International Mortality and Smoking Statistics System (IMASS)

II. Relating mortality to previous smoking habits in 30 developed countries

IIB. Ischaemic heart disease

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EXECUTIVE SUMMARY

Sex- and age-specific IHD mortality in 30 developed countries has been related to smoking habits in the same birth cohort 5 years earlier. Three indices of smoking have been used; prevalence of cigarette smoking, consumption of cigarettes per adult unadjusted for tar and consumption of cigarettes per adult adjusted for tar. The definition of cigarette consumption includes hand-rolled as well as manufactured cigarettes.

Two types of correlation analysis have been used. One is conducted within-country and relates variations in mortality and smoking over time. The other is conducted at specific points in time and relates variations in mortality and smoking by country.

The first, within-country, analyses showed that in men in many countries there was a relatively strong positive correlation over time between smoking and IHD mortality. This was explained by a large decline in IHD mortality occurring over the last 30 years or so of the 20th century, a period when smoking in men also declined. However the extent of the mortality decline, in percentage terms, often considerably exceeded the decline in smoking. Furthermore there were a number of countries where little correlation or even a negative correlation was seen in males. In females, there was no consistent trend towards a positive correlation between IHD and smoking. Indeed negative correlations were seen more often than positive correlations.

The second, between-country, analyses showed that in men the general tendency was for countries with higher IHD mortality to have smoked less. Positive correlations were generally seen in women, however. The magnitudes of these correlations, though sometimes statistically significant, were never very strong, and there were still many examples of countries with similar smoking habits and widely varying mortality and of countries with similar mortality and widely varying smoking.

Overall the results do not suggest that variation in smoking habits alone is a major contributor to the marked changes in IHD mortality that have occurred in many countries over the second half of the 20th century or to the considerable variation in IHD risk between countries. In view of the very large number of determinants of IHD mortality, which include effects of treatment as well as genetic and environmental factors, this conclusion is unsurprising.

The IMASS database is limited by having data only on smoking as a risk factor, so that correlations with lung cancer and with non-acute respiratory disease, where smoking is widely considered a much more dominant factor than is the case for IHD, are more relevant. These are presented in separate reports.

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1. Introduction

The "International Mortality and Smoking Statistics System" (IMASS)[1] contains nationally-based data for 30 developed countries on mortality from major smoking-related diseases and on selected tobacco and smoking statistics. Part I of this report characterized and compared mortality trends, IA considering lung cancer, IB ischaemic heart disease (IHD) and IC chronic obstructive pulmonary disease (COPD) and respiratory diseases, non-acute (RDNA).

Part II of this report relates mortality from lung cancer, IHD and RDNA to previous smoking habits. COPD is not considered because of major changes over time in definition of the disease, as discussed in Part IC.

Two correlational approaches are used to investigate the relationship of mortality to previous smoking habits. One considers the relationship based on data over a range of time periods within a country. The other considers the relationship based on data for a set of countries at a given time. The first, within-country approach, is essentially asking the question "Can variations in mortality over a given time period within a country be explained by corresponding variations in previous smoking habits over the same period"? The second, between-country approach is asking the question "Do countries with high (or low) mortality at a given time tend to have correspondingly high (or low) previous smoking habits"?

Part IIB is concerned with IHD. Because it is generally considered that any effect of smoking is a fairly acute one, with the risk in those who give up smoking returning quite rapidly to those of never smokers, attention is restricted to smoking habits five years earlier. Thus, mortality for, say 70-74 year olds in 1991-1995 is studied in relation to the smoking habits five years earlier of members of the same birth cohort, i.e. of 65-69 year olds in 1986-1990.

It is recognized that the approach used is quite a simple and unsophisticated one. In view of variations in other risk factors, presence of a

statistically significant correlation does not imply a cause-and-effect relationship between smoking and IHD. Nor indeed does absence of a correlation imply absence of such a relationship. However, provided the smoking habit data used are accurate and relevant, some inferences can be drawn. For example, if mortality rises markedly over a period when smoking habits decline, it is reasonable to infer that factors other than smoking are responsible for the rise.

The main purpose of this report is to present the various relationships in an organized way to form a useful reference work. Some broad conclusions are reached, but detailed examination of all the various relationships presented has not been attempted.

