MEDICAL GEOGRAPHY AT LANCASTER UNIVERSITY

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INTRODUCTION

Is there any relationship between the incidence of childhood leukaemia and proximity to nuclear reprocessing installations? Why is the incidence of campylobacter food poisoning so very much higher in Lancaster than in other districts? What, if any, is the link between the incineration of wastes and human health? How can we plan the allocation of scarce resources for community care in a district so that they are distributed equitably among the local population?

All these, and many more, are questions that serve to bind the study of geography to medical science and practice. Geographers are trained to ask questions about the spatial distribution of human activity and environmental variation. There is a long tradition, dating from at least the 19th century [1,2] of the coming together of geographers interested in disease and medical practitioners asking geographical questions. In recent years there has been a resurgence of interest in medical geography, as instanced by the appearance of several books [3,4,5,6]. In part, this is due to the development of enabling technologies and the availability of machine-readable data-sets; several examples follow in this paper. It is also linked to geographers' growing interests in issues of human welfare, and to the posing of searching questions about relationships between such welfare and environmental degradation.

As the rhetorical questions posed earlier suggest, there are two strands to medical geography. The first is what we might call geographical epidemiology; this seeks to enquire about the spatial distribution of diseases and to describe and account for such patterns. The second deals more with health care planning; how to allocate resources over space in efficient and equitable ways. Although some research has been conducted by geographers at Lancaster University in the second area [7], as well as at other institutions [8], the present paper focuses on epidemiological applications. It begins by outlining some essentially descriptive work, involving computer mapping and database management systems work. This shows how it is possible to extract valuable information from (suitably anonymised) patient data. We then discuss how it is possible to go beyond this to do more analytical work. Some research into human behaviour and health is reviewed briefly. The paper concludes by outlining recent research developments that give some prominence and focus to the kind of work discussed earlier.

It will become clear that the work reported on here would have been impossible without active collaboration and co-operation from numerous individuals – consultants, specialists in Community Medicine, and so on, both within Lancaster and elsewhere in the region. It is also the case that such work increasingly requires the skills of more than one discipline; help from statisticians and environmental scientists is an obvious example.

Geographers at Lancaster University are indeed fortunate to be able to draw on such local expertise as well as that provided by the medical community.

A map is worth a thousand words . . .

Many sources of published medical data are available at an aggregate level. Most notably, these include the various data sets (for instance, on cancers and congenital malformations) published by the Office of Population Censuses and Surveys. Other sources include the documents produced by Regional Health Authorities, which now routinely offer data at district and electoral ward level on morbidity and mortality – see for example NWRHA, 1989 [9]. Although many issues of cartographic design and convention arise, it is straightforward to map such data. The increasing availability of computer mapping packages, including some for microcomputers, means that graphical displays (of varying quality!) frequently accompany such reports.

Such maps can be extremely useful tools if the data on which they are based are reliable. What does this mean? First, it is usually of little point to map rates (that is, number of cases per head of population) without standardising for population structure; otherwise, for instance, a map of mortality will simply reflect the distribution of elderly population. Consequently, maps of standardised mortality (or morbidity) ratios are usually produced (figure 1). The value of these depends further on the time period over which the data have been collected. Inevitably, numbers of cases fluctuate over time and so more faith can be placed on such ratios if they are based on longer runs of data. These ratios are notoriously unreliable if based on small numbers.

