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Regular Review

Geographical variations in disease in Britain

D J P BARKER

In 1889 the *British Medical Journal* published a report on the geographical distribution of rickets, rheumatism, chorea, cancer, and urinary calculus in the British Isles.[1] The report was based on questionnaires completed by more than 3000 doctors at the request of the BMA. Among the findings were that urinary calculus was especially common in Norfolk and that rickets was mainly a disease of industrial areas. The author of the paper, Dr Isambard Owen, offered no explanation of these and other findings, simply urging that the study of geographical distributions of disease in Britain should be continued.

This important report was one of the first large-scale attempts to document geographical variations in the frequency of common disorders, but general interest in this subject was by no means new. For example, doctors in Norfolk had long been aware that bladder stones were remarkably common in their county, with records going back to 1600. In 1874 a Norwich surgeon had written to other surgeons in the large hospitals throughout Britain and obtained from each the number of cases of stone treated in the previous five years as a proportion of all inpatients.[2] Speculating on the causes of the geographical variation shown, he discounted climate in favour of associations with lack of milk, malt liquor, and hardness of drinking water.

A year after the *BMJ* report Palm[3] published the findings of a survey of rickets. He had asked medical missionaries in many countries about "the prevalence or absence of rickets, the habits of the people, and their climatic and sanitary conditions." Analysis of the replies led him to the brilliant discovery that lack of sunshine was the main aetiological factor in rickets.

During the second half of the nineteenth century the annual reports of the Registrar General showed quite clearly that mortality varied from one part of Britain to another. A striking feature of this variation was consistently higher death rates in the north and west than in the south and east. As the report of the Local Government Board for 1915 and 1916 stated, a map of the coal measures in Britain would amost have served as a map of the chief areas in which child mortality was excessive.[4]

Remarkably, the decline in mortality during this century has not eliminated the disparity between the north and west and the south and east. Figures for the 61 largest county boroughs in England and Wales show that from 1911 to 1967 death rates among middle-aged people steadily declined, but the highest rates have remained just less than double the lowest.[5] Mortality in towns such as Oldham and Salford has consistently been almost twice that in towns like Ipswich and Norwich. The magnitude of the current differences is shown by the variations in life expectancy. Based on regional death rates for 1974-5, the expectation of life at birth for men ranges from 67·9 years in the North-western region to 71·3 years in the East Anglian region; for women the figures are 74·3 and 76·9 years.[6]

Whereas in the past these geographical inequalities in survival reflected differences in the incidence of infective diseases, they now reflect differences in mortality from a large number of non-infectious diseases, including ischaemic heart disease, cerebrovascular disease, bronchitis, and total mortality from malignant disease. As might be expected, however, not every cause of mortality has followed or follows the general trend. A map of mortality from thyrotoxicosis in 1936 showed no systematic north/south variation but localised areas of high mortality which correlated with the prevalence of brunettes.[7 8] Currently breast cancer is one of several diseases with mortality rates showing an atypical distribution: the highest rates are in East Anglia and the Midlands and the lowest in the north.

How far does this imbalance in mortality reflect a similar imbalance in morbidity (that is, ill health)? The most recent *Hospital In-patient Enquiry* (for 1977) shows that hospital discharge rates for all diseases combined are lowest in Wessex, East Anglia, the West Midlands, and the South-western region.[9] Of course, not every disease follows this trend: discharge rates for upper urinary tract stones, for example, are generally higher in the southern regions of England than in the north.[10] Hospital admission data are imperfect indicators of frequency of many chronic disorders, and the two national morbidity surveys conducted by the Royal College of General Practitioners provide an additional source of data. But for most diseases information on prevalence or incidence must be obtained by special surveys. For example, the prevalence of gall stones cannot be inferred from hospital or general-practitioner statistics, but an indication of their frequency may be obtained by recording their prevalence at necropsy. The most recent survey in Britain, carried out in nine towns, showed a strong negative correlation between the prevalence of gall stones and mortality from ischaemic heart disease[11]—yet both have been classified as "diseases of civilisation" and are said to have similar causes.

What, then, are the causes of the remarkable variations in incidence and mortality within so small a country? For a few diseases a single specific influence dominates the distribution. The concentration of mesothelioma in ports and certain towns is determined by its association with exposure to asbestos.[12] For most diseases, however, it is not yet possible to go beyond general influences—genetic, social, climatic, geophysical.

Some writers have emphasised the ethnic diversity of Britain. For example, blood group O is more common in the north and west, and there is a positive correlation between mortality from all causes and the percentage of blood donors of group O.[13] Nevertheless, multiple correlation analyses show that variation in genetic influences, as indicated by the ABO genes, could provide only a partial explanation of the variation in mortality.

Socioeconomic differences offer another possible explanation. In a study of mortality in the 61 largest county boroughs of England and Wales a range of intercorrelated socioeconomic indices, such as social class distribution and population density, was used to produce a single social factor score for each county borough. The social factor scores were strongly correlated with mortality. Multiple regression analysis showed, however, that they accounted for only part of the variation in death rates.[5] Latitude was one of several factors which had a relation with mortality that was independent of the social factor score.