2. Materials and methods

2.1 Countries included

The 30 countries for which data are available are listed in section 2.1 of part IA of this report, and shown in the tables of the present document. The country names relate to political boundaries as they existed pre-1990s.

2.2 Periods

Results are shown in the within-country analyses for the periods 1946-50, 1951-55 … 1996-2000. In the between-country analyses, attention is restricted to the periods 1961-65, 1976-80 and 1991-95.

2.3 Age groups

Attention is restricted to three age groups: 40-44, 55-59 and 70-74.

2.4 Definition of IHD

Section 2.3 and Appendix 1 of part I of this report gives details of when successive revisions of the International Classification of Diseases (ICD) came into use in each country and some general remarks about the problems of defining cause of death.

As noted in section 2.3 of part IB of this report, the definitions used in the 8th, 9th and 10th revisions are quite comparable, but the definitions used in the 6th and 7th revisions are somewhat broader. As the 8th revision came into force in 1968 or 1969 for virtually all the countries used, trends over time may be somewhat affected by the non-compatibility. However, in many cases the changes over time in mortality were much larger than any likely effect of this change in definition. No attempt has been made to adjust for it.

2.5 Smoking habits

Three indices of smoking have been used, all based on total cigarette consumption, i.e. of manufactured and hand-rolled cigarettes combined. "Prevalence" is the estimated percentage of the population who are current smokers, "Consumption" is the estimated daily number of cigarettes smoked per adult, and "Consumption (square root tar adjusted)" is the estimated daily

number of cigarettes smoked per adult multiplied by a factor $\sqrt{T/35}$ where T is the sales-weighted average tar consumption at the time. The square root adjustment is an attempt to take "compensation" into account, i.e. the tendency of smokers to increase the intensity of smoking following a reduction in the tar level of the brand smoked. Estimates of the three indices are not available for all countries in all periods studied.

2.6 Correlations

Correlations always relate mortality for a given age group in a given period to the estimated smoking habits of members of the same birth cohort five years earlier. Standard Pearson correlation coefficients (R) are presented, together with the number of data pairs (N) used for the correlation. Correlations are not calculated where N<3. The statistical significance of correlations can be obtained from Table 1.

2.7 Individual country tables (Tables I5.1 to I5.30)

Each page relates to one of the 30 countries. On each page, the relevant data (mortality and three smoking indices for each period from 1946-50 to 1996-2000) are shown separately for the two sexes x three age groups considered. At the end of each set of smoking data, the N and R values are shown.

2.8 Summary over countries (Tables I5.31 to I5.33)

A separate page for each smoking index summarizes the N and R values for all 30 countries.

2.9 Between-country correlations (Tables I6.1 to I6.16 and Figures I6.1 to I6.16)

There are separate pairs of pages for each combination of sex x age group (40-44, 55-59, 70-74) x period (1961-65, 1976-80, 1991-95). The left-hand page of each pair gives the relevant data for each country in a table, together with the estimated N and R values for the between-country correlations. The right-hand page presents the same data as scatter plots, one

for each of the three smoking indices. The R value from the table is repeated on the figure for convenience.

3. Results

3.1 Within-country analyses (Table I5)

Looking at the summary tables (Tables I5.31-33), it is evident that the completeness of the data varies markedly by index of smoking and by country. 28 of the 30 countries provide at least 3 data pairs for relating mortality to prevalence (Table I5.31), with USSR and Bulgaria the only countries for which correlations cannot sensibly be calculated. For 19 of the 28, there are at least 6 data pairs. For consumption (Table I5.32), correlations are available for 23 countries, with only 10 based on at least 6 data pairs. For tar adjusted consumption (Table I5.32), correlations are available for only 12 countries, with 5 based on at least 6 data pairs.

In the IHD mortality trends part of the report (IB), we noted that declines in IHD were most clearly marked in USA, Canada, Australia and Israel, with the extent of the decline broadly similar in both sexes and all age groups. In men, in these four countries, correlations were always high at each age group for prevalence and for tar adjusted consumption, and positive but not so high for unadjusted consumption. This reflected the coincident declines in mortality and smoking. For example, in the USA (Table I5.28), mortality and prevalence in 40-44 year olds were fairly constant up to 1966-1970 and then both started to decline markedly. Between 1966-1970 and 1996-2000 mortality declined by 74% and prevalence by 45%. Although the correlation is very high (R = 0.98), the decline in mortality is in fact much steeper than the decline in prevalence. This is also true for Canada, Australia and Israel.

