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Regional variations in mortality from ischaemic heart and cerebrovascular disease in Britain

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SUMMARY In middle-aged men and women, mortality from ischaemic heart disease and cerebrovascular disease is highest in the north and west of Britain. The worst region is West Central Scotland. Statistical analysis using a linear logistic model shows that the differences between the regions are significant and the yearly fluctuation in numbers of deaths contributes little to the overall variation.

Within Britain there are large variations in mortality from ischaemic heart disease and stroke. While differences in mortality from cardiovascular diseases have been reported in the county boroughs of England and Wales (Crawford *et al.*, 1968) and more widely throughout the country by Howe (1970), we wish to reappraise these by applying new methods of analysis and assessing their importance in statistical terms.

Methods

The numbers of deaths which form the basic data of this paper were obtained from the Registrar General's Statistical Reviews of England and Wales and the Annual Reports of the Registrar General for Scotland. The age groups chosen for study were 35 to 44, 45 to 54, and 55 to 64 for men and women. At younger ages the numbers of deaths were too small for analysis while at older ages the accuracy of death certification is less satisfactory (General Register Office, 1966; Alderson and Meade, 1967).

The figures were extracted for each year from 1969 to 1973, making a total 5-year period. The 1971 census (the central year of the period) was used as the source of population data in the calculation of rates.

The following diagnostic groups were used: (a) all causes of death, (b) ischaemic heart disease (IHD) (ICD 410–414), (c) cerebrovascular disease (CVD) (ICD 430–438), (d) malignant neoplasms of trachea, bronchus, and lung (ICD 162).

The 8th revision of the International Classification of Disease (ICD) was in force throughout the period of the study.

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England and Wales were subdivided into the 9 standard regions described in the publications of the Office of Population Censuses and Surveys (*Registrar General's Statistical Review of England and Wales*, 1969). In Scotland 5 regions were chosen based on the Registrar General's geographical divisions (Annual Report of the Registrar General for Scotland, 1969). Regional boundaries have the disadvantage that they have developed for historical and political reasons and, therefore, do not necessary take epidemiological characteristics into account. This study was made before the new regional structure was introduced in 1974.

Results

Table 1 shows the study populations in each region. South Scotland has the smallest population followed

Table 1 *1971 census population in thousands in the regions of England and Wales and Scotland*

Region	*Men*			*Women*		
	35–44	*45–54*	*55–64*	*35–44*	*45–54*	*55–64*
Scotland						
North west	16·5	15·9	16·4	16·0	16·4	18·6
North east	39 5	38·5	38·6	41·6	42·6	45·7
East central	86·3	87·2	81·1	90·6	94·6	94·4
West central	142·8	140·8	126·5	150·8	153·5	147·4
South	13·8	14·1	14·2	14·3	15·0	16·4
England and Wales						
North	197·5	207·5	181·2	197·2	210·4	199·1
Yorkshire and Humberside	279·2	296·9	273·4	277·6	300·7	300·6
North west	389·3	403·5	378·5	385·7	422·4	431·8
East Midlands	203·9	211·9	188·5	198·8	209·3	199·3
West Midlands	317·1	322·5	281·5	302·5	321·7	294·4
East Anglia	98·9	97·4	93·1	95·9	98·9	102·0
South east	1019·5	1031·8	991·6	1017·0	1091·0	1099·3
South west	212·8	220·0	219·4	213·0	236·4	251·6
Wales	158·4	172·2	156·6	157·0	178·2	174·6

by North West Scotland. These regions were not merged with neighbouring ones as they have characteristics of population and topography different from adjacent regions. The largest region is South East England which includes London.

