACS CPS-II prospective study

Age at death	Current / Never smoker	Lung cancer		Upper aero-dig cancer		Other cancer		COPD		Other respiratory		Vascular disease		Cirrhosis		Other medical		Non-medical		All causes		Person-years (100,000s)	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
35-9	C*	0	7	0	0	0	52	0	0	18	0	55	7	27	7	46	13	64	20	211	104	0 1091	0 1533
	N	7	3	0	0	14	42	0	0	0	0	14	16	0	3	27	0	27	3	89	68	0 1456	0 3081
	(n)	(2)	(2)																				
40-4	C*	23	12	0	4	30	39	0	0	0	4	128	19	0	0	53	16	105	27	338	120	0 1333	0 2580
	N	0	0	7	0	22	70	0	0	0	2	14	15	14	2	7	2	36	17	100	109	0 1393	0 4576
	(n)	(3)	(3)																				
45-9	C	35	49	13	2	45	79	0	3	3	7	209	60	16	2	48	27	61	15	430	243	0.3113	0 5960
	N	9	4	0	0	44	98	0	0	0	5	53	17	0	1	28	5	28	12	162	142	0.3211	1 1687
	(n)	(5)	(4)																				
50-4	C	114	71	29	3	117	139	14	11	4	7	312	93	10	6	46	21	51	14	698	367	0.7625	0 9679
	N	5	5	2	2	71	120	1	1	5	3	86	31	4	2	25	13	27	13	226	188	0 8141	1 9652
	(n)	(7)	(7)																				
55-9	C	227	136	23	11	217	228	27	24	30	20	477	164	19	9	68	52	62	27	1150	669	0 8538	1.0187
	N	3	8	7	1	113	174	3	1	8	6	149	54	1	1	42	29	28	16	355	290	0 8792	2.2411
	(n)	(10)	(10)																				
60-4	C	375	195	54	30	342	300	53	42	32	18	772	298	24	19	118	66	51	12	1821	980	0 7524	0 8987
	N	11	14	6	3	197	239	4	3	9	7	331	103	12	4	60	32	32	17	663	422	0 8057	2 2740
	(n)	(14)	(14)																				
65-9	C	599	310	77	18	567	404	170	101	83	35	1170	553	36	19	188	135	43	24	2934	1600	0 5058	0.6218
	N	24	18	10	4	303	338	7	7	24	12	583	219	7	7	82	57	40	15	1081	676	0.6967	1 9256
	(n)	(20)	(19)																				
70-4	C	899	339	93	48	778	593	324	166	141	67	1977	868	52	11	413	182	96	35	4773	2307	0 2904	0 3746
	N	36	28	12	4	505	449	22	11	57	35	1059	415	8	11	148	107	59	27	1906	1089	0.5053	1 4328
	(n)	(27)	(26)																				
75-9	C*	1168	429	106	36	1380	584	572	250	327	131	3243	1715	82	24	645	292	82	83	7604	3544	0 1224	0 1679
	N	38	42	3	9	821	547	35	19	149	86	1981	961	14	9	391	213	73	46	3504	1932	0 2888	0.9590
	(n)	(35)	(34)																				
80+	C*	1191	400	154	71	1809	872	882	657	684	271	5537	3129	44	14	1103	857	287	57	11691	6330	0 0453	0 0700
	N	88	64	10	19	1264	778	124	54	599	277	4268	3237	0	14	888	573	165	70	7406	5088	0.1938	0 8289
	(n)	(46)	(44)																				

N B The absolute risks may be artificially low, but (except for lung cancer) only relative risks are used
The risks (at age 35) of dying at age 35-69 indicated by these all-causes death rates are: Males smokers 32%, non-smokers 13%; Females smokers 18%, non-smokers 9%
* Smoker rates based on less than 20,000 person-years C=Cigarette smoker in 1982, N=Never smoked regularly, (n)=Smoothed lung cancer rates for these non-smokers.
Smoothing 5-year age-groups with lower limits 35, 40, , 70, 75 involved the best-fitting line of slope 4 on a logarithmic graph of non-smoker rates vs these lower limits[14]