In women, the correlations in these countries are much more variable. Correlations are always positive, and often high, in Australia. However, in the USA and Canada, correlations vary markedly by age, being positive at age 40-44 but negative at age 70-74. In Canada, for example, rates declined between 1971-1975 and 1996-2000 by 61% at age 40-44 and by 62% at age 70-74, while prevalence declined by 19% at age 40-44 (R = 0.84) and increased by 50% at age 70-74 (R = -0.96).

A general pattern of correlations tending to be much more likely to be positive in men than in women is evident when one looks at the overall data in Tables I5.31-33.

In men, correlations of mortality with all the smoking indices are consistently high (averaging at least 0.80) in Australia, Belgium, Canada, Finland, Germany, Iceland, Ireland, Ireland, New Zealand, Portugal, UK and USA. These are all countries where a decline in rates between 1971-75 and 1991-95 of at least 20% had been noted in the table on p 6 of part IB of this report. The correlations reflect the decline in smoking occurring over the same period as the decline in IHD mortality. However, as already noted for USA, the declines in mortality are sometimes steeper than would be expected were smoking wholly responsible for it. In some countries, however, correlations are negative. While the marked negative correlation with prevalence of R = -0.88 for Czechoslovakia for age 40-44 seems to be due to an unusually low prevalence estimate of 23.1% in 1981-1985 based on a single survey, that of -0.80 for Greece for the same correlation reflects a continuing rise in mortality over the period 1961-65 to 1996-2000 by 148%, while prevalence declined by 18%. Other countries showing no real evidence of a positive relation included Hungary, Poland, Switzerland and Yugoslavia. In Japan, there was some positive correlation for prevalence and tar adjusted consumption at all the ages studied but the correlation with unadjusted consumption was negative. Even where positive correlations were seen, the decline in mortality was substantially greater and started earlier than the decline in the smoking index.

In women, there is no consistent trend towards a positive association. This is clearly illustrated by summarizing the direction and magnitude of the R values shown in Tables I5.31-33.

Index	Age	Negative correlations Total	<-0.80	Positive correlations Total	>0.80	Number studied
Prevalence	40-44	11	1	17	8	28
	55-59	14	3	14	5	28
	70-74	19	5	9	5	28
Consumption per adult (unadjusted)	40-44	13	6	10	2	23
	55-59	13	3	10	1	23
	70-74	15	9	8	0	23
Consumption per adult (tar adjusted)	60-64	7	2	5	4	12
	55-59	6	2	6	3	12
	70-74	8	4	4	3	12
	Total	106	35	83	31	189

It can be seen that the number of negative correlations and markedly negative correlations ($R < -0.80$) somewhat exceeds the corresponding number of positive correlations and markedly positive correlations ($R > 0.80$). The excess is particularly marked for IHD at age 70-74. Attention can be drawn to Italy where, in all the age groups studied, mortality has declined hugely and essentially continuously between 1951-1955 and 1996-2000, in contrast to an increase in smoking over the same period.

3.2 Between-country analyses (Table I6 and Figure I6)

Between-country correlations have been estimated for each combination of sex, age (40-44, 55-59, 70-74), and period (1961-65, 1976-80, 1991-95). Earlier periods were not chosen due to the relatively small number of countries providing data, and even for 1961-65 numbers of countries are quite small, particularly for the tar adjusted data. The correlations are summarized in Table 2.

Of the 27 R values for males, 7 are positive and 20 are negative. Of the positive correlations, only three are of moderate size (0.40 or more) and only one is statistically significant ($p<0.05$). Two of the non-significant moderate positive correlations are seen for age 40-44 in 1961-1965. These are based on relatively few data points, and dominated by the high IHD rate and a high estimate of consumption per adult for the USA (white triangle). The only

significant positive correlation is for the data for age 40-44 and period 1991-1995 for consumption per adult. In contrast, there are ten correlations of –0.40 or less, four of which are statistically significant. A number of the plots show that Japan (yellow square) has a relatively low mortality and high prevalence or consumption of smoking, this contributing to the fact that so many of the correlations are negative. However, as Table 2 shows, even excluding Japan from the correlations, there is still little evidence of a consistent positive correlation.