Tables 2 to 5 give the age and sex specific rates for all causes of death, ischaemic heart disease, cerebrovascular disease, and malignant neoplasms of trachea, bronchus, and lung. Table 6 presents for comparison the death rates for all remaining

Table 2 *All causes of death: observed death rates per 100 000 (averaged over 1969 to 1973)*

	Scotland					*England and Wales*								
Age	*North west*	*North east*	*East central*	*West central*	*South*	*North*	*Yorkshire and Humberside*	*North west*	*East Midlands*	*West Midlands*	*East Anglia*	*South east*	*South west*	*Wales*
Men														
35–44	323	245	272	323	254	268	253	275	227	233	187	204	205	263
45–54	871	714	821	998	747	850	768	866	685	771	587	644	650	813
55–64	2140	2087	2264	2654	2180	2326	2185	2372	1960	2157	1702	1854	1873	2329
Women														
35–44	170	164	186	216	176	183	175	182	158	165	141	151	149	178
45–54	482	470	531	602	529	503	462	505	438	432	379	406	402	466
55–64	1085	1081	1191	1370	1191	1144	1094	1185	1006	1035	892	932	939	1104

Table 3 *Ischaemic heart disease (ICD 410–414) death rates per 100 000: comparison of observed rates (averaged over 1969 to 1973) and estimated rates*

		Scotland					*England and Wales*								
Age		*North west*	*North east*	*East central*	*West central*	*South*	*North*	*Yorkshire and Humberside*	*North west*	*East Midlands*	*West Midlands*	*East Anglia*	*South east*	*South west*	*Wales*
Men															
35–44	Observed	81	65	82	95	71	84	75	84	61	66	42	54	54	84
	Estimated	82	74	83	97	90	78	73	78	61	64	50	56	59	79
44–54	Observed	346	285	326	385	361	328	303	333	252	279	209	240	252	332
	Estimated	347	312	351	407	378	330	308	329	257	267	210	236	248	331
55–64	Observed	875	813	855	979	957	803	783	816	669	688	581	637	670	842
	Estimated	892	804	903	1047	973	849	794	848	663	689	542	610	640	853
Women															
35–44	Observed	14	9	17	20	13	12	12	14	11	13	7	7	8	16
	Estimated	13	12	14	16	15	13	12	13	10	10	8	9	10	13
45-54	Observed	59	61	84	94	91	68	55	66	48	42	30	36	36	57
	Estimated	62	56	63	73	68	59	55	59	46	48	37	42	44	59
55–64	Observed	271	249	296	351	300	268	235	252	183	184	135	154	164	243
	Estimated	252	227	255	296	274	239	224	239	187	194	153	172	180	240

Table 4 *Cerebrovascular disease (ICD 430–438) death rates per 100 000: comparison of observed rates (averaged over 1969 to 1973) and estimated rates*

		Scotland					*England and Wales*								
Age		*North west*	*North east*	*East central*	*West central*	*South*	*North*	*Yorkshire and Humberside*	*North west*	*East Midlands*	*West Midlands*	*East Anglia*	*South east*	*South west*	*Wales*
Men															
35–44	Observed	17	10	16	18	28	14	12	15	12	12	9	10	8	13
	Estimated	15	13	15	17	17	14	12	14	11	12	10	9	11	14
45–54	Observed	60	38	47	63	47	53	43	52	43	48	32	36	42	54
	Estimated	57	48	55	64	62	52	44	51	42	46	36	35	42	51
55–64	Observed	202	174	197	223	197	191	165	185	158	168	128	121	136	190
	Estimated	202	173	197	230	223	187	158	184	151	165	129	124	140	183
Women															
35–44	Observed	13	12	15	16	22	15	13	15	12	13	10	10	11	12
	Estimated	16	14	15	18	18	15	12	14	12	13	10	10	12	14
45–54	Observed	51	48	56	62	59	49	36	47	39	41	33	33	36	44
	Estimated	52	44	51	59	57	48	40	47	39	42	33	32	39	47
55–64	Observed	151	140	150	179	190	137	118	136	106	122	103	94	132	135
	Estimated	153	131	150	174	169	142	120	139	114	125	98	94	114	139

causes (that is excluding those for ischaemic heart disease, cerebrovascular disease, and malignant neoplasms of trachea, bronchus, and lung). Some of these results are illustrated in the Figure.

