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A STUDY OF LUNG CANCER AND BRONCHITIS MORTALITY IN RELATION TO COAL-MINING IN SCOTLAND

BY

EILEEN C. CROFTON, B.M., B.Ch.

Research Assistant, Department of Respiratory Diseases, University of Edinburgh

Lung cancer and bronchitis share two main aetiological factors and may co-exist in the same patient. Both are associated with cigarette smoking and atmospheric pollution, though the degree of responsibility of each factor varies. Cigarette smoking is of very great significance in the causation of both diseases, but there is probable disparity between them in the importance of atmospheric pollution. Pollution makes a major contribution to the development of chronic bronchitis but probably plays only a minor part in causing lung cancer (Buck and Brown, 1964; Ashley, 1967). In chronic bronchitis cigarette smoking and atmospheric pollution probably act synergistically (Holland and Reid, 1965). In spite of these aetiological links an examination of death rates from lung cancer and bronchitis in different parts of the United Kingdom shows less correlation than might be expected (Ashley, 1967). It is possible that there are other factors concerned in these differences. Ashley and Davies (1966) have pointed out that, in Wales, where bronchitis mortality is very high, there is a relative deficiency of deaths due to lung cancer. An examination of the use of hospital beds in different regions of England and Wales showed that regions which served coal-mining areas used fewer beds for lung cancer in relation to those used for bronchitis than did those serving areas not connected with coal-mining. Further evidence (Ashley, 1967) was provided from a study of mortality in large urban areas of England and Wales in which it was shown that most of the towns characterized by high bronchitis mortality and low lung cancer mortality were associated with coal-mining or textile industries. The present paper examines the situation in Scotland in relation to coal-mining areas in that country. In Scotland as a whole the lung cancer mortality is a little higher than in England and Wales, and considerably higher than in Wales alone.

Methods and Results

Occupation and Industry Tables from the 1961 Census were used to obtain the proportion of the economically-active section of the population engaged in coal-mining in different areas of Scotland. As no city or 'large burgh' (in Scotland this is generally a town of over 20,000 population*) contained any significant proportion of the population working in coal-mining, they have been excluded from the present study. The areas studied were based on the Scottish counties, and were composed of rural areas, and, with the exception of Buckhaven and Methil, urban areas under 20,000 population. Two county areas (Lanark and Renfrew) included part of the Central Clydeside conurbation. There were 32 county areas (Perth and Kinross counties were considered together); 22 had under 5% of the population engaged in coal-mining, 3 had 5–9%, 4 had 10–19%, and 3 had 20–29%.

Population tables from the County Reports of the 1961 Census were used to obtain the proportion of the population by age and sex living within each county area in areas within the county classified as 'landward' (*i.e.*, rural), 'small burghs' (in general urban areas under 20,000 population, but see footnote) and areas within the boundaries of the Central Clydeside conurbation. Each of these areas in aggregate has a different mortality rate from bronchitis and also from lung cancer. The mortality from bronchitis in the aggregate areas was ascertained for 10 years from 1954 to 1963, and that from lung cancer for six years from 1958 to 1963 (earlier figures being unavailable). By applying these mortality rates to the population distribution in the individual county areas within the aggregates, the expected deaths could be calculated and compared with those that actually occurred, giving the standardized mortality ratios shown in Table I. By this method (which is similar to that used by Ashley and Davies (1966)), many of the differences due to differences in urbanization are eliminated.

*Exceptions are Arbroath, population 19,537, classified as a 'large burgh' and excluded from the areas studied, and Buckhaven and Methil, population 21,102, not classified as a 'large burgh' and therefore included in the present analysis. It is predominantly concerned with coal-mining.

Bronchitis Mortality (Table I)

Bronchitis mortality in both sexes is higher in the counties concerned with coal-mining than in the others. There is a consistent trend in the male rates from areas of low to areas of higher amounts of coal-mining, and this trend is significant ($P < 0.001$). The female rates show a significant difference ($P < 0.001$) between coal-mining counties (5% and over) and non-coal-mining counties (under 5%), but the trend is not entirely consistent, possibly due to the smaller number of expected deaths in the counties with 5–9% of coal-mining (31 per annum).

Lung Cancer Mortality (Table I)

Lung cancer in males follows the trend in bronchitis in that there are significantly more deaths ($P < 0.001$) in all the coal-mining areas taken together than in non-coal-mining areas. There is no significant difference between the counties with different proportions engaged in coal-mining. The ratios shown for females are unreliable, being based in two instances on less than 20 expected deaths per annum. The apparent excess of female lung cancer mortality in non-coal-mining counties is not significant ($P < 0.2$) when compared with counties with 10% and over of coal-mining.

These figures suggest that lung cancer, like bronchitis, is more rather than less prevalent in the coal-mining areas of Scotland.

