A study of male patients under 60 years with coronary heart disease has shown a negative relationship between volume of current smoking and such risk factors as hypertension and abnormal glucose tolerance, and no association with serum cholesterol and increasing age. Association with other possible risk factors was not tested.

CIGARETTE SMOKING RELATED TO GEOGRAPHIC VARIATIONS IN CORONARY HEART DISEASE MORTALITY AND TO EXPECTATION OF LIFE IN THE TWO SEXES

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Introduction

For some years, cigarette smoking has been regarded as an important factor in the incidence of coronary heart disease morbidity and mortality, though evidence of a causal connection is still disputed. Over the last 50 years, both certified mortality from coronary heart disease and per capita cigarette consumption have risen sharply in most countries.

Since coronary heart disease mortality is a significant component of total mortality, and accepting the hypothesis that cigarette smoking is a major risk factor in coronary heart disease, the mortality rate for a smoking population should be higher than for a nonsmoking population. Similarly, since risk is assumed to increase with the number of cigarettes smoked, the mortality rate should increase with increased smoking. Hammond and Horn,[1] in their prospective survey of 187,000 New York citizens, noted a highly significant increase in the death rate among cigarette smokers compared to nonsmokers, and they showed that coronary heart disease accounted for one-half of the excess deaths.

An important demographic phenomenon observed over the past 50 years is the change in the life expectancy of males and females in many countries. Fifty years ago the male and female expectations of life showed differences varying from zero to three years at the most, almost always in favor of the female. Since then both male and female expectations of life have increased at all ages, but the female expectation of life has increased far more rapidly than the male expectation. In most western countries the female expectation of life now exceeds the male by three to six years.[2]

A number of reasons may be advanced to explain this better female experience. Of particular interest here is the fact that female per capita cigarette consumption has been shown to be lower than male per capita consumption in countries where such data are available. We have previously postulated this lower female cigarette consumption as a possible reason for the relatively better fe-

male expectation of life experience in the last 50 years.[8]

It is of interest to see whether the available data are consistent with the proposal that a cigarette smoking population has a higher CHD mortality, and whether the better female expectation of life can be attributed to heavier male cigarette smoking.

The aims of this study were therefore as follows:

1. To examine the relationship between cigarette smoking and certified coronary heart disease mortality in different countries;

2. To examine the relationship between cigarette smoking and the ratio of female/male expectation of life in different countries.

This analysis involves the assumption that the pattern of cigarette smoking between the two sexes and at all age groups is similar in each of the countries included in the study. For this reason all that such an analysis can establish is whether the data are consistent *or* inconsistent with the hypothesis.

Methodology and Results

Data for the survey are recorded in Tables 1 and 2. Table 1 records, for a

Table 1—Cigarette consumption and 420-422 mortality in certain countries

Year	Country	Cigarette consumption[1] per adult/year	Mortality (per 100,000)[2] 420*	420, 422†
1962	United States	3900	244.5	256.9
"	Canada	3350	201.6	211.6
"	Australia	3220	219.9	238.1
"	New Zealand	3220	202.2	211.8
1963	United Kingdom	2790	179.1	194.1
1962	Switzerland	2780	82.0	124.5
"	Ireland	2770	151.4	187.3
"	Iceland	2290	47.3	110.5
"	Finland	2160	192.5	233.1
1963	West Germany	1890	103.1	150.3
1962	Netherlands	1810	113.2	124.7
"	Greece	1600	29.6	41.2
"	Austria	1770	136.0	182.1
"	Belgium	1700	105.3	118.1
"	Mexico	1680	27.7	31.9
1963	Italy	1510	69.3	114.3
1961	Denmark	1500	136.8	144.9
1962	France	1410	55.6	59.7
"	Sweden	1270	103.9	126.9
1961	Spain	1200	22.1	43.9
1962	Norway	1090	124.8	136.3

Correlation coefficient = 0.7295

Countries have been arranged in order of per capita cigarette consumption.

1. Data relates to manufactured cigarettes only, except for Australia, Canada, New Zealand, and Norway which include estimates for hand-rolled cigarettes.

2. Figures relate to the age group 35-64.

Sources: (1) Tobacco Research Council Paper No. 6, London, 1963. (2) WHO Epidemiological and Vital Statistics, Vol. 18, No. 1, 1965.

* Arteriosclerotic heart disease.

† Arteriosclerotic heart disease and myocardial degeneration.