Statistical commentary

The method of statistical analysis used is that of the 'linear logistic model' (Nelder and Wedderburn, 1972) which considers P, the probability of dying from a disease for given age, sex, and region, to be a function of these factors and any other factors we may wish to consider. An analysis of variance approach to this type of data is given by El-Shaarawi *et al.* (1976).

To establish whether the yearly fluctuations in the observed deaths were unduly pronounced, the first linear model tried included the factors age, sex, region, and year. The results of this analysis convincingly showed that the annual fluctuations in the data contributed a statistically insignificant amount to the overall variations, the main contributions to which were age, sex, and region. For all further analysis, therefore, the average number of deaths, expressed as age and sex specific death rates per 100 000, for the 5-year period 1969 to 1973, was used.

The reduced linear logistic model (that is using the average 5-yearly age-sex specific death rates per region) was fitted separately for the disease categories ischaemic heart disease, cerebrovascular disease, and malignant neoplasms of trachea, bronchus, and lung. The factors included were age, sex and interaction[1] of age and sex, and region. The results are shown in Tables 3, 4, and 5 where the estimated values calculated from the logistic model are compared with the average death rate per 100 000 over the 5-year period. The comparison is adequate and in parts astonishingly close especially as the model only requires 18 degrees of freedom out of the total of 83 degrees of freedom. This strongly suggests that the combined effect of 4 factors, namely age, sex, age-sex interaction, and

[1]An 'interaction' variable allows for some combined and interrelated effect due to 2 variables over and above the effect of each of the variables considered separately.

Table 5 *Malignant neoplasms of trachea, bronchus, and lung (ICD 162); death rates per 100 000: comparison of observed rates (averaged over 1969 to 1973) and estimated rates*

		Scotland					*England and Wales*								
Age		*North west*	*North east*	*East central*	*West central*	*South*	*North*	*Yorkshire and Humberside*	*North west*	*East Midlands*	*West Midlands*	*East Anglia*	*South east*	*South west*	*Wales*
Men															
35–44	Observed	6	11	15	23	7	18	15	19	13	14	11	10	10	11
	Estimated	8	12	14	18	11	16	14	15	12	14	11	13	11	11
45–54	Observed	58	75	83	118	62	104	87	100	69	90	65	70	61	66
	Estimated	51	73	86	112	67	94	82	92	70	84	67	78	66	66
55–64	Observed	173	243	298	384	214	315	291	319	251	299	240	281	239	248
	Estimated	181	258	304	395	236	332	292	325	247	296	238	277	234	235
Women															
35–44	Observed	6	8	6	8	6	9	6	6	4	5	3	5	3	5
	Estimated	3	5	6	7	4	6	6	6	5	6	5	5	4	4
45–54	Observed	16	30	31	37	39	34	26	29	18	24	21	23	18	17
	Estimated	16	22	26	34	20	29	25	28	21	26	21	24	20	20
55–64	Observed	35	49	57	68	52	55	48	54	44	46	46	60	47	34
	Estimated	33	48	56	73	44	61	54	60	46	55	44	51	43	43

Table 6 *All other causes of death (excluding ischaemic heart disease, cerebrovascular disease, and malignant neoplasms of trachea, bronchus, and lung): observed death rates per 100 000 (averaged over 1969 to 1973)*

	Scotland					*England and Wales*								
Age	*North west*	*North east*	*East central*	*West central*	*South*	*North*	*Yorkshire and Humberside*	*North west*	*East Midlands*	*West Midlands*	*East Anglia*	*South east*	*South west*	*Wales*
Men														
35–44	219	159	158	186	148	152	151	158	140	141	125	131	133	155
45–54	407	317	365	431	277	365	335	382	321	354	281	298	296	361
55–64	890	856	915	1068	812	1017	945	1052	883	1003	754	815	828	1049
Women														
35–44	138	136	148	171	135	147	144	147	131	135	122	128	127	144
45–54	356	332	359	409	341	352	345	363	333	325	295	313	311	348
55–64	629	643	686	773	649	684	692	744	673	683	608	625	596	692

