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Unemployment, socioenvironmental factors, and coronary heart disease in Scotland

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SUMMARY Scotland, which has one of the highest death rates in the world from coronary heart disease, also has considerable regional variation in mortality from this cause. The relation between standardised mortality ratios for coronary deaths (1979–83) for 56 local government districts and a range of socioeconomic factors from the 1981 Census as well as climatic factors and water hardness were investigated. Strong associations were seen with several measures of social disadvantage, the strongest being with percentage of male unemployment. A fitted multiple regression model with mortality from coronary heart disease in men found independent effects of two social variables (percentage male unemployment and percentage social class III–V) and one climatic factor (rainfall). The model explained much (73%) of the geographical variation in mortality from coronary heart disease, but part of the geographical pattern, in particular some of the east–west gradient in mortality, remained unexplained by it. Explanations for the geographical variation and the association with economic factors are currently being sought in terms of individual risk factors in a large screening study, the Scottish Heart Health Study.

Mortality from coronary heart disease in Great Britain is among the highest in the world.[1 2] There are, however, considerable differences within Britain.[3 4] Many investigations have focused on England and Wales,[5–7] whereas Scotland, which has the greater problem, has been comparatively neglected, although a recent paper has described a complex and interesting geographical pattern of mortality from coronary heart disease.[8]

There has been much concern about socioeconomic differences in mortality since the Black report on Inequalities in Health[9] and the more recent report from the Health Education Council.[10] One factor of particular interest has been the effect of unemployment on health.[11 12]

The potential of socioenvironmental factors for explaining regional variation in disease mortality was recognised many years ago. In particular, the decennial censuses in Britain provide a wealth of regional data on socioeconomic variables and there have been regional studies based around the 1951,[13] the 1961,[14 15] and the 1971[4 16] censuses. Many of the studies of regional variation, however, have merely sought to control for socioeconomic factors while investigating physical factors such as water hardness,[14] climate,[6 17 18] or air pollution.[16]

We report an investigation of the association between socioeconomic and environmental factors and coronary heart disease in Scotland.

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Methods

GEOGRAPHICAL UNITS, MORTALITY, AND POPULATION DATA

Local government districts were chosen as the geographical unit because they divide Scotland into a convenient number (56) of relatively homogeneous units.[8] Deaths from coronary heart disease diagnosed according to the International Classification of Diseases 410–414 (ninth revision) for the age group 35–64 years for the period 1979–83 were obtained from the annual reports of the Registrar General (Scotland).[19] Standardised mortality ratios were calculated for each sex as described by Armitage[20] for five year age specific mortality and population data from the 1981 census.[21] The standardised mortality ratios for each sex for the whole of Scotland are defined as 100.

SOCIOECONOMIC DATA

The *1981 Census Reports for Regions* provides data on socioeconomic variables organised in four categories: demographic characteristics; economic characteristics; housing and amenities; and household composition.[21] To ensure adequate coverage of the types of variables several (at least four) were selected from each category. One further variable (percentage of households with no car), which could not be allocated to one of the categories, was also taken. The choice of variables was taken to include (where possible) those used by two previous major studies.[4 15] The variables chosen are listed in the appendix.

CLIMATIC DATA

Rainfall (average annual in millimetres) and temperature (overall means for January, July, and the whole year) were based on 30 year averages and obtained from the Meteorological Office (Edinburgh). The largest town in each district was linked to the closest meteorological station (often in the town itself) and 46 stations were used. Latitude and longitude were also taken for the largest town in the district according to the values given in *The Times Atlas of the World*.[22]

WATER HARDNESS

Data on total and permanent water hardness were obtained from the departments of water services of the Scottish regional councils as previously described.[23]