Within England and Wales mortality rates are higher in the connurbations than in the rural districts—a fact noted in the first annual report of the Registrar General in 1839 and dwelt on repeatedly since. These differences are still seen in every age, but they are small except for middle-aged and older men.[14] The principal cause of excess mortality in older urban men is chronic bronchitis, due in part to air pollution arising chiefly from domestic coal fires. Legislation to control air pollution has led to a decline in the urban-rural gradient in bronchitis, but this hazard is not yet past. A number of other adverse influences in the urban environment may be identified from the complex of social and economic influences: occupational factors are probably responsible for the higher urban rates for bladder cancer; overcrowding facilitates the spread of respiratory infections; and cigarette smoking became widespread in cities before it did so in the rural areas.

As affluence and improved transport lessen the contrast between urban and rural life styles so, too, may differences in health diminish, but for the time being they remain important. The interrelation of adverse factors in the north-western and urban environments is shown by perforated duodenal ulcer. Comparison of hospital discharge rates for perforated duodenal ulcers in Trent and Wessex shows that within each region urban rates are higher than rural, but Trent urban rates are higher than Wessex urban rates and, likewise, Trent rural rates are higher than Wessex rural rates.[15] The strength of the adverse northern (that is, Trent) influence when combined with the urban influence is almost enough to counterbalance the male preponderance of the disease—the rate among women in urban Trent being 6·3 per 100 000 compared with 7·8 among men in rural Wessex.

When we attempt to correlate disease distribution with that of socioeconomic and behavioural influences regional comparisons are often unsatisfactory. For example, dietary factors are suspected in the aetiology of many diseases. The National Food Survey, which uses a regional sampling frame, has shown appreciable differences between regions. The average consumption of green vegetables, for example, ranges from 300 g per person per week in the Northern region to 533 g in the South-western region.[16] Yet interpretation of such average figures is difficult because of the heterogeneity within regions. Likewise an average figure for incidence or prevalence for a region may be misleading: higher prevalence rates for Paget's disease of bone in the North-western region result from a remarkably localised area of high prevalence within Lancashire.[17]

Difficulties in interpreting regional data are less in relation to environmental influences such as climate. In England and Wales the regional incidence of melanoma, a cancer which is becoming increasingly common, shows a positive correlation with the mean daily hours of sunshine[18]—a finding in line with other epidemiological evidence that exposure to sunlight is a causal factor. The distribution of arsenic in the environment has been suggested as an additional factor, for there are high arsenic levels in the soil of south-west England, the region with the highest incidence of melanoma.[19] Several such relations between environmental trace elements and human disease have been postulated—for example, between zinc and stomach cancer,[20] which has a remarkably high incidence in Wales.[21] The relation between iodine deficiency and goitre has already established that trace elements can determine the geographical distribution of human disease. Recent publication of a detailed geochemical survey of England and Wales will facilitate this line of inquiry.[22]

The trace element content of drinking water has been postulated as a cause of ischaemic heart disease. A study of adult mortality from heart disease in England and Wales during 1911-4 showed higher rates in the northern and western counties.[23] Over half the deaths were due to valvular disease, and the distribution correlated with that of deaths from acute rheumatic fever. Ironically, as ischaemic heart disease has replaced rheumatic heart disease as the major cardiac disorder, the excess cardiac mortality in the north and west has persisted. This, together with the higher rates of ischaemic heart disease in the lower social classes, highlights the paradox that within Britain some of the so-called diseases of affluent communities have a predilection for the less affluent groups in the population. The inverse relation between the distribution of ischaemic heart disease mortality and water hardness led to the well-known hypothesis of a direct causal association with soft water, mediated either through the calcium concentration or the concentration of trace elements —which differs between soft and hard water.[24]

The geographical distribution of diseases in children are of particular significance. Anencephaly rates (1965-7) ranged from 3·6 per 1000 total births in Northern Ireland to 2·9 in Wales and southern Scotland and 1·3 in East Anglia and the south-eastern region of England.[25] The annual incidence of Perthes's disease of the hip is 11·1 per 1000 children aged 14 and under in the Mersey region but only 5·5 in Wessex.[26] These findings imply that the geographical imbalance of mortality and morbidity in Britain is not just a legacy of past social inequalities but is due to influences still present in the environment.

To what extent this web of interrelated influences can be unravelled remains to be seen. Owen concluded his 1889 paper[1] by stating that "geographical distribution is the basis of sound aetiology, and on sound aetiology the success of preventive medicine depends." Even those working in units engaged in the study of geographical distributions will feel that his claim for it as the basis of aetiology is too strong. Maps of disease compel speculation about aetiology, but only rarely has such speculation by itself led directly to the discovery of causes. More usually the solution comes from interaction with ideas generated in clinical practice and the laboratory.

Few would disagree, however, that the remarkable geographical variations in disease in Britain offer tantalising clues to aetiology, and that the discovery of modifiable influences in the environment which adversely affect the health of people living in one part of the country is a major challenge to preventive medicine.

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