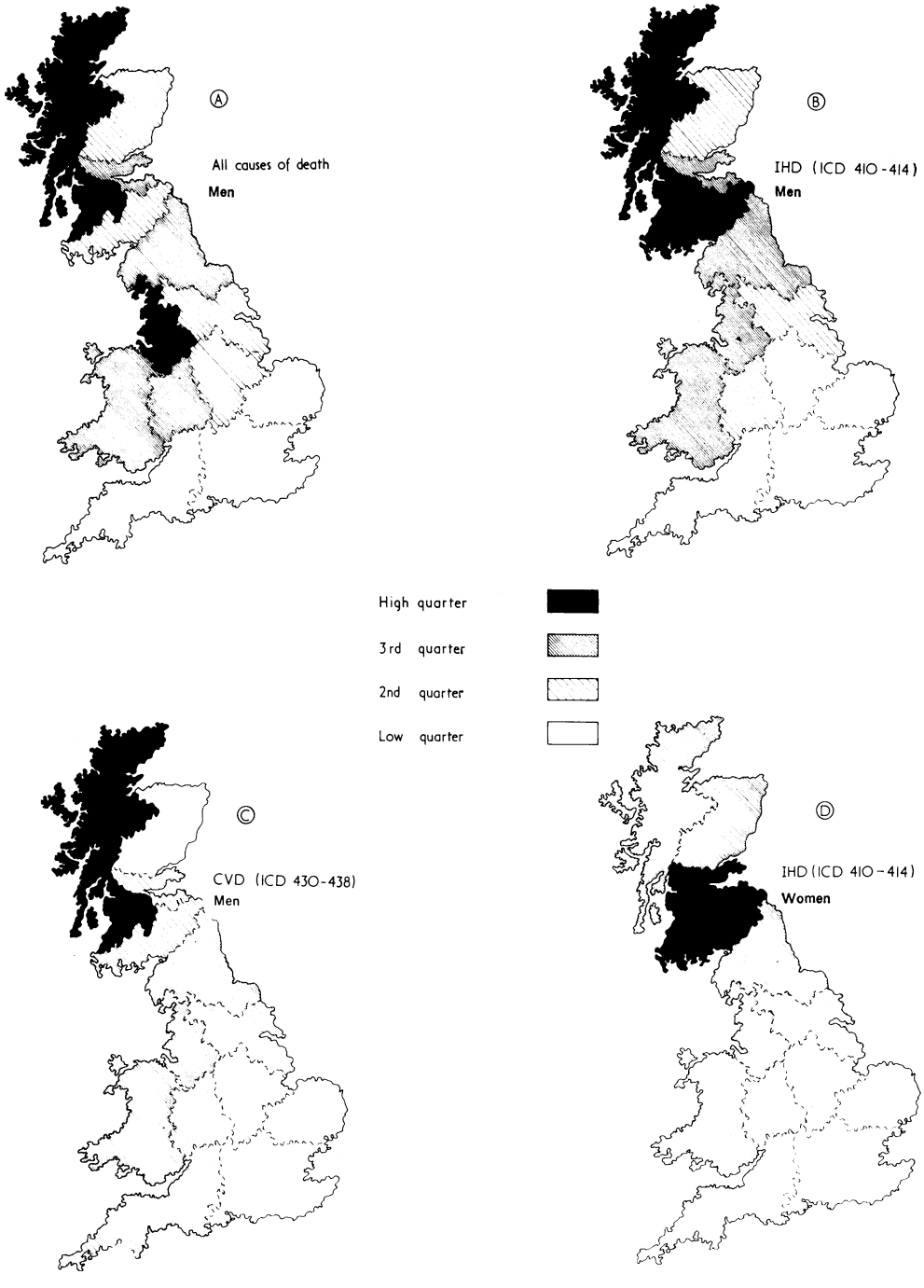

Fig. *Death rates per 100 000 at ages 45 to 54 in the regions of England and Wales and Scotland. The shading has been decided on the basis of division into quartiles in so far as this is possible with 14 regions. (A) All causes of death, men; (B) ischaemic heart disease (ICD 410–414), men; (C) cerebrovascular disease (ICD 430–438), men; (D) ischaemic heart disease (ICD 410–414), women.*