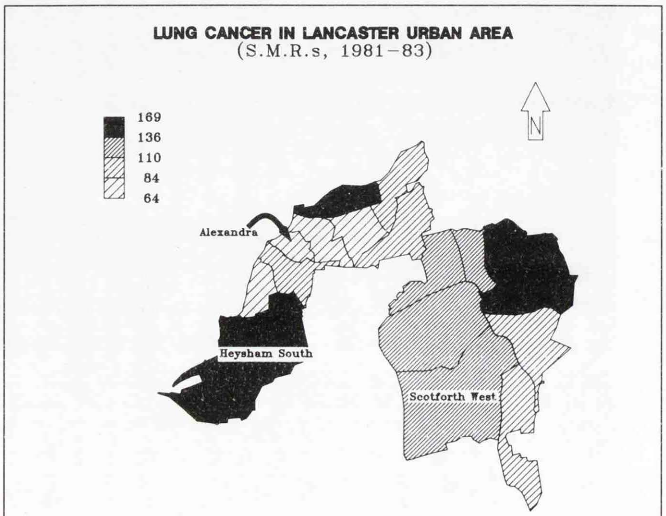

Figure 1 – Lung Cancer in Lancaster (1981-83): Standardised Mortality Ratios

One very common solution to this 'small number problem' is to calculate Poisson probabilities. Briefly, these identify areas where the observed number of cases is significantly in excess of (or less than) the average for a wide area. A good example comes from the work of John Whitelegg and David Gorst on adult leukaemia in North West England [10]. This has shown a striking band of wards along the Lune Valley with a significant excess of cases (figure 2). As usual, some caution must be attached to such maps; any map based on areal units gives an impression of homogeneity within an area. Yet the cases occur at discrete locations and the two or three cases in a ward may have arisen in very different parts of that ward.

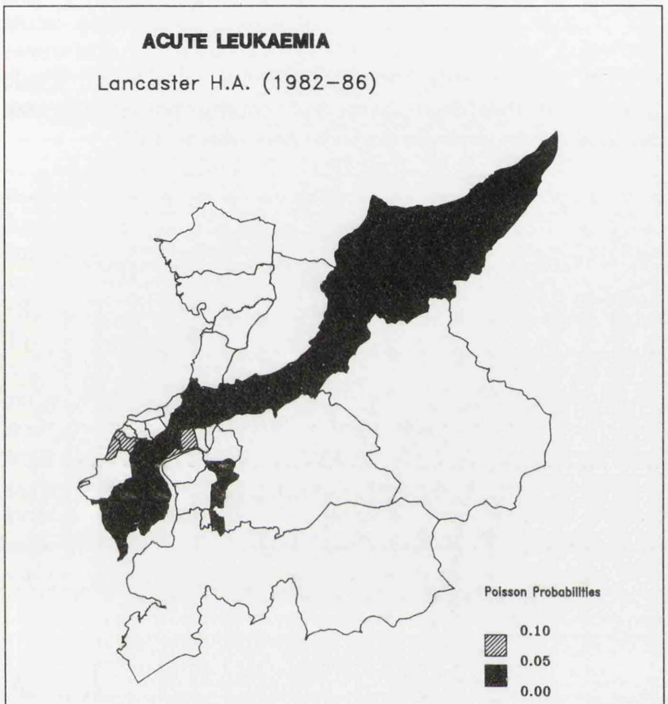

Figure 2 – Acute Leukaemia (Adult Patients) in Lancaster H.A. (1982-86): Poisson Probabilities

This reference to discrete locations leads us to consider a further problem with such shaded maps, namely the 'modifiable areal unit problem'. This means that the results we obtain in mapping and analysing areal data are dependent on the set of areal units we have chosen (or been given). One example of the difficulties we may have is where there may be several cases in close proximity, yet split between two or three adjacent areal units. What may be a genuine 'cluster' is masked when we calculate ratios for the separate areal units. This problem has bedevilled geographical analysis for many years. One solution is to devise analytical methods that use the discrete locations of cases rather than aggregating these to arbitrary areal units. This is discussed later. But how is it possible to map discrete cases?

If we have patient data with full addresses and if the number of cases is modest then it is of course trivial to map the distribution by hand (though problems of confidentiality must be considered). Increasingly, however, data are being made available in postcoded form. How does this allow us to produce maps? The key lies in having access to the Central Postcode Directory (CPD), a large computer file (containing some 1.5 million records) which matches each unit postcode (such as LA1 4RP or M5 4BT) with an Ordnance Survey grid reference, accurate to 100 metres. An extract from the CPD is shown here (figure 3). It is easy to write a computer program that takes a file of postcoded data and generates the accompanying grid references, which may then be mapped; plenty of software is available to do this point mapping.

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PR1 OAA 80018112351904284068N 111010
PR1 OAD 8001     352404286068N 110010
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PR1 ODP 8307     350204272068N 081112
PR1 ODQ 8001     351804284068N 110010
PR1 ODR 8001     351904285068N 110010
PR1 ODS 8001     351704285068N 110010
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Figure 3 – An Extract from the Central Postcode Directory, matching postcodes to Ordnance Survey grid references

To illustrate this, consider some data on mortality in Preston for 1981-1988. These data, made available through the Health Authority, comprised information on date of birth and death, sex, postcode, and primary cause of death. Some 13,000 records are part of this data set. Grid references have now been attached using the CPD.