While the data for males do not indicate any general tendency for countries with relatively high IHD rates to have a higher smoking prevalence or consumption, the data for females generally do show a positive correlation. As shown in Table 2, all of the 27 R values for females are positive with 20 exceeding R = 0.40. While a number of these are statistically significant (at $p<0.05$), the relationships are never that strong and leave much of the variation unexplained. For example, taking the large significant correlation, of 0.69 for age 55-59, period 1976-80 and unadjusted consumption, the scatter plot in Figure I6.14 shows that there are countries with similar consumption and widely varying mortality. For a consumption of about 2 cigarettes per adult per day, rates vary from 26.6 (per 100,000 per year) for France, through 69.2 for Yugoslavia and 75.3 for Austria to 127.4 for Finland. Similarly, there are countries with similar mortality and widely varying consumption. The correlations are generally not greatly affected by omitting Japan.

4. Summary and conclusions

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5. References

1. Forey BA, Hamling J, Lee PN. *International mortality and smoking statistics system. A brief description and user's guide*. Sutton, Surrey: P N Lee Statistics and Computing Ltd; 2002. www.pnlee.co.uk

TABLE 1 : Critical values of the correlation coefficient for statistical significance at $p<0.05$, $p<0.01$ and $p<0.001$

Number of pairs considered	Critical value of correlation coefficient* $p<0.05$	$p<0.01$	$p<0.001$
3	0.997	0.9999	1.000
4	0.950	0.990	0.999
5	0.878	0.959	0.991
6	0.811	0.917	0.974
7	0.754	0.875	0.951
8	0.707	0.834	0.925
9	0.666	0.798	0.898
10	0.632	0.765	0.872
11	0.602	0.735	0.847
12	0.576	0.708	0.823
13	0.553	0.684	0.801
14	0.532	0.661	0.780
15	0.514	0.641	0.760
16	0.497	0.623	0.742
17	0.482	0.606	0.725
18	0.468	0.590	0.708
19	0.456	0.575	0.693
20	0.444	0.561	0.679
21	0.433	0.549	0.665
22	0.423	0.537	0.652
23	0.381	0.487	0.597
28	0.349	0.449	0.554

* Values on or above the given value or on or below minus the given value are statistically significant at the level stated.

TABLE 2 : Summary of between-country correlation coefficients

Sex	Age	Period	Prevalence R	Prevalence R´	Consumption per adult (unadjusted) R	Consumption per adult (unadjusted) R´	Consumption per adult (tar adjusted) R	Consumption per adult (tar adjusted) R´
Male	40-44	1961-65	-0.24	-0.17	0.50	0.50	0.90	0.90
		1976-80	-0.27	-0.10	0.03	0.22	-0.09	0.20
		1991-95	0.33	0.48 *	0.45 *	0.66 **	-0.65	0.01
	55-59	1961-65	-0.21	-0.14	-0.07	0.15	0.12	0.82
		1976-80	-0.43 *	-0.29	-0.30	-0.16	-0.23	0.05
		1991-95	0.03	0.22	-0.02	0.24	-0.62	-0.23
	70-74	1961-65	-0.57 *	-0.53	-0.56	-0.56	0.39	0.39
		1976-80	-0.53 **	-0.44 *	-0.59 **	-0.51 *	-0.47	-0.22
		1991-95	-0.34	-0.15	-0.44	-0.28	-0.62	-0.27
Female	40-44	1961-65	0.02	0.12	0.55	0.55	0.53	0.53
		1976-80	0.40 *	0.35	0.55 *	0.49 *	0.66 *	0.59 *
		1991-95	0.09	0.03	0.60 **	0.58 **	0.80 *	0.74
	55-59	1961-65	0.51	0.50	0.77	0.77	0.72	0.72
		1976-80	0.67 ***	0.68 ***	0.69 ***	0.67 **	0.68 **	0.64 *
		1991-95	0.29	0.24	0.60 **	0.57 *	0.83 *	0.79 *
	70-74	1961-65	0.36	0.57 ***	0.70	0.70	0.62	0.62
		1976-80	0.48 *	0.57	0.45 *	0.51 *	0.36	0.44
		1991-95	0.37	0.36	0.48 *	0.44	0.50	0.38

R´ Correlations omitting Japan. * p<0.05 ** p<0.01 *** p<0.001
See Table I6 for data correlations based on.