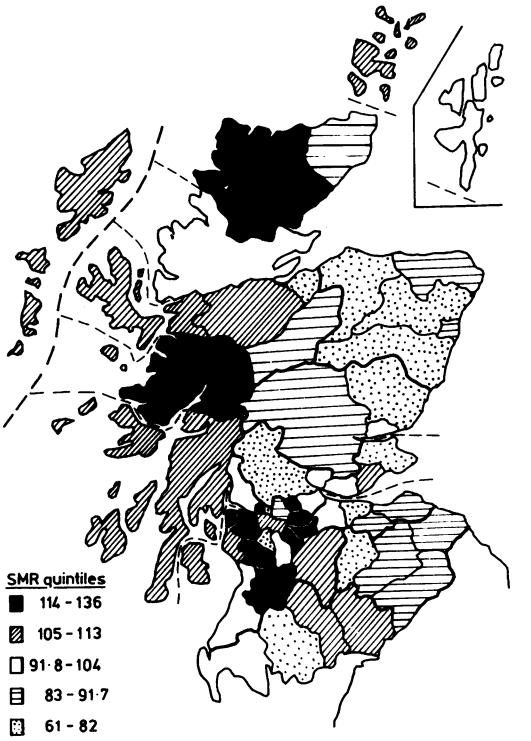

Fig 1 *Standardised mortality ratios for coronary heart disease for men aged 35–64 years for the period 1979–83.*

STATISTICAL ANALYSIS

Simple correlations—Spearman's rank correlation coefficient was used because several variables were highly skewed by outlying observations.

Multiple regression model—A linear additive model was fitted by the optimum method described by Pocock *et al.*[24] To enable comparison of the importance of the effect of the independent variables in the model the standardised regression effects were estimated.[25]

Results

A map of coronary heart disease mortality among men showed an interesting geographical distribution (fig 1). There is a wide range in standardised mortality ratios (from 61 to 136) with a clear tendency for mortality to be high in the west and low in the east. In west central Scotland there was a grouping of high standardised mortality ratios, including eight of the highest ten districts. Within this grouping, however, are two districts with very low standardised mortality ratios (values of 61 and 73). There is also a block of low mortality districts in the north east.

Mortality from coronary heart disease among women had a broadly similar pattern.[8] Because these rates are based on much smaller numbers of deaths than for men (approximately one third of the number) they are potentially much more variable. Thus in the following analyses only the results for men are presented and those for women are alluded to.

The complex pattern of mortality raises the question of which factors are responsible for it, and in particular what is the role of socioeconomic factors. Table 1 shows the simple correlations between the standardised mortality ratios of male and female coronary heart disease and several socioenvironmental variables. The socioeconomic variables shown are those that had correlations with coronary heart disease that were significant at the 1% level. There were strong correlations with several variables which indicated low social class or social disadvantage. The other variables that correlated strongly with male mortality were longitude and rainfall. These last two associations are expected because all three variables show a pronounced east–west distribution. Latitude,

Table 1 *Association between mortality from coronary heart disease in men and women and certain socioenvironmental variables*

	Rank correlation*	
	Male SMR	*Female SMR*
Socioeconomic:		
Population density	(0·12)†	0·38
Percentage population change	−0·33	−0·41
Percentage married	−0·29	(−0·12)
Percentage < 16 years	0·29	(0·10)
Percentage not private household	−0·29	−0·42
Percentage rural	(−0·15)	−0·34
Percentage male unemployed	0·74	0·74
Percentage female unemployed	0·74	0·70
Percentage men economically active	(−0·13)	−0·30
Percentage in manufacturing	0·37	0·40
Percentage social class III-V	0·66	0·57
Percentage council house rented	0·55	0·65
Percentage owner occupied	−0·54	−0·63
Percentage > one person/room	0·61	0·54
Percentage > 3 dependent children	0·35	(0·07)
Percentage single parent	0·39	0·55
Percentage single pensioners	(0·12)	0·37
Percentage no car	0·55	0·61
Environmental:		
Longitude	0·58	0·36
Rainfall	0·41	(0·16)
Latitude	(−0·17)	−0·41
Temperature	(−0·02)	(0·18)
Total water hardness	(−0·26)	(−0·10)

SMR, standardised mortality ratio.
*Spearman's rank correlation coefficient.
†Coefficients not significant at the 1% level are shown in parentheses.

temperature, and water hardness were only weakly correlated with mortality from heart disease in men.

To examine the extent to which socioenvironmental variables could explain the variation in coronary heart disease within Scotland a multiple regression model was fitted. The model assumes that the variables have an additive effect; fitting a model assuming a multiplicative effect (by taking the logarithm of the standardised mortality ratio) resulted in a model containing the same independent variables.

