people of different birth weights differ is unlikely to be adequately represented by socioeconomic status as indicated by occupation. What is clear is that more research is required on the interrelation between early development, adult experiences and behaviour, and later risk of mortality. This research should be carried out in recognition of the fact that, particularly in the presence of crudely measured variables such as occupational social class, confounding can produce strong associations which are resistant to simple interpretations and are robust to attempts at statistical "control".³⁵⁻³⁶

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Socioeconomic deprivation in Britain: Commentaries

Socioeconomic deprivation and health and the ecological fallacy

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The three papers addressing the issue of socioeconomic deprivation and health published in this week's journal all conclude that deprivation is associated with increased mortality. Two of them are ecological studies in which the unit of observation is a geographically defined group.^{1,2} Such studies are susceptible to the ecological fallacy,³ which was first explained formally by Robinson.⁴ The advantages and disadvantages of ecological studies have been reviewed in depth by Morgenstern.⁵

The problem is that the correlation between two variables when the group is used as the unit of analysis may be quite different from the correlation between those two variables when individual people are used as the unit of analysis. A simple example with two dichotomous variables demonstrates the fallacy (table). When the area is the unit of observation there is an association between exposure and disease, area 2 showing both greater exposure (300/1000) and greater incidence (300/1000) of the disease than area 1 (100/1000 and 100/1000). But when individuals within the areas are the units of observation there is no such association: in each area the same proportions of exposed and non-exposed individuals have the disease (10% in area 1 and 30% in area 2).

Fortunately, substantial evidence using individuals as the unit of observation does exist to support the conclusion that ecological correlations between socioeconomic deprivation and health arise from associations among the relevant variables in individuals. One such piece of evidence comes from the paper by Sloggett and Joshi.⁶ They used data from the longitudinal study of the Office of Population Censuses and Surveys on a 1% sample of the population of England and Wales begun at the time of the 1971 census—that is, census records for the subjects in the longitudinal study were related to the subsequent deaths of these subjects. Sloggett and Joshi found that such socioeconomic variables as access to a car, being an owner-occupier, unemployment, and lower social class explained nearly all the relation between the degree of deprivation in an area of residence in 1981 and subsequent premature death before 1990. Of course, these results add support to the Black report⁷ and to the

Relation between exposure and disease in two areas. Values are numbers of people

	Exposed	Not exposed	Total
Area 1:			
Disease	10	90	100
No disease	90	810	900
Total	100	900	1000
Area 2:			
Disease	90	210	300
No disease	210	490	700
Total	300	700	1000

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research on this issue carried out since then (that published up to 1990 being reviewed by Davey Smith *et al*).⁸

So, those who would seek to criticise or ignore research on socioeconomic deprivation and health using ecological correlation studies in which appropriate indices of deprivation have been used cannot legitimately seek support from the ecological fallacy.

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Appropriateness of deprivation indices must be ensured

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Since 1971, census information has been used to identify localities where a high proportion of households are living under adverse social and economic conditions. The initial intention was that such areas should be provided with extra resources to improve the quality of life of individual people and their families.

Underlying this exercise was the assumption that improving local facilities (by upgrading housing estates or setting up educational priority areas) could improve residents' opportunity and quality of life without changing individual circumstances such as low wages or unemployment.¹ The items from the 1971 census used for the original Department of Environment deprivation index therefore included measures of housing quality and proxy measures of income such as employment status. Other variables such as the numbers of children aged up to 14 years would not in themselves constitute "disadvantage", but they were included as a measure of the need for services. In general, area deprivation index scores measure the proportion of households within a defined small geographical unit with a combination of circumstances indicating low living standards or a high need for services, or both.

Several deprivation indices have been developed

since the original 1971 Department of Environment measure. The underprivileged area index developed by Jarman was intended as an indicator of the demand for primary medical care. Accordingly, it included items thought to indicate the likelihood of high demand such as the proportion of elderly people living alone and the number of children under 5. Two other well known measures developed by Carstairs and colleagues and by Townsend and colleagues were guided by an interest in the effects of living standards on health. They contain items that might be regarded as good indicators of the amount and stability of household income: housing tenure, car ownership, unemployment, and social class.

Deprivation indices therefore need to be understood and evaluated in terms of (a) the purpose for which they are being used and (b) the validity of the assumptions about social and economic life that they embody. This is true of the decisions to include or exclude different items. It is also true of the different types of statistical procedures used to combine items together into a summary score. Items are often converted into a standardised Z score, which expresses each one in terms of its mean value in the population and its standard error. If this were not done then items with longer scales would have more weight than those with shorter scales in the overall score. For example, the number of children in a household could vary from, say, 0 to 10, while the number of cars available would lie between 0 and 3. Simply adding these together would give children more weight than cars. Standardisation is intended to avoid this problem, though this is easier for some items than for others. On the other hand, some components may deliberately be weighted more heavily if they are thought to be more important—for example, in the Jarman index "pensioners living alone" is weighted highest, whereas in the Department of the Environment's 1981 index unemployment has double the weight of other variables.

Information on the relation between mortality and deprivation in individual people can be obtained by linking death certificates to census information. This is what the longitudinal study of the Office of Population Censuses and Surveys makes possible—though only for 1% of the population. As a growing number of people find themselves without a single stable occupation, social class is becoming less satisfactory as a measure of living standards and lifestyle. The use of additional measures of disadvantage, both in the form of linked individual data and in the form of small area statistics, will therefore become increasingly valuable in estimating social variations in health.

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Relation between rates of leg amputation and distal arterial reconstructive surgery

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A recent audit of vascular surgical practice in the Oxford region showed distinct variation between districts in the rate and level of leg amputations for occlusive arterial disease.¹ There were also considerable differences between districts in the volume and nature of reconstructive arterial surgery. Arterial

bypass grafting of the calf or foot, operations largely reserved for limb salvage, were undertaken in only two hospitals in the region.

We carried out a six month prospective audit to study in greater detail the relation between distal reconstructive arterial surgery and leg amputation.

Subjects, methods, and results

The Oxford region has a total population of 2.5 million, with eight districts serving populations of 150 000 to 550 000. On the basis of the previous audit we divided districts into three high volume and five low volume districts, depending on whether they were carrying out above or below the average rate of arterial reconstructions for the region.¹

Vascular surgeons in each district were invited to participate in a prospective audit of all leg amputations

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