International Mortality and Smoking Statistics System (IMASS)

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

IIC. Respiratory disease, non-acute (RDNA)

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Date : January 2004

EXECUTIVE SUMMARY

Sex- and age-specific mortality from respiratory disease (non-acute) in 30 developed countries has been related to previous smoking habits in the same birth cohort. Many of the analyses relate to smoking habits 20 years previously, but some analyses relate to average smoking habits over the period 15 to 5, 25 to 5 or 35 to 5 years previously. 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 no consistent evidence in females for time trends in mortality to be positively correlated with time trends in previous smoking. In males, analyses relating time trends in mortality to time trends in previous prevalence of smoking and to time trends in previous tar adjusted cigarette consumption tended markedly more often to show positive than negative correlations, but analyses relating time trends in mortality to time trends in previous cigarette consumption unadjusted for tar showed a similar frequency of positive and negative correlations.

The second, between-country analyses showed, in contrast, a very clear tendency for mortality rates to be positively correlated with previous smoking habits, but no such tendency for a correlation to be seen in males. While the various correlations studied in females were consistently positive and commonly statistically significant, the correlations studied in males were about as commonly negative as positive and never statistically significant.

Possible explanations for the findings are discussed.

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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 IIC is concerned with RDNA. Because it is generally considered that any effect of smoking is a fairly long-term one, attention is mainly restricted to smoking habits 20 years earlier. Thus, mortality for, say 60-64 year olds in 1991-1995 is studied in relation to the smoking habits 20 years earlier of members of the same birth cohort, i.e. of 40-44 year olds in 1971-1975. Alternative analyses relate to average consumption over the periods 15 to 5, 25 to 5 or 35 to 5 years previously.

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 RDNA. 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 1971-75, 1981-85 and 1991-95.

2.3 Age groups

Attention is restricted to three age groups: 45-49, 60-64 and 75-79.

2.4 Definition of RDNA

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 IC of this report, there are considerable problems in obtaining a disease definition from the various ICD revisions which would include only the terms chronic bronchitis, emphysema and chronic obstructive pulmonary disease (COPD). An attempt to define a version of COPD was comparable enough for the 9th revision of ICD, introduced in 1979, and the 10th revision, introduced quite recently, but led to discontinuities earlier, which vary by country. In this report attention is restricted to the broader definition of respiratory diseases (not-acute), which has fewer continuity problems, but includes various diseases that are not associated with smoking.

See Appendix 1 of report IC for a detailed definition of RDNA (and COPD), and sections 2.3 and 3 of that report for a discussion of the problems and the basis for the decision to restrict attention to RDNA rather than COPD.

In the tables RDNA is often referred to simply as Respiratory Disease.

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.

For the United Kingdom, some additional results are also shown based on consumption of manufactured cigarettes only.

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 at a previous time or for a previous period. 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 R5.1 to R5.30)

Each page relates to one of the 30 countries. On each page, the relevant data (mortality for each period from 1946-50 to 1996-2000 and three smoking indices for 20 years earlier) 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 relating mortality to smoking habits 20 years earlier.

Table 5.27 (United Kingdom) is split into 2 pages, one for total cigarettes (manufactured + handrolled) and one (Table 5.27a) for manufactured cigarettes only.

2.8 Summary over countries (Tables R5.31 to R5.33)

Tables R5.31-R5.33 consist of a separate page for each smoking index summarizing the N and R values for all 30 countries shown in Tables R5.1-R5.30 (and Table R5.27a).

Tables R5.34-R5.36 are similar to Tables R5.31-R5.33 but summarize N and R values based on smoking habits averaged from 5 to 25 years earlier than the mortality rates to which they refer.

Table R5.37 is similar to Table R5.31 but relates RDNA mortality to prevalence of smoking 20 years earlier, of all tobacco products, rather than of total cigarettes.

2.9 Between-country correlations (Tables R6.1 to R6.30 and Figures R6.1 to R6.30)

Tables and Figures R6.1 to R6.18 relate mortality to smoking habits 20 years earlier and consist of separate pairs of pages for each combination of sex x age group (45-49, 60-64, 75-79) x period (1971-75, 1981-85, 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. Note that tar is assumed constant up to 1955 for virtually all countries, so 1971-75 results for consumption and tar adjusted consumption differ little.

Tables and Figures R6.19 to R6.22 relate to smoking habits averaged from 15 to 5 years previously, while Tables and Figures R6.23 to R6.26 relate to smoking habits averaged from 25 to 5 years previously and Tables and Figures R6.27 to R6.30 relate to smoking habits averaged from 35 to 5 years

previously. The format is the same as R6.1 to R6.18, but the data relate to mortality in 1991 to 1995, with the four pairs of tables and figures giving results for the two sexes x two age groups (60-64, 75-79).