Three variables (percentage male unemployment, percentage social class III–IV, and rainfall) were found to have a significant independent association with mortality from heart disease in men (table 2). Their relative importance can be assessed by comparing the standardised regression effects, which gives the percentage change in the dependent variable for an increase of one standard deviation in the independent variable with the other variables being fixed. These indicate that the two socioeconomic variables, particularly male unemployment, have the greater effects, with that of rainfall being slightly weaker. Overall the model explains 73% of the variance in mortality from coronary heart disease in men.

The important question to ask of the regression

Table 2 *Regression model of mortality from coronary heart disease in men on the socioenvironmental factors*

Variable	*Standardised regression effect*
Percentage male unemployment	7·549
Percentage social class III-V	6·934
Rainfall	5·771

Percentage of variance explained = 73%.

model is the extent to which it can explain the geographical distribution of coronary heart disease shown in fig 1. One way to do this is to obtain that part of heart disease mortality not explained by the model (the residuals) and to investigate the geographical pattern of this unexplained mortality. This technique is an extension of that suggested by Gardner.[15]

The map of the unexplained mortality (fig 2) shows that the cluster of districts with high mortality in the west has largely disappeared. Thus whereas eight of the ten highest standardised mortality ratios were in this cluster, only three districts now remain in the top ten. One feature of the original map that is preserved is the block of low mortality districts in the north east. The interpretation of this map is that while part

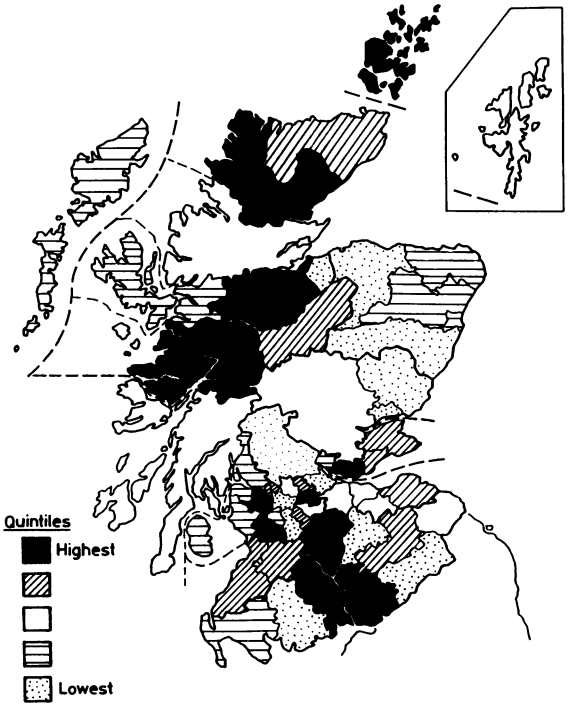

Fig 2 *Quintiles of the residuals from the regression of mortality from coronary heart disease in men on the socioenvironmental variables.*

of the geographical pattern can be explained by the fitted model a part remains that cannot.

Discussion

In Scotland, where mortality from coronary heart disease is one of the highest in the world,[1 2] there is considerable geographical variation in this mortality. In contrast with Britain as a whole,[3] there is not a south east to north west gradient but instead a pronounced east (low mortality) to west (high mortality) separation. Within a cluster of high mortality districts in the west, however, are two districts with very low mortality.

We found a strong association between this geographical variation in mortality and a range of measures of social disadvantage. Further, for male mortality a fitted regression model with two of these social factors (percentage male unemployment and percentage in social classes III–V) and one climatic one (rainfall) accounted for a large proportion (73%) of the variation in the geographical mortality.

Notable by their absence from the model and indeed for their lack of significant association with mortality from coronary heart disease are temperature and water hardness. The observation that within England and Wales there was an association between cardiovascular mortality and water hardness dates back to the early 1960s.[13] In his review of the subsequent studies, including two of trends in mortality after changes in hardness of drinking water, Shaper[26] concluded that there was a weak causal relation between water hardness and cardiovascular mortality. The absence of a significant relation in Scotland, which we have reported previously,[23] does not exclude the possibility that water hardness may have a very small effect that could not be detected. However, the range of water hardness was that in which an effect, if it occurred, would have been detected.[26]

An independent effect of climatic factors especially rainfall and temperature has been found in several studies.[4–6] One group, however, has failed to find an association with temperature.[7] The present study has found an effect of rainfall but not of temperature, so that the pattern in Scotland is not dissimilar to that in England and Wales. Several possible mechanisms have been suggested to account for the effect of climatic factors. These include body cooling, the enhanced spread of infection in winter months, and changes in physical activity (either inactivity or unaccustomed exercise).[26] At present the climatic effect remains an interesting unexplained observation.