Of course, it makes little sense to map all deaths! A map of 13,000 such points would merely mimic population distribution. Of much more value is to be able to enquire about a selected subset of the data and to generate the locations of such a subset for mapping. This can be done readily if the data are put into a Data Base Management System (DBMS). Many such systems are available, for micros and mainframes. At Lancaster we use a system called INGRES and this has associated with it a 'Structured Query Language' (SQL), which allows us to make simple enquiries, such as 'select the grid references of all cases of males under 65 years of age dying of ischaemic heart disease'. The grid references are then mapped as a point pattern (see figure 4 for an example).

Much of the work described here lies within the umbrella of what has come to be called 'Geographical Information Systems' (GIS). GIS deals in general with the computerised

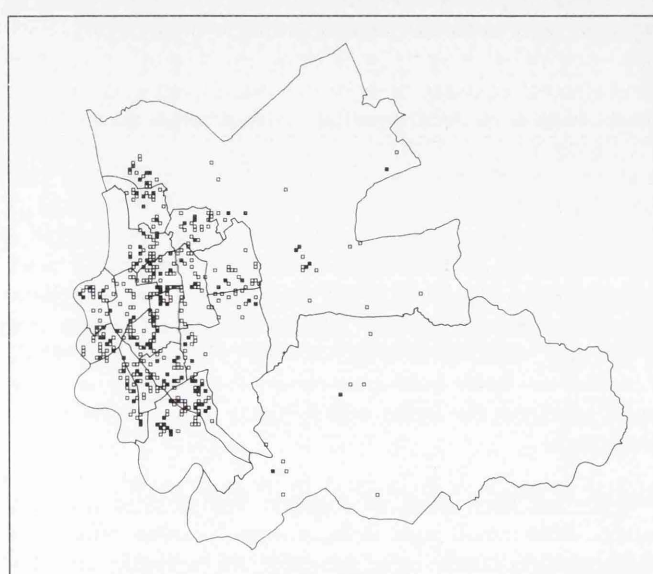

Figure 4 – Males under 65 years dying of ischaemic heart disease in Preston H.A. (1981-88). Note: solid squares denote multiple cases

handling of spatial data. Members of this university (including the author) are associated with the North West Regional Research Laboratory (NWRRL), which has been funded by the Economic and Social Research Council to conduct research and develop applications in this area. Although we conduct research in several areas we are very interested in epidemiological applications; one current project is examining the distribution of cancers of the larynx and lung within the North West as a whole.

From description to analysis . . .

A picture or map may be worth a thousand words but how can we assess whether there is anything unusual about the pattern? Are visual 'clusters' statistically significant? Does the map reveal something other than the natural 'clumping' of population?

To answer these questions requires some analysis, frequently based on statistical modelling. Two examples will suffice here. The first is concerned with the detection of clusters, the second with what is known as 'case-control methodology' in epidemiology.

Arguments about the recognition and detection of clusters of disease have existed for many years. Statistical tests are available to perform such analyses (several are reviewed in Elliot [11] and Hills and Alexander [12]). Geographers at Lancaster became involved in this kind of work when asked by one District Health Authority to look at the distribution of cancers in that district, with a view to assessing whether continuing concerns about the operation of a closed industrial incinerator were at all justified. Nothing unusual was detected, save for a striking 'cluster' of five cases of laryngeal cancer within two kilometres of the site. This visual evidence has been supplemented by using a new statistical methodology devised by Professor Peter Diggle of the Department of Mathematics, Lancaster University. Briefly, the method uses data on a much more common cancer to produce a map of 'background intensity' and then fits a model to the distribution of larynx cancer which estimates whether proximity to the possible pollution source is a risk factor. The results have confirmed the existence of a cluster (and more recent work suggests it is the only such cluster in that district), though we can of course speak only of 'association' and not causation. The work needs to be repeated using other measures of 'background intensity'.

A second example of how individual data may be used comes from work on congenital malformations on the Fylde of Lancashire (1957-83). This has been conducted by Andrew Lovett and the author, in association with Drs. Bound (Blackpool) and Harvey (Lancaster); Dr. Bound, a Consultant Paediatrician, had for many years assembled a quite superb set of data on malformations. Some earlier work is reported on elsewhere [13] but we have been able to show links between neural tube defects and social class [14] by linking the malformation data to 1971 Census data. More recently, we have used case-control methods to pinpoint small areas on the Fylde which had a significantly raised prevalence.