Table 2—Male and female expectation of life at 40 years, actual and estimated excess female/male expectation of life, and per capita cigarette consumption for selected countries

Country	Year	Per capita adult cigarette consumption	Expectation of life at age 40		Excess female/male expectation of life	Estimated excess female/male expectation of life†
			Males	Females		
Australia	1920-22	640	30.05	33.14	3.09	—
	1932-34	430	31.11	34.04	2.93	2.84
	1946-48	780	31.23	34.91	3.68	3.26
	1953-55	1640	31.65	36.00	4.35	4.29
Austria	1930-33	1025	28.7	31.1	2.4	—
	1949-51	1100	30.74	34.20	3.46	2.49
	1960	1720	30.92	35.22	4.30	3.23
Belgium	1928-32	1100	29.48	31.77	2.29	—
	1946-49	1295	30.61	34.20	3.59	2.52
Canada	1930-32	640	31.98	33.02	1.04	—
	1940-42	1030	31.87	33.99	2.12	1.51
	1950-52	1600	32.45	35.63	3.18	2.19
	1955-57	2480	32.74	36.69	3.95	3.15
	1960-62	3060	32.96	37.45	4.49	3.94
Denmark	1921-25	460	32.1	32.3	0.2	—
	1926-30	620	32.0	32.4	0.4	0.39
	1931-35	420	32.1	32.5	0.4	0.15
	1936-40	550	32.2	33.1	0.9	0.31
	1946-50	860	33.81	35.00	1.19	0.68
	1951-55	1230	34.38	35.89	1.51	1.12
	1956-60	1320	34.25	36.59	2.34	1.23
England and Wales	1920-22	1080*	29.19	31.86	2.67	—
	1930-32	1410*	29.62	32.55	2.93	3.13
	1950-52	2200*	30.98	35.32	4.34	4.19
	1958-60	2670*	31.6	36.6	5.0	4.64
	1961-63	2680*	31.4	36.5	5.1	4.65
Finland	1921-30	1310	27.55	31.01	3.46	—
	1936-40	1660	27.38	31.57	4.19	3.88
	1946-50	1520	28.02	33.59	5.57	3.71
	1951-55	1780	29.20	34.20	5.00	4.02
	1956-60	1750	29.72	34.96	5.24	3.99
Iceland	1931-40	320	32.0	35.4	3.4	—
	1941-50	1670	34.3	36.5	2.2	5.02
	1951-60	1730	35.2	38.0	2.8	5.09
Ireland	1925-27	730	30.43	30.83	0.40	—
	1935-37	1230	30.26	31.18	0.92	1.00
	1940-42	1260	30.58	31.63	1.05	1.04
	1950-52	2830	31.31	33.28	1.97	2.92
	1960-62	2800	32.35	35.28	2.93	2.88
Norway	1921/22-1930/31	260	32.40	34.00	1.60	—
	1931-1941	330	33.15	34.89	1.74	1.68
	1946-1950	600	35.16	36.96	1.80	2.01
	1951-1955	520	35.54	37.79	2.25	1.91

* U.K. Data

Sources: (1) UN Demographic Yearbooks 1937-64. (2) Tobacco Research Paper No. 6., 1963.

† Derived from regression equation (see text).

(Continued on following page.)

Table 2—Continued

Country	Year	Per capita adult cigarette consumption	Expectation of life at age 40		Excess female/male expectation of life	Estimated excess female/male expectation of life†
			Males	Females		
Netherlands	1921–30	480	32.10	32.50	0.40	—
	1931–40	685	32.9	33.3	0.4	0.65
	1950–52	1170	34.9	36.3	1.4	1.23
	1956–60	1650	34.7	37.3	2.6	1.80
New Zealand	1921–22	465	31.56	33.23	1.67	—
	1934–38	590	32.03	34.05	2.02	1.82
	1950–52	1540	32.65	35.64	2.99	2.96
	1955–57	1750	32.82	36.35	3.53	3.21
Sweden	1921–30	280	32.29	33.35	1.06	—
	1936–40	380	32.37	33.67	1.30	1.18
	1946–50	720	33.84	35.29	1.45	1.59
	1959	1090	35.03	37.43	2.40	2.03
	1962	1270	34.50	37.59	3.09	2.25
Switzerland	1933–37	540	29.4	32.2	2.8	—
	1939–44	825	30.42	33.35	2.93	3.14
	1948–53	1540	31.88	35.02	3.14	4.00
	1959–61	2380	33.70	37.60	3.90	5.01
United States	1919–21	610	29.63	30.58	0.95	—
	1929–31	1370	28.68	30.86	2.18	1.86
	1939–41	1820	29.57	32.68	3.11	2.40
	1949–51	3250	30.79	35.06	4.27	4.12
	1959	3720	31.20	36.40	5.20	4.68
	1963	n.a.	31.2	36.7	5.5	—

* U.K. Data

Sources: (1) UN Demographic Yearbooks 1957-61. (2) Tobacco Research Paper No. 6., 1963.