Table 7 *Analysis of deviance*

Source of variation	*Degrees of freedom*	*Deviance*			*95 per cent critical value*	*99·9 per cent critical value*
		Ischaemic heart disease	*Cerebrovascular disease*	*Lung cancer*		
Age	2	27 390	8569	11 312	6·0	13·8
Sex	1	17 114	139	6716	3·8	10·8
Age-sex interaction	2	304	31	155	6·0	13·8
Region	13	1269	432	253	22·4	34·5
Unaccounted remainder	65	163	32	84	84·8	106·0
Overall	83	46 240	9203	18 520	—	—

the 'regional effect' explains nearly all the variation in the data. This is again shown in another way in Table 7.

From Table 7 it is immediately clear whether any of the 'effects' are statistically significant, at either the 95 per cent or 99·9 per cent levels, by comparing the value in the deviance[1] column with the corresponding critical χ^2 value; if the deviance exceeds the critical value then the effect is statistically significant at that level (Nelder and Wedderburn, 1972). It is clear that statistically the regional effect for all these disease categories cannot be explained by random variation. The regional effect is real and contributes to the variation in the death rates. In absolute terms, age and sex have more effect than the regions. But the regional effect may suggest aetiological factors not at present recognised and is the more important in terms of medical intervention.

By fitting a linear logistic model including 'region-age' and 'region-sex' interaction terms, some evidence is found that there is a greater regional effect (variation) for women with ischaemic heart disease but there is no indication that the regional effect is more pronounced for any one of the age groups for ischaemic heart disease. There is no indication that the regional effect is in any way more distinct for one of the sexes or for one of the age groups for cerebrovascular disease or lung cancer. However, these statistically significant results must be seen in relation to their practical effects. When these 'region-age' and 'region-sex' interaction terms were included in the linear logistic model and when this model was used to calculate estimated death rates, the improvement in estimated values was slight as compared with estimates from a model omitting these interaction terms. Present evidence, therefore, suggests that regional variation is only marginally changed when considering men compared with women or the younger with the older age group.

[1]The analysis of deviance can be considered as a generalisation of the analysis of variance. A definition is given by Nelder and Wedderburn (1972).

A similar analysis was undertaken to examine changes in regional effect with the disease category. Ischaemic heart disease and cerebrovascular disease have a very similar pattern of variation over the country, while lung cancer shows a different pattern. There is thus some evidence that the regional effect or variation is different for at least some diseases.

Discussion

The highest rates for ischaemic heart disease and cerebrovascular disease mortality are in the north and west of Britain. There are, in general, higher rates in the west compared to the east side of the country. The worst region is west central Scotland. Further north the rates tend to be lower. Most rates in the age-sex groups studied are substantially higher in Scotland than in the English regions. The problem of the very high mortality from ischaemic heart disease in Scotland has recently been emphasised by figures from the *World Health Statistics Annual for 1972* (1975) which indicates that Scotland is second only to Finland in having the highest rates in the world for men aged 35 to 64 (359 per 100 000 at age 45 to 54): this contrasts with England and Wales where the rates are appreciably lower (289 per 100 000 at age 45 to 54).

Criticism has been directed at mortality data on the grounds of the inaccuracy of death certification. While some of this is justified, it is clear that the use of mortality statistics can given an overall picture of many diseases. The use of broad diagnostic categories such as ischaemic heart disease and cerebrovascular disease has been shown to reduce inaccuracy and the proportion of new facts found at necropsy is lower in the age groups below 65 (Reid and Rose, 1964; General Register Office, 1966; Alderson and Meade, 1967). There is at present no evidence to suggest that there are regional differences in death certification practice.

We do not propose to speculate about the reasons for the regional differences in mortality data.

Studies are needed to determine whether these

differences apply also to morbidity data.

The implication of these findings should be heeded in the distribution of health service and research resources.

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