GEOGRAPHICAL DISTRIBUTION OF PRIMARY TUMOURS OF BONE IN ENGLAND AND WALES

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A study of the reliability of the diagnosis of primary malignant tumour of bone as the cause of death has enabled an estimate to be made of the mortality from bone tumours in England and Wales, by sex and age (Mackenzie, Court Brown, Doll, and Sissons, 1961). The data obtained can be used in conjunction with census data to see whether the mortality from bone tumours varies significantly in different parts of the country. In the present study a comparison is made between the observed and expected mortality in 39 areas, and the variation in the mortality has been compared with the variation in the radioactivity of local water supplies.

METHOD.—The population of each local authority area is known for each sex and 5-year age group at the time of the census in 1951, and estimates of the home populations for both sexes and for all ages combined are known for each of the major areas for the 3 years 1951, 1952, and 1953. The number of bone tumour deaths expected in each area has, therefore, been calculated in three steps. First, the census population in each sex and 5-year age group in each area has been multiplied by the ratio between the average population in that group in the whole country throughout the period 1951–53 and the corresponding population recorded at the time of the census. Secondly, the resulting populations in each sex and age group have been multiplied by the corresponding sex and age-specific annual mortality rates, and the results have been summed for all ages

under 65 years. Thirdly, the expected numbers of bone tumour deaths so obtained have been corrected for differential rates of population growth by multiplying by the ratio between the total estimated population for each area for 1951–53, and the total population obtained for that area by assuming that the rate of population growth in each sex and age group was equal to that for the whole country. For example, 201,267 boys aged 15–19 years were recorded as living in Greater London at the 1951 census; the ratio between the average population of England and Wales in 1951–53 and the census population for the entire country in this sex and age group was 1·0474, so that the corrected population was 210,807. The corresponding average annual mortality rate from bone tumours in 1951–53 was estimated to be 13·72 per million, so that the number of deaths expected in this sex and age group in Greater London in one year was calculated to be 2·8923. The annual total number of deaths in both sexes and at all ages under 65 years was 37·4931, so that the number expected in a 3-year period was 112·48. Since the correcting factor for the differential rate of population growth in Greater London was 0·9949, the final estimate of the expected number of bone tumour deaths in Greater London was 111·91.

Data were calculated separately for each county and for County Boroughs of more than 700,000 population. The only exceptions were the following:

(1) If the number of expected deaths was less than

four, the county was combined with a neighbour*;

- (2) Greater London and the remaining parts of the Home Counties (*i.e.* Kent, Surrey, Hertfordshire, and Essex) were treated as two areas;
- (3) Wales, apart from Glamorganshire and Monmouthshire, was treated as a single unit.

RESULTS

GEOGRAPHICAL DISTRIBUTION.—The numbers of deaths observed and expected in each area are shown in Table I.

TABLE I
DEATHS FROM PRIMARY TUMOURS OF BONE IN
DIFFERENT PARTS OF ENGLAND AND WALES,
1951–1953

Observed compared with expected

Area	No. of Deaths		Standardized Mortality Ratio
	Observed	Expected	
Manchester	17.40	9.68	180
Norfolk	12.89	7.52	171
Monmouthshire	9.73	5.80	168
Cheshire	27.29	17.24	158
Northumberland	15.33	10.89	141
Leicestershire and Rutland	12.22	8.75	140
Glamorgan	23.04	16.59	139
Sussex	16.85	12.31	137
Cambridgeshire and Hunting- donshire	5.88	4.55	129
Warwickshire, less Birmingham	12.52	10.15	123
Liverpool	13.03	10.69	122
Devon	13.04	10.99	119
Leeds	8.13	6.86	119
Hertfordshire and Shropshire	6.91	6.02	115
Lincolnshire	10.94	9.67	113
Sheffield	7.66	6.91	111
Yorkshire, less Sheffield and Leeds	51.84	49.28	105
Cornwall	4.86	4.74	103
Staffordshire	22.36	22.04	101
Lancashire, less Liverpool and Manchester	49.86	49.26	101
Birmingham	14.57	14.82	98
Home Counties*, less Greater London	41.24	42.56	97
Hampshire	17.51	18.23	96
Durham	19.17	20.17	95
Dorset	3.87	4.14	93
Wiltshire	5.37	5.79	93
Wales, less Glamorgan and Monmouth	11.89	13.34	89
Buckinghamshire and Oxford- shire	8.00	9.44	85
Cumberland and Westmorland	4.03	4.81	84
Derbyshire	9.38	11.27	83
Nottinghamshire	9.34	11.51	81
Gloucestershire	10.08	12.80	79
Greater London	82.91	111.91	74
Bedfordshire	3.05	4.40	69
Somerset	4.98	7.35	68
Berkshire	3.00	5.72	52
Worcestershire	3.61	7.18	50
Northamptonshire	2.00	5.74	35
Suffolk	1.63	6.15	27
All Areas	597.41	597.27	100

* Kent, Surrey, Middlesex, Hertfordshire, Essex, and London.

* This was determined independently, without knowledge of the results, so as to avoid bias in the choice of counties to be combined.