This has been done as follows. We took as cases all infants with neural tube defects (mainly spina bifida and anencephalus). Data were available on several variables, including age of mother, parity, date of last menstrual period, and area of residence (electoral ward). Ideally, we would have wished to match these cases to normal births but this was not possible. Instead, we took data on another class of malformations, cardiovascular ones, following a suggestion in the epidemiological literature that this was acceptable practice. For each case we then scanned the cardiovascular 'controls' to find those which matched it. For instance, those controls conceived to mothers of near-identical age, of the same parity, and in a near-identical month and year were taken to match. The risk factor of interest was geographical location; were the cases significantly more localised than the controls? We found evidence for such localisation at both a district and ward scale, with significantly raised prevalence in parts of Blackpool and Fleetwood (figure 5). This was repeated when other malformations were used as controls. It is still not entirely clear what explains this. We have recent, but patchy, data on lead in tap water, lead having being identified by others as a possible risk factor and this shows high levels in similar parts of the Fylde. Ideally, we would have liked data from case and control households; but medical geographers do not live in an ideal world!

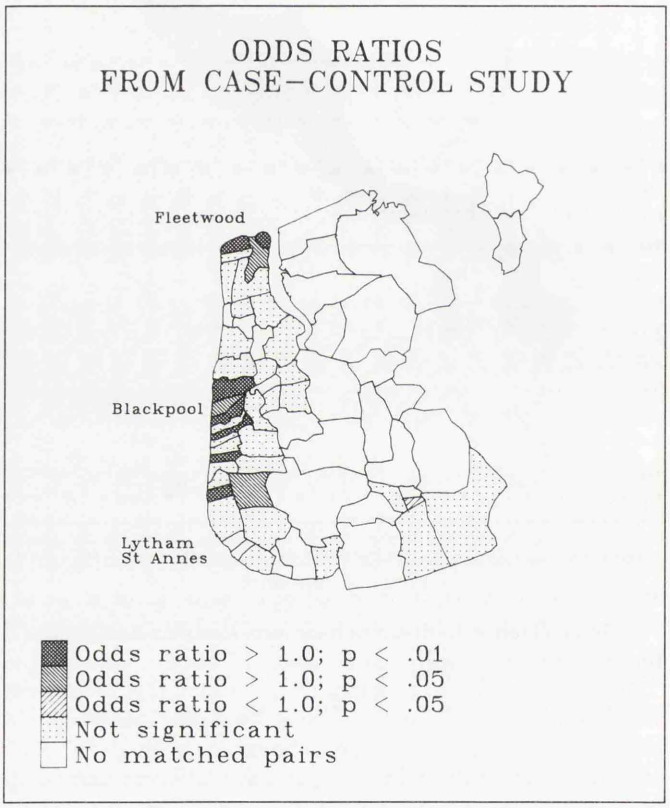

Figure 5 – Prevalence of neural tube defects on the Fylde (1957-1983): Odds Ratios from a Case-Control Study

There are, then, severe methodological problems in carrying out geographical-epidemiological investigations. Another important issue is that of migration. We tend to assume that place of death or residence at time of disease notifications is important; what we must not forget is the fact that some diseases (most obviously some cancers) will have quite long 'latent' periods; there may well be long gaps between exposure to some risk factor and notification of a disease. During this time the patient may have moved home, perhaps more than once. A high rate for cancer in one small town may simply reflect the fact that several people exposed to a carcinogen in different parts of the country happen to have migrated – perhaps retired – to that town.

How are we to deal with this problem? One helpful way is to look at life histories of patients. This inevitably takes us away from the essentially spatial analytical tools used in some of the work discussed above towards more behavioural studies of individuals. Let us consider a couple of examples.

Individuals, not areas, get ill . . .

Work on adult leukaemia in Lancashire has progressed from the aggregate spatial analyses referred to earlier (figure 2) to more 'micro-scale' approaches [15]. This has involved conducting in-depth interviews with patients living on the Fylde coast, using qualitative rather than quantitative techniques. Open-ended conversations, recorded on tape, covered topics such as residential and occupational histories, medical histories, exposure to chemicals, diets, hobbies, and so on. The focus was on the twenty years prior to diagnosis. There are obvious problems of recall, but the fifteen case studies yielded considerable detail. The aim was not to produce simplistic generalisations and it was clear that for any individual there were several possible factors that, in combination, could have led to the development of leukaemia. Some of these included exposure to exhaust fumes and local industrial pollution, with stress as a 'trigger' factor.