3. Results

3.1 Within-country analyses (Table R5)

Looking at the summary tables (Tables R5.31-R5.37), it is evident that the completeness of the data varies markedly by country, index of smoking and period covered. Data are most complete for prevalence of smoking and least complete for tar adjusted consumption, with unadjusted consumption intermediate. They are somewhat more complete for analyses relating to smoking habits 20 years previously than for analyses relating to average smoking habits over the period 25 to 5 years before the mortality data. For prevalence of smoking 20 years earlier, the data in Table R5.31 (total cigarettes) and Table R5.37 (all tobacco products) provide estimates for 24 countries for males and for 22 countries for females.

The data in Table R5.31 show a variable relationship between RDNA mortality and smoking prevalence 20 years previously. There are only three countries where positive correlations are seen in all age groups in both sexes (Austria, USA and UK – Manufactured cigarettes). There are also a number of other countries where positive correlations are seen at all age groups in one sex, but where the data for the other sex show one or more negative correlations (Canada, Finland, France, Germany, Ireland, Poland and UK – Total Cigarettes). Overall, the data for females show similar numbers of positive and negative correlations (31 vs 38). However, in males there are markedly more positive than negative correlations (54 vs 20). Even so, the data do not convincingly demonstrate any evidence of a consistent relationship between changes over time in RDNA mortality and prevalence of cigarette consumption 20 years ago.

For females, similar numbers of positive and negative correlations are seen in the data relating mortality to consumption 20 years earlier (Table R5.32, 19 vs 23), to tar adjusted consumption 20 years earlier (Table R5.33, 14 vs 13), to prevalence averaged from 25 to 5 years earlier (Table R5.34, 21 vs 18), to consumption averaged from 25 to 5 years earlier (Table R5.35, 14 vs 16) or to tar adjusted consumption averaged 25 to 5 years earlier (Table R5.36,

9 vs 9). The same is true in Table R5.37 (18 vs 18), which related mortality to prevalence of smoking any tobacco product 20 years earlier.

For males, similar numbers of positive and negative correlations are seen for the data relating mortality to consumption, whether 20 years earlier (Table R5.32, 31 vs 26) or averaged from 25 to 5 years earlier (Table R5.35, 20 vs 16).

However the excess number of positive correlations already noted for prevalence of manufactured cigarettes 20 years ago in Table R5.31 (54 vs 20) is also seen, and more markedly so, for prevalence 25 to 5 years earlier (Table R5.34, 49 vs 5) and for prevalence of total tobacco products 20 years earlier (Table R5.37, 46 vs 5).

An excess number of positive correlations for males is also seen for tar adjusted consumption 20 years ago (Table R5.33, 24 vs 10) and more markedly when consumption is averaged 25 to 5 years ago (Table R5.36, 17 vs 2).

3.2 Between-country analyses (Table R6 and Figure R6)

Between-country correlations have been estimated for each combination of sex, age (45-49, 60-64, 75-79) and period (1971-75, 1981-85, 1991-95) for smoking habits 20 years previously. Earlier periods were not chosen due to the relatively small number of countries providing data, and even for 1971-75 numbers of countries are small, particularly for consumption. Between-country correlations have also been estimated for the period 1991-95 for each combination of sex, age (60-64, 75-79) and period of smoking habits (5-15, 5-25, 5-35 years previously). The correlations are summarized in Table 2.

As can be seen from Table 2, none of the correlations for males are statistically significantly positive (or negative). Of the 45 correlation coefficients cited, 25 are positive and 20 are negative, and the evidence, taken as a whole, does not suggest a positive relationship.

In contrast, with only two minor exceptions based on limited data, the correlations for females are consistently positive and 28 of the 45 correlation coefficients are statistically significantly positive at $p<0.05$. Significant positive correlations are seen for all ages, time periods and smoking indices and lag times studied. Although significant correlations are generally seen for females, there is still considerable unexplained variation. Thus, for example considering Figure R6.24 (age 60-64, period 1991 to 1995, smoking 25 to 5 years earlier), there is a set of 8 countries (Spain, Finland, Japan, Austria, Greece, France, Italy, Poland) with similar mortality rates of around 15 to 20 per 100,000 per year, but whose smoking prevalence varies from 11.6% (Spain) to 23.2% (Poland). Similarly Ireland and Norway, and also Denmark and UK, have similar smoking prevalence but RDNA mortality rates which differ, in each pair of countries, by a factor of about 2.