The principal finding of this study was the importance of measures of social deprivation in explaining the geographical variation in mortality from coronary heart disease in Scotland. There have been several studies relating cardiovascular disease or coronary heart disease to socioeconomic variables, usually just in England and Wales[5–7 27] although one included some Scottish areas.[4] Only the one including some of Scotland and that of Brenner[27] found that the social (or socioeconomic) factors had an independent association with mortality from cardiovascular disease; the others found weak or inconsistent effects. Part of the explanation for the lack of effect of social factors in previous studies could be that they dealt with earlier time periods. Mortality from heart disease changed from being higher in the non-manual occupations in the 1950s to being higher in the manual occupations in 1970–73.[28] This trend has continued, to produce an even larger manual–non-manual gradient in 1979–83[29]—the period covered by the present study.

The finding of an increasing importance of social factors in coronary heart diseases raises questions about their meaning and the mechanism(s) by which they act. For example does the fact that male unemployment shows the strongest association with mortality mean that death among the unemployed is responsible for a large part of the geographical variation? This possibility is not supported by the range from 3·7% to 21·6% in unemployment rates. To produce the large range in coronary heart disease mortality ratios, from 61 to 136, the mortality rate among the unemployed, because they are such a small proportion of the whole population, would have to be many times that of those in employment. Although mortality may be higher among the unemployed[11 12] this is not sufficient to contribute greatly to the observed geographical pattern.

It has been suggested that social factors[4] may reflect a generally unhealthy lifestyle. This, however, begs the question of what are the "unhealthy lifestyle" features, and how do they translate into biological risk factors. Two studies[30 31] which investigated this found that only part of the social class differences could be explained by the classic risk factors (smoking, serum cholesterol, blood pressure). Further, although two of these risk factors, smoking and raised blood pressure, followed the expected pattern, the third, serum cholesterol, was actually lower in the manual workers. The idea that there may be major unknown risk factors awaiting identification has been rejected by one group.[31] But another group claimed that fibrinogen may be just such a new risk factor,[32] so the matter is far from being settled.

Whatever the mechanism by which these social factors operate it is clear that an important part of the geographical variation in mortality from coronary heart disease remains unexplained by them. Thus we

found that although the cluster of high mortality districts in the west may be largely explained by the social factors, the area of low mortality in the north east is not. It is clear that routine data on mortality and censuses pose as many questions about socioeconomic status, lifestyle, and coronary risk factors as they answer. Linked to this statistical exercise has been a large-scale survey of coronary risk factors and lifestyle in 22 of the Scottish districts of 12 000 men and women, called the Scottish Heart Health Study.[33] This study aims to investigate the factors underlying the geographical and social variation in mortality from coronary heart disease; the results are being analysed currently.

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Appendix *The socioeconomic categories and variables selected for initial analysis*[a]

Demographic
(1) Population density (persons per hectare)
(2) Percentage net change in population between censuses (1971 minus 1981)
(3) Percentage married adults[b]
(4) Percentage population less than 16 years
(5) Percentage population not in private household[c]
(6) Percentage population in rural areas (localities of less than 1000 population)

Economic characteristics
(7) Percentage men unemployed ages 16–64
(8) Percentage women unemployed ages 16–59
(9) Percentage men economically active ages 16–64[d]
(10) Percentage women economically active ages 16–59
(11) Percentage men in manufacturing industry ages 16+
(12) Percentage men aged 16–64 in private households in social classes III, IV, and V

Housing and amenities
(13) Percentage households council rented
(14) Percentage households owner occupied
(15) Percentage households not in self-contained accommodation
(16) Percentage households sharing or lacking a bath

Household composition
(17) Percentage households with more than one person per room
(18) Percentage households with three or more dependent children
(19) Percentage children under 16 in households with lone adult
(20) Percentage usually resident pensioners living alone

Other
(21) Percentage households with no car

[a]All population data refer to usually resident persons.
[b]Adults are aged $\geqslant 16$.
[c]Those in hospital, hostels, defence establishments, prison.
[d]Economically active includes those in employment and those seeking employment.