A second example of behavioural work being conducted within the department is that on geographical variations in knowledge, attitudes and practice in relation to HIV infections and AIDS. This is a project, currently in infancy, involving Andrew Lovett (Lancaster) and Christine Henry (S. Martin's College), with collaboration from Health Promotion Officers in Lancaster, Preston and Blackpool. The work will involve conducting interviews with a stratified random sample of adults in electoral wards. Opinions will be sought on a range of statements about HIV and AIDS, together with questions (to be included in a form for self-completion by the respondent) about drug use and sexual practices. The hope is that such work will inform health education strategies and assist the planning and targetting of campaigns.

A focus for research . . .

It should be clear from the above that several individuals within the Geography Department are involved in such research. Recognising this local expertise, and acknowledging a concern with 'green' issues, Lancashire County Council has funded an Environmental Epidemiology Research Unit for a five year period, to be based in the department. This came into being in January 1990 and is being directed initially by Dr. Colin Pooley, with Dr. John Whitelegg taking over this role for the main phase. An Executive Committee (comprising representatives from the Department and LCC) will oversee the work programme, advised by a larger group involving professionals from the health services. A Senior Research Fellow, with a background in environmental monitoring, has been appointed with effect from January. She will liaise with many individuals and groups, both within and outside the university, to ensure that the level of expertise brought to bear on a particular topic is maximised. The Executive Committee will take responsibility for identifying areas of research interest, in consultation with the Advisory Group. We regard this initiative as highly significant, offering the opportunity for capitalising on earlier research and widening our links to health professionals and environmental scientists.

More generally, Lancaster University as a whole has recognised the importance of health studies by setting up an inter-disciplinary Centre for Health Research. This involves major inputs from those in Departments of Social Administration, Sociology and Operational Research, as well as Geography. Members of S. Martin's College are also important contributors to this research group. The Centre will also take some responsibility for new teaching in this area, with a new MA in Health Research being one of its early initiatives.

Hopefully, this article has highlighted some of the range of research interests of a group of geographers. A feature of this research is its inter-disciplinarity and the need for collaboration with statisticians and environmental scientists, as well as the obvious essential links with health professionals. Future research is being developed via the Environmental Epidemiology Research Unit, and some via the Centre for Health Research. We shall look forward to reporting on some of this work in future issues of this journal.

References

1. Haviland A. The Geographical Distribution of Disease in Great Britain. Swan Sonnenschein, London. 1892.
2. Gilbert EW Pioneer maps of health and disease in England. Geographical Journal 1938; 124:172-183
3. Jones K, Moon G. Health, Disease and Society: An Introduction to Medical Geography. Routledge and Kegan Paul, London. 1988
4. Learmonth A. Disease Ecology. Blackwell, Oxford. 1988.
5. Hutt MSR, Burkitt DP. The Geography of Non-Infectious Disease. Oxford University Press. 1986.
6. Cliff AD, Haggett P. Atlas of Disease Distributions. Blackwell, Oxford. 1989
7. Whitelegg J. Inequalities in Health Care. Straw Barnes Press, Retford, Nottinghamshire. 1982.
8. Eyles J, Woods KJ. The Social Geography of Medicine and Health. Croom Helm, London. 1983.
9. North West Regional Health Authority Comparative Vital Statistics. North West Regional Health Authority, Statistical Analysis Section, Gateway House, Manchester. 1989
10. Burch J, Gorst DW, Whitelegg J. Geographical Distribution of Leukaemia in North West England. Department of Geography, Lancaster University. 1987.
11. Elliot P. Methodology of Enquiries into Disease Clustering. London School of Hygiene and Tropical Medicine. 1988
12. Hills M, Alexander F. Statistical methods used in assessing the risk of disease near a source of possible environmental pollution: a review. Journal of the Royal Statistical Society 1989; 152:353-363
13. Bound JP, Harvey PW, Brookes DM, Sayers BMcA. The incidence of anencephalus in the Fylde peninsula 1956-76 and changes in water hardness. Journal of Epidemiology and Community Health 1981; 35: 102-105
14. Lovett AA, Gatrell AC, Bound JP, Harvey PW, Whelan AR. Congenital malformations in the Fylde region of Lancashire, England 1957-73. Social Science and Medicine 1990; 30:103-109
15. Pooley CG, Gorst D, Bayman M. Investigating the life histories of adult leukaemia patients: a pilot study on the Fylde (Lancashire). Report submitted to the Leukaemia Research Fund. 1989