Correlation between Bronchitis and Lung Cancer Mortalities

There is a significant ($P < 0.001$) correlation between the male standardized mortality ratio for bronchitis and that for lung cancer in the Scottish counties, exclusive of cities and 'large burghs' ($r = +0.74$). This correlation is greater than that found by Ashley (1967) for 84 'major urban areas' in England and Wales ($r = +0.3$; $P < 0.01$). It is also greater than that for Scottish cities and larger towns ($r = +0.48$; $P < 0.01$).

Hospital Discharges and Deaths

Particulars of the use of hospital beds for bronchitis and lung cancer in these county areas were obtained through the courtesy of the Department of Home and Health in Scotland who made available unpublished data obtained in the Scottish Hospitals In-patient Survey from 1961 to 1964 inclusive.

Table II shows the hospital discharge rates for lung cancer and bronchitis per 100,000 population. It should be noted that these rates are not standardized for age nor for the relative proportions of the population living in urban and rural areas within the counties.

Counties with more than 10% engaged in coal-mining have higher hospital discharge rates for bronchitis in males than do the non-coal-mining counties. This is in general agreement with the standardized mortality ratios shown in Table I. The lower rates in the 5–9% counties in both males and females may be due to the less urban environment of these counties which has been allowed for in Table I but not in Table II. Apart from the 5–9% counties there is little difference in the rates for bronchitis in females. The excess in the 10–19% counties is significant ($P < 0.001$) but the deficit in the 20–29% group is not ($P < 0.02$).

In lung cancer in males there is a highly significant excess ($P < 0.001$) of discharges in the 20–29% counties, but the excess in all counties with more than 10% coal-mining is only just significant ($P < 0.05$). For female lung cancer the lower rates in the counties with 10% and more of coal-mining are

Table I

STANDARDIZED MORTALITY RATIOS (SMRs) IN SCOTTISH COUNTIES RELATED TO COAL-MINING. (CITIES AND LARGE TOWNS EXCLUDED)

SMR from	Proportion of Population Engaged in Coal-mining				
	< 5%[1]	5–9%[2]	10–19%[3]	20–29%[4]	Over 10%[5]
Bronchitis					
Male	65·6	97·7	101·2	116·7	106·4
Female	86·6	83·1	102·2	111·2	105·4
Lung cancer					
Male	80·0	114·9	113·1	110·6	112·2
Female	108·7	114·7*	87·4	91·7*	88·8

*Based on < 20 expected deaths per annum

[1]Total population: Male 482,797; Female 519,822.
[2]Dumfries, Dunbarton, Stirling. Total population: Male 158,813; Female 167,481.
[3]Ayr, Clackmannan, East Lothian, Lanark. Total population: Male 333,580; Female 354,716.
[4]Fife, Midlothian, West Lothian. Total population: Male 208,287. Female 217,600.
[5]Total population: Male 541,867; Female 572,316.

Table II

HOSPITAL DISCHARGE RATES IN SCOTTISH COUNTIES RELATED TO COAL-MINING. (CITIES AND LARGE TOWNS EXCLUDED)

Discharge Rate per 100,000 from	Proportion of Population Engaged in Coal-mining				
	< 5%	5–9%	10–19%	20–29%	10% and over
Bronchitis					
Male	146·9	121·7	192·4	195·4	193·5
Female	90·0	58·1	98·0	80·7	91·4
Lung cancer					
Male	127·1	111·1	106·0	176·1	133·0
Female	22·2	16·4	14·7	19·2	16·4

significant, but in the counties with 20–29% there are in fact rather more discharges than would be expected on the basis of experience of all the counties concerned ($P < 0.01$). There is thus no evidence from hospital discharge rates to indicate that coal-mining has a sparing effect upon the development of lung cancer, and this is in line with the evidence from the mortality experience.

Population Density and Fuel Consumption

The coal-mining counties have a higher average density of population than non-coal-mining counties in both the rural areas and the small towns. The figures shown in Table III are obtained from the 1961 Census Report. These counties also have a higher consumption of domestic fuel, which might be a measure of atmospheric pollution. The figures for fuel consumption were obtained in 1952 by the Ministry of Fuel and Power for the Beaver Report on Atmospheric Pollution. It is likely that results would be very different now if the survey were repeated, but the figures are included here as they provide an indication of the degree of pollution to which the population has been subjected in the past, and probably the relative consumption in different areas is little changed. Industrial fuel consumption is not included, as figures are not available for some areas, but as far as they go they indicate, as might be expected, a higher consumption in the coal-mining counties.