† Derived from regression equation (see text).

recent year, annual per capita cigarette consumption[4] and coronary heart disease mortality for 21 countries.[5] Coronary heart disease mortality is expressed in two ways: (1) arteriosclerotic heart disease (420), and (2) arteriosclerotic heart disease and myocardial degeneration (420-422).

The countries included were those for which reasonably accurate smoking and biostatistical data could be obtained. The countries in Table 1 are arranged in order according to per capita cigarette consumption. The latter varies from 3,900 in the United States down to 1,090 in Norway. If the corresponding mortality rates are examined it will be seen that there is a similar tendency for mortality rates to decline. It is thus possible to postulate a numerical association between cigarette consumption and coronary heart disease mortality.

In Figure 1, cigarette consumption and total coronary heart disease mortality (420-422) are plotted. The coefficient of linear correlation between the two variables is $r=0.7295$. There is therefore a fairly strong and statistically significant relation between cigarette consumption and coronary heart disease mortality. A similar coefficient was found between cigarette consumption and death rate from arteriosclerotic heart disease (420).

In four countries (Greece, Mexico, France, and Spain) coronary heart disease mortality rates (420-422) are considerably lower than in the other coun-

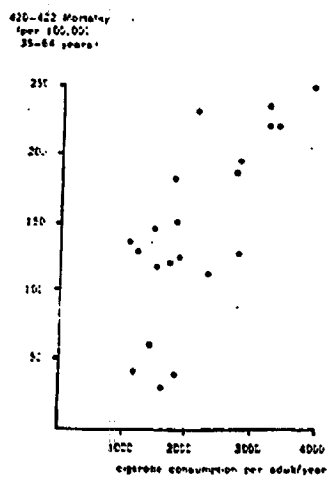

Figure 1—The relationship between total average cigarette consumption and mortality from coronary heart disease (420-422) in 21 countries

tries included in the study. Differences in death certification may account in part for these low figures, although there is evidence that the low mortality from coronary heart disease reported in Greece is a true one.[6] Another cause may be a deficiency of other coronary heart disease risk factors in these countries. Aravanis and his colleagues[6] report a relatively low incidence of hypertension and hypercholesterolemia in Greece.

Table 2 is a combination of "cross sectional" and time series data for 15 of the 21 countries. These 15 countries were chosen for this aspect of the study because of the reliability and comprehensiveness of the life expectation and tobacco data available over the past 50 years. The other six countries were excluded because of inadequate data available over this time or because of political considerations which may have affected the continuity of the data.

In each of these 15 countries the female expectation of life has increased more than the male expectation of life. Associated with this increasing excess female/male expectation of life is a similar upward trend in the per capita adult cigarette consumption. It should be noted that this latter figure is based on the total adult male and female population of each country. A more useful figure would have been the *difference* between male and female per capita cigarette consumption. These data are not available. However, it is not unreasonable to assume that the figures recorded do indicate the relative magnitudes of per capita male cigarette consumption in different countries and at different times. Data from Ireland,[7] the United Kingdom,[8] and the United States[9] indicate that the ratio of quantitative male to female smoking in these countries is of the order of 2½/1 to 3/1.

The coefficient of linear correlation between the excess female expectation of life at age 40 and per capita adult cigarette smoking consumption is r=0.70. In Figure 2 the data have been plotted on a scatter diagram and a linear regression line fitted to the data. The equation to the line is

$$Yc=1.1+0.0012\ X$$

where Yc=estimated excess female life expectation at age 40, and X=per capita cigarette consumption.

The equation suggests that, for an increase of 100 in annual per capita cigarette consumption, the excess female life expectation will rise by 0.12, arising from increased male coronary heart disease mortality. This assumes of course, that the increase of 100 in cigarette consumption arises mainly through increased male consumption.

In Table 2, the estimated excess female life expectation, derived from the regression equation, is also recorded. Comparison with the actual excess female life expectation shows fairly marked correspondence.

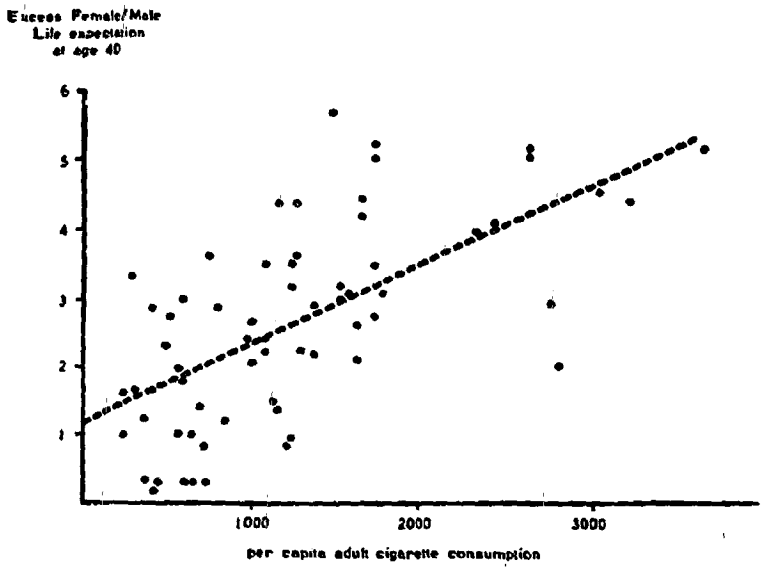

Figure 2—Excess female/male life expectation at age 40 for 15 countries at various dates related to per capita adult cigarette consumption

Conclusions

An international comparison of smoking experience, coronary heart disease mortality and trends in the life expectation of males and females suggests:

(1) that there is a strong positive association between per capita cigarette consumption and coronary heart disease mortality in different countries;

(2) that there is a strong positive association between per capita cigarette consumption and the excess female/male expectation of life between different countries and within the same country over time.

In general, these results are consistent with the hypothesis that smoking is at least a significant associative factor in the incidence of coronary heart disease. In view of the assumptions underlying these data, the results cannot be taken to provide positive support for the hypothesis that smoking is a cause of coronary heart disease, but the results are consistent with such a hypothesis.

It is possible but improbable that the relationship between coronary heart disease and cigarette smoking can be attributed to an association between the latter habit and another coronary heart disease risk factor. In a study of 444 male patients under 60 years with coronary heart disease, we have failed to show a positive relationship between volume of current smoking and such acknowledged risk factors as hypertension, hypercholesterolemia, abnormal glucose tolerance and increasing age. An association with other possible risk factors has not been tested.

Summary

Cigarette consumption shows a significant positive association with coro-

Table 3—Correlations between current cigarette smoking (average number of cigarettes per day) and certain acknowledged risk factors in male patients under 60 years with coronary heart disease

Factor	No. of pairs with data available	R	T	P-value
1. Age	319	—.075	—1.345	NS
2. Diastolic blood pressure	311	—.127	—2.261	<0.05
3. Glucose tolerance (Aggregate of fasting, half-hour, one- and two-hour readings)	291	—.184	—3.188	<0.01
4. Serum cholesterol	284	—.028	.472	NS

nary heart disease mortality in 21 countries. A significant association is also noted in 15 countries between total cigarette consumption and excess female/male expectation of life. This association may be accounted for by the documented or assumed heavier male cigarette smoking experience in these 15 countries.

The results of this study are consistent with, but not proof of, the hypothesis that cigarette smoking is a significant risk factor in coronary heart disease mortality. They are also consistent with the proposal that cigarette smoking, because of its association with coronary heart disease and other chronic disorders, may partly or completely account for the better female compared to male life expectation experience over the past 50 years.

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A program for reducing primary exposure during dental x-ray examinations is described and its achievements are indicated. Despite a considerable reduction in radiation exposure, since 1960 dentists still use more radiation than necessary per exposure. Reasons for this situation are discussed. Implications of the program for other states are mentioned.

A STATE PROGRAM FOR REDUCING RADIATION EXPOSURE FROM DENTAL X-RAY MACHINES

K. L. Travis, B.S., F.A.P.H.A., and J. E. Hickey, M.S.

Introduction

THE ideal goal in the field of diagnostic radiology is to obtain excellent quality x-rays with the minimum possible exposure to the patient. In 1960, a study conducted by Barr[1] of 200 dental x-ray installations in the Boston area indicated that this was not being accomplished. He found that the exposure per film at the skin entrance averaged 2640 mR. The U. S. Public Health Service in a much broader but less detailed study[2] indicated a much reduced value of the 1138 mR in 1964. Barr pointed out in his paper[1] that excellent dental x-rays can be taken with significantly less radiation exposure, as is done routinely at the Tufts University Dental X-Ray Clinic and many other dental facilities throughout the country.

The study described in this paper was instituted to learn the reasons for this high average exposure and to ascertain if an exposure, when found to be excessive, could be reduced at the time of the survey visit. This could be done by using the talent and resources of an existing state radiological health program, namely, that of the Division of Occupational Health, Department of Health, State of Rhode Island.

Organization of Study

Preliminary Arrangements

In this study, consultative visits were made to dentists under the joint sponsorship of the State Department of Health and the State Dental Association. Letters announcing the availability of the service were sent to all licensed dentists in the state. A return postcard was provided, so that dentists could express their desire to receive this service. Before each visit, an appointment was made by phone to assure maximum cooperation of the dentist during the visit.

Visit Procedure

Each survey was conducted by a two-member team and took from 15 to 30 minutes to complete, depending upon conditions found and the number of machines to be calibrated. In each case, the dentist was apprised that the pur-