3.3 Comments

There are a number of unusual features of the data that are difficult to explain. One is the difference between the findings for males and females. Females show no evidence of a consistent association of smoking with RDNA in the within-country analyses, but clear evidence of a positive association in the between-country analyses. Males, in contrast, show no evidence of a consistent association in the between-country analyses, but some evidence of a positive association in the within-country analyses. Other unusual features relate to the positive association seen in the within-country analyses for males. This is:

(i) not evident in the analyses relating RDNA mortality to consumption, but is evident in the analyses relating it to prevalence and to tar-adjusted consumption,

(ii) more evident in analyses relating to average smoking habits 25 to 5 years ago than to smoking habits 20 years ago and

(iii) more evident for prevalence of smoking any tobacco products than it is for prevalence of smoking manufactured cigarettes.

A full explanation of these features is beyond the scope of this report. Factors that need consideration include the following:

(i) Within-country analyses vary in the number of countries which are able to provide data in any one analysis and between-country analyses vary in the number of time points which can do so.

(ii) Smoking data for some countries for some periods of time may derive from very limited sources and be unreliable.

(iii) Some within-country analyses may be based on a limited number of time points where the mortality rate or smoking index varies very little, with the correlation coefficient depending on minor fluctuations in the values. Rather than estimating correlation coefficients an alternative approach may be to estimate the slope of the regression line (with an accompanying estimate of its variance) but this has not been attempted at this stage.

(iv) The approach used assumes a relationship between mortality and a single simple index of smoking, when a more precise approach, taking simultaneously into account a combination of prevalence, daily consumption, frequency of past smoking, duration of smoking and type of product may be more appropriate.

(v) The analyses take no account of variation over time or between country in exposure to factors other than smoking.

(vi) The analyses also take no account of possible variations over time or between country in the diagnosis of RDNA.

4. Summary and conclusions

Sex- and age-specific mortality from respiratory disease (non-acute) in 30 developed countries has been related to previous smoking habits in the same birth cohort. Many of the analyses relate to smoking habits 20 years previously, but some analyses relate to average smoking habits over the period 15 to 5, 25 to 5 or 35 to 5 years previously. 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.

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Possible explanations for the findings are discussed.

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	Time of smoking habits	Prevalence R(N)	Consumption per adult (unadjusted) R(N)	Consumption per adult (tar adjusted) R(N)
Male	45-49	1971-75	20 years earlier	-0.11 (8)	0.53 (3)	-0.54 (3)
		1981-85		0.07 (20)	0.13 (15)	0.16 (10)
		1991-95		-0.12 (25)	0.15 (21)	0.20 (14)
	60-64	1971-75		-0.29 (8)	0.02 (3)	0.01 (3)
		1981-85		0.04 (21)	0.13 (16)	0.17 (10)
		1991-95		-0.04 (25)	0.17 (21)	0.20 (14)
	75-79	1971-75		0.24 (8)	0.25 (3)	0.23 (3)
		1981-85		0.27 (22)	0.36 (17)	0.52 (11)
		1991-95		0.17 (25)	0.25 (21)	0.43 (14)
Female	45-49	1971-75		0.51 (9)	0.99 (3)	0.99 (3)
		1981-85		0.60 (14) *	0.68 (11) *	0.75 (8) *
		1991-95		0.02 (25)	0.28 (19)	0.36 (14)
	60-64	1971-75		0.67 (9) *	0.05 (3)	0.95 (3)
		1981-85		0.89 (14) ***	0.64 (11) *	0.81 (8) *
		1991-95		0.67 (25) ***	0.63 (19) **	0.70 (14) **
	75-79	1971-75		0.00 (9)	-0.95 (3)	-0.95 (3)
		1981-85		0.60 (14) *	0.30 (11)	0.46 (8)
		1991-95		0.47 (25) *	0.78 (19) ***	0.89 (14) ***
Male	60-64	1991-95	15 to 5 years earlier	-0.03 (23)	-0.02 (19)	-0.32 (8)
Female				0.77 (23) ***	0.69 (19) **	0.92 (8) **
Male	75-79			-0.07 (23)	-0.10 (19)	-0.28 (8)
Female				0.54 (23) **	0.69 (19) **	0.99 (8) ***
Male	60-64		25 to 5 years earlier	-0.07 (21)	0.06 (14)	-0.27 (6)
Female				0.77 (20) ***	0.64 (11) *	0.87 (5)
Male	75-79			0.01 (21)	0.06 (15)	-0.30 (6)
Female				0.56 (20) **	0.74 (11) **	0.97 (5) **
Male	60-64		35 to 5 years earlier	-0.29 (12)	-0.09 (6)	0.19 (3)
Female				0.87 (10) **	0.66 (5)	0.76 (3)
Male	75-79			-0.28 (13)	-0.50 (8)	-0.61 (5)
Female				0.91 (10) ***	0.88 (5) *	0.96 (3)

* p<0.05 ** p<0.01 *** p<0.001

R correlation coefficient

N number of countries with data on mortality and smoking that R is based on

See Tables R6.1 to R 6.30 for the data these correlations are based on