It will be noted that in most cases the number of observed deaths is not an integer. This anomaly is due to the fact that the data from which the deaths have been obtained were incomplete (Mackenzie, Court Brown, Doll, and Sissons, 1961). In the 3-year period 1951–53, 1,169 deaths were attributed to primary tumours of the bone among persons aged less than 65 years, who were resident in England and Wales. Inquiries showed that the diagnosis could be confirmed in approximately 52 per cent. Further information beyond that recorded on the death certificate was, however, obtained for only 990 cases, and an estimate had to be made of the number of true bone tumours corresponding to the 179 deaths for which no further information was available. The detailed information obtained for the 990 cases allowed this to be done with considerable confidence. For example, none of the deaths attributed to cancer of the ethmoid proved to be due to a primary bone tumour, whereas the diagnosis was confirmed in 44 out of 45 deaths (98 per cent.) described as occurring in association with Paget's disease. Consequently, it was possible to give a value (between 0.00 and 1.00) for each of the 179 deaths in which no further information was obtained, indicating the probability that the death was due to a primary bone tumour, and these values have been included in the total number of cases observed in each area.

The extent of the variation in mortality between the different areas can be seen by comparing the standardized mortality ratios (that is, the ratios of the observed to the expected deaths, expressed as a percentage). Table I shows that these varied from 27 per cent. in Suffolk to 180 per cent. in Manchester. With the small number of deaths recorded in some of the areas, considerable variation must, however, be expected due to chance factors alone. A test of the significance of the difference between the observed and expected deaths shows that $\chi^2 = 47.12$. For 38 degrees of freedom this value has a probability of between 0.3 and 0.4, and it must, therefore, be concluded that the extent of the variation recorded between the different areas is no more than could reasonably be attributed to chance. It does not necessarily follow that there are no local factors which affect the incidence of bone tumours, but only that the effects of any such factors are too small in comparison with the effect of random factors to be detected with the amount of data now available. In fact, examination of the Figure (opposite), in which the data from Table I are presented cartographically, suggests that there may be real regional differences. Several counties with low standardized mortalities are grouped together in the southern and south-midland regions and it is possibly significant that the

FIGURE.—Map of England and Wales showing standardized mortality ratio for malignant tumours of bone at ages under 65 years, in 39 areas, in 1951-53.

areas with a high mortality include a large proportion of industrialized communities with a relatively low economic status. Whether these groupings are of any significance can be tested by seeing whether they are repeated in other studies of the distribution of the disease at other periods.

RADIOACTIVITY OF WATER.—Drinking water supplies one of the principal sources of ingested radium, and it is of interest to see whether there is any correlation between the radium content of the water and the mortality from bone tumours in different parts of the country. No fully representative data for the radium content of water are available, but Turner, Radley, and Mayneord (1961) have published the results of measurements carried out on 63* samples of water from nineteen of the areas shown in Table I.

Average values of the samples for each of the nineteen areas are shown in Table II, in com-

parison with the corresponding standardized mortality ratios. There is no obvious correlation between the two sets of data and the correlation coefficient ($r = -0.086$; S.E. 0.228) is not significantly different from zero. This does not necessarily mean that the small amounts of naturally-occurring body radioactivity are not responsible for any cases of bone tumour. First, the samples of water may not be properly representative of the areas from which they were taken. Secondly, drinking water is only one source of natural body radium. If the water content is high and the dietary content of α -emitters is low, drinking water may be the most important source. If, however, the diet contains a large proportion of cereals, the relative importance of drinking water may be small. For example, Mayneord (personal communication) has shown that the average α -ray activity of the bones of residents in Cornwall is only about twice that of the bones of Londoners, whereas the difference between the activity of the water supplies shown in Table II is approximately four-fold. It may, however, be noted that the range of the differences in the α -activity of water is large (more than thirty-fold) and the data may be regarded as evidence that the radioactivity of drinking water is not a major factor in the production of primary malignant tumours of bone in Britain.

SUMMARY

A comparison has been made of the observed and expected mortality from true primary tumours of the bone in 39 parts of England and Wales in 1951–53. The results show that there was a zone of relatively low mortality in the southern and south-midland parts of the country, but that the variation in mortality throughout the country was no more than could reasonably be attributed to chance.

The standardized mortality ratio was not significantly correlated with published figures for the long-term radioactivity of drinking water in nineteen of the areas.

REFERENCES

- Mackenzie, A., Court Brown, W. M., Doll, R., and Sissons, H. A. (1961). *Brit. med. J.*, 1, 1782.
Turner, R. C., Radley, J. M., and Mayneord, W. V. (1961). *Nature*, 189, 348.

TABLE II
COMPARISONS BETWEEN STANDARDIZED MORTALITY RATIOS FOR BONE TUMOURS AND LONG-LIVED α -ACTIVITY OF LOCAL DRINKING WATER

Area	Standardized Mortality Ratios (1951–53)	α -Activity of Drinking Water at 30 Days (1960)	
		No. of Samples	Mean Value ($\mu\text{c./litre}$)
Somerset	68	1	0.33
Greater London	74	6	0.54
Gloucestershire	79	5	1.20
Buckinghamshire and Oxfordshire	85	2	0.17
Wales, less Glamorgan and Monmouthshire	89	7	0.07
Dorset	93	1	0.11
Hampshire	96	1	0.23
Home Counties, less Greater London	97	3	0.38
Birmingham	98	1	0.07
Staffordshire	101	3	0.91
Cornwall	103	10	2.23
Yorkshire, less Leeds and Sheffield	105	2	0.41
Sheffield	111	1	0.09
Lincolnshire	113	1	1.34
Devon	119	3	0.34
Warwickshire, less Birmingham	123	1	1.60
Sussex	137	1	0.11
Glamorgan	139	2	0.36
Manchester	180	3	0.07

* Excluding the data for spa water, but including the figures for Sampford Spinny given in the addendum.