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Area variations in infant mortality 1975–7

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SUMMARY Infant mortality rates vary from area to area. Part of this variation is due to the socioeconomic characteristics of the area and part to other factors including the obstetric, paediatric, and community health services. Four social indicators associated with infant deaths are used to control for some of the variations in socioeconomic characteristics and residual variation is then examined. The four social indicators are the level of unemployment, the proportion of large families, the proportion of lone-parent families, and the level of overcrowding.

In 1978 the Department of Health and Social Security (DHSS)[1] contacted health authorities whose infant and perinatal mortality rates were worse than the national average, and asked them what they were doing to combat the problem. In its letter the DHSS recognised that:

> . . . variations in infant and perinatal death rates are in no sense a true measure of the effectiveness of an area's health services and may also reflect a whole range of wider social and environmental factors.

In their responses nearly half of the 33 area health authorities mentioned such factors as multiple deprivation, large ethnic minority groups or having a large proportion of their population in the lower social classes as accounting for their high rates.

The association between infant death, poor housing conditions, and other socioeconomic factors is widely recognised.[2 3] Although previous research has explored the nature of these relationships, it has not yet succeeded in providing policy-makers with a means of comparing infant mortality rates after making allowances for variations in these socioeconomic characteristics. In July 1980 the House of Commons Social Services Committee[4] expressed concern about the lack of information available on the links between adverse socioeconomic circumstances and perinatal and neonatal mortality. It recommended that high priority be given to research aimed at exploring these links. More recently the Research Working Group on Inequalities in Health has also concluded that 'further work on relationships between indicators of social disadvantage and mortality is needed'.[5]

PREVIOUS RESEARCH

The relationship between infant mortality and socioeconomic conditions has previously been studied in two distinct ways:

(1) Studies of the social characteristics of mothers whose infants die

The Office of Population Censuses and Surveys (OPCS) has recently published the latest in a series of reports[6–12] on the social and biological factors associated with infant mortality, based on data drawn from the linking of birth and death registrations. Analysis has centred mainly on such factors as social class (derived from the occupation and status of the father if the birth is legitimate), residence, country of origin, and age and parity of the mother.

Surveys provide another source for deriving data about the social characteristics of mothers who lose

babies, either those undertaken of the population in a small area[13] or large-scale national cohort surveys like the 1958 Perinatal Mortality Survey[14] or the 1970 British Births Survey.[15 15a] Both of these national surveys were primarily concerned with maternity services and, apart from information on social class, provided limited data on the socioeconomic background of mothers.

(2) Studies of the social characteristics of areas with high infant mortality rates

Richard Titmuss[16] in his prewar study of infant mortality drew on the work of Stocks,[17] who used census data to study the association between mortality and housing. In 1947 Woolf[18] showed that infant mortality was related to unemployment, low pay, and overcrowding, by analysing the characteristics of local authorities in England and Wales. Brennan and Lancashire[19] later employed this method to study the association of childhood mortality with indicators of socioeconomic deprivation, in particular housing status and unemployment.

Several American studies have analysed variations in infant mortality; in particular, Brooks[20] examined the extent to which family income, low education, sound housing and the percentage of blacks directly and jointly relate to neonatal and postneonatal mortality rates in 2237 counties in the USA by means of path analysis. In a more recent paper, Brooks[21] used hierarchical multiple regression analysis in order to determine the extent to which low infant birth weight intervened in the association between infant mortality and the social and economic characteristics of populations residing in areas of Cleveland, Ohio.

Variations in the effectiveness of maternity care systems in the pre-1974 local authorities of England and Wales were studied by Ashford *et al*[22] using as output measures unadjusted and adjusted perinatal mortality rates and the proportion of low-birthweight births. About four-fifths of the total variation in the proportion of low-birthweight births, and about three-quarters of the total variation in perinatal mortality, were accounted for by the set of social indicators used in the study. Perinatal mortality rates for the years 1966–8 were used, and variations in infant mortality rates were not examined.

Mallet and Knox,[22] developing previous work by Chalmers *et al*,[24] standardised the perinatal mortality rates for the 90 area health authorities in England for the years 1974–6 according to birth weight. They concluded that even when standardised for birth weight, the perinatal mortality rates in the worst areas were about twice as high as in the best. In a later paper Knox *et al*[25] related perinatal mortality rates to social indicators and health provision statistics and concluded that together with birth weight the social factors explained 74% of the inter-area variance in perinatal mortality but that the health care statistics added little to the explanations of variance. Fryer *et al*[26] had carried out a similar analysis on 1966–8 early mortality rates including late neonatal and postneonatal as well as perinatal deaths. Variations in infant mortality rates in English local authorities since 1974 have not yet been analysed in relation to social conditions. This is the focus of this paper.

Material

There are two possible approaches that can be adopted for selecting independent variables in a multivariate analysis. By computer-based automatic selection procedures a large number of plausible social indicators can be examined and those which singly or in combination satisfy certain statistical criteria can be included. This is the method adopted by Fryer *et al*.[26] The other way is to select a set of variables which are known to be related to the dependent variable on the basis of previous research and whose inclusion may be justified *a priori*. This second approach was adopted in this analysis.

We did experiment with the first approach, seeking sets of explanatory variables which maximised the adjusted R^2 goodness-of-fit measure. However, some of the variables which this procedure selected could not be satisfactorily justified. Two of these were:

(1) The standardised mortality rate (SMR) was excluded because it is not independent of the infant mortality rate. Also, even that part of the SMR which is independent of infant mortality is a 'second order' variable—derived from social conditions and not a social condition itself. The SMR for the years in question correlates $r = 0{\cdot}55$ with the infant mortality rate and if it had been included in the first regression analysis below it would have increased the proportion of variance explained by only 2·2%.

(2) Low birth weight was another variable that has been used in the previous work on area variations in perinatal mortality but was excluded in this analysis. In fact birth weight was found in this analysis to correlate more highly with infant mortality ($r = 0{\cdot}47$) than with perinatal mortality ($r = 0{\cdot}43$) but it was excluded because it is another second order variable—the result of social conditions rather than a social condition itself. Also the data were available only at area health authority level, so that only estimated figures for some of the London boroughs could be used.

Other social indicators were excluded either because they were highly correlated with the

variables below or, as already mentioned, the justification for inclusion was not clear.

Four socioeconomic variables known to have a positive association with the level of infant mortality were selected for the analysis.

(i) Level of unemployment

Among people below retirement age the unemployed are the largest single group in poverty. The level of unemployment correlates fairly well with two other measures of family poverty, the proportion of the population in receipt of supplementary benefit ($r = 0{\cdot}77$), and the proportion of children receiving free school meals ($r = 0{\cdot}76$). These two variables could have been selected as alternative indicators but the first is heavily influenced by the numbers of elderly in an area and the use of the second, although it is perhaps the best indicator of poverty among families with children, would have meant excluding from the analysis the 13 authorities comprising the Inner London Education Authority. Brennan[19] has shown that unemployment of the father has a highly significant association with early child mortality even when the effect of social class is eliminated. We believe that the level of unemployment is also a more age-specific indicator and is thus more suitable for area analysis than social class, the indicator of socioeconomic status most often used in analysing variations in infant mortality. Furthermore, the most recent social class data are only from the 1971 census, whereas unemployment data are available for 1976, the year central to the infant mortality data being studied.

(ii) Proportion of large families

Layard *et al*[27] have shown that the chances of couples with children living in poverty increase with the number of children; over two-thirds of couples with five or more children lived on incomes below the standard of 140% of supplementary benefit, the level taken as a poverty standard. Lambert[28] found that the diets of large families were poorer and more clearly determined by family size than social class or level of income. The age of the mother is also higher in large families and both this and high parity are factors associated with infant mortality.[12]

(iii) Proportion of lone-parent families

In 1975–7 the infant mortality rate for illegitimate births in England and Wales was 20·7 while for all legitimate births it was 14·6.[12] The 1970 British Births Survey found that the perinatal mortality rate for mothers who were unsupported at the time of the infant's birth was 37·4, whereas for all births in Britain in 1970 it was 20·9.

(iv) Level of overcrowding

An association between overcrowded housing and infant mortality was found by Woolf,[18] and Brennan[19] has shown that housing factors bear a highly significant relationship with early child mortality even when the effect of social class and unemployment is eliminated. Either the level of overcrowding or the proportion of houses lacking a basic amenity could have been selected as the indicator of poor housing. They are both closely associated ($r = 0{\cdot}69$) and the former was selected on *a priori* grounds.

There was one other social indicator, the proportion of New Commonwealth immigrants, which might have been used in the analysis. It was excluded partly because it correlates highly with the level of overcrowding ($r = 0{\cdot}64$) and partly because of its very skewed distribution. To check whether the variable had explanatory power of its own, it was correlated with and plotted against the residuals from the regression equation below. The correlation coefficient was not significant and the scatter plot did not show any pattern. Nevertheless, individual authorities. for example, Wolverhampton and Camden, may partly owe their infant mortality rates to the proportion of immigrants in their populations.

The basic descriptive statistics of the variables in the analysis are given in Table 1. The four variables selected to describe the characteristics of areas are not entirely independent of one another and their relationships to each other and to the infant mortality rate are given in the correlation matrix in Table 2.

Methods

Two techniques were used to examine the relationship between infant mortality and the four social indicators.

(1) Cluster analysis. This was tried to see whether local authorities could be grouped on the basis of their values on the four social indicators. Using the CLUSTAN package,[29] authorities were grouped together so as to maximise within-group similarity relative to that between groups; however, inspection of graphical displays of the clusters obtained suggested that the clusters of local authorities were not particularly homogeneous and the clustering was therefore spurious.

(2) Regression analysis. A multiple regression analysis was carried out with infant mortality as the dependent variable and the four social indicators as independent variables. Only two indicators, large families and lone parents, made a significant contribution to the explanation of variance, and between them they explained 36·9% of the variation in infant mortality. Various transformations of the data were tried and the best results were obtained by transforming the dependent and independent variables into logarithmic form. This increased the proportion of variance explained to 39·2%. The results of both

these analyses are summarised in Table 3. The regression equation derived from the transformed data was used to predict an infant mortality rate for each local authority and the differences between the observed and the predicted rates were examined.

Results

There is considerable variation in infant mortality rates between local authorities in England. Table 1 shows that the average rate for the period 1975–7 ranged from 8·9 per 1000 live births (in Sutton) to 21·3 per 1000 (in Wolverhampton). Straight comparisons of rates in the form of a league table are not a fair assessment of the performance of health services. Chalmers[30 31] has been particularly critical of the use of crude mortality rates in perinatal research because they fail to take account of the social and

Table 1 *Basic descriptive statistics of the infant mortality rate and the four social indicators used to examine variation in that rate**