Table III

DOMESTIC FUEL CONSUMPTION AND POPULATION DENSITY IN SCOTTISH COUNTIES RELATED TO THE PROPORTION OF THE POPULATION ENGAGED IN COAL-MINING

Proportion of Population engaged in Coal-mining	Average D.F.C. (tons per acre)	Average Population Density (persons per acre)		
		Small Towns only	Rural Areas only	Small Towns and Rural Areas combined
20–29% (3 counties)	0·73	38·0	0·47	0·83
10–19% (4 counties)	0·57	3·6	0·35	0·63
5–9% (3 counties)	0·25	20·1	0·27	0·43
< 5% (23 counties)	0·09	6·4	0·06	0·13

Discussion

The evidence presented here suggests that there is, in Scotland, more lung cancer in males in areas concerned with coal-mining than in other areas. This is in contrast to the situation which has been reported in England and Wales by numerous observers (*e.g.*, Kennaway and Kennaway 1947, 1953; James, 1955). Ashley (1967) found that most of the large urban areas he studied in which the ratios of the standardized mortality ratio for bronchitis to that for lung cancer was significantly high were associated with the coal and textile industries, and that in the large towns of the coal and textile areas there was an overall deficit of lung cancer deaths compared with other areas. The deficit in lung cancer deaths in coal-mining areas has been attributed to pneumoconiosis (James, 1955; Golman, 1965). In this connexion it is of interest to note that the Scottish Division of the National Coal Board has the lowest prevalence rate of pneumoconiosis, *viz.*, 3·7% (National Coal Board, 1967) compared with the average rate for all divisions of 11·5%. This low rate may explain the difference in Scotland where there appears to be no deficit of lung cancer deaths in coal-mining areas.

It is unlikely that differences in smoking can explain these results. Table IV summarizes the findings of two surveys undertaken at about the same time (Ashford, Brown, Duffield, Smith and Fay, 1961; Todd, 1962) into smoking habits of miners and all men in Scotland and England and Wales. As far as these results go it suggests that miners who smoke cigarettes, smoke approximately the same number in Scotland and the United Kingdom as a whole, but the smallness of the sample in the Todd survey does not permit of a comparison of the proportion of miners who smoke. Men in Scotland smoked more in 1961 than men in England and Wales, but this may be a recent phenomenon.

Table IV

CIGARETTE CONSUMPTION AMONG MINERS AND NON-MINERS IN SCOTLAND AND ENGLAND AND WALES

Occupation Group	Cigarettes/ Week/ Smoker	Proportion of Cigarette Smokers
Scottish miners (Ashford *et al.*, 1961)	106½	80·1%
U.K. miners (Todd, 1962)	104½	52·5% (based on < 100 informants)
All men England and Wales (Todd, 1962)	130	72%
All men Scotland (Todd, 1962)	141	

The possibility that cases of lung cancer in Wales are being missed seems to be a remote one. James (1955) has pointed out that, because of the compensation due for pneumoconiosis, a large proportion of miners undergo radiographic examination, and more miners undergo necropsy examination than do members of the general population. He

concluded that lung cancer was less likely to be missed in miners than in other people. Coal-mining areas naturally tend to have high rates of fuel consumption, and those in Scotland are no exception. Whether the actual pollution is higher in Scotland is not certainly known in the absence of direct measurements specifically designed to elucidate this. It does seem on the face of it very unlikely that miners living in the steep coal-valleys of South Wales, where one would expect the dispersal of smoke to be delayed, should experience a level of pollution so much lower than Scottish miners living in a more open landscape that the risk from the carcinogenic effects of smoke is impressively reduced.

On the whole it appears to be the case that the lower prevalence of pneumoconiosis in Scotland, the evidence for which is based on a very complete radiographic survey in 1966, is far more likely to account for the difference between the lung cancer mortality in coal-mining areas of Scotland and in similar areas in England and Wales.

SUMMARY

In view of the observed deficiency of lung cancer deaths in coal-mining areas in England and Wales the situation was examined in Scotland. Coal-mining areas were defined as closely as possible, using information obtained in the 1961 Census. Deaths from lung cancer and bronchitis by sex were obtained from the Annual Reports of the Registrar-General for 1954–63 for bronchitis, and 1958–63 for lung cancer. These were compared with the deaths that would be expected in these areas allowing for differences in age structure of the population and the relative degree of urbanization. The results showed that in males there was more lung cancer, as well as bronchitis, in the areas concerned with coal-mining and this excess was significant. In females there were more deaths from bronchitis but fewer deaths from lung cancer in the coal-mining areas. The mortality ratios for females were unreliable as in some instances they were based on less than 20 expected deaths per annum, and in any case the apparent deficit was not highly significant.

In the same areas unstandardized hospital discharge rates for lung cancer and bronchitis showed similar trends.

Reasons have been discussed for the observed differences in Scotland and England and Wales, including diagnosis, smoking habits, pollution levels, and the incidence of pneumoconiosis. It seems likely that the low rates of pneumoconiosis in the mining areas of Scotland may account for the worse lung cancer experience in Scottish mining areas than in similar areas in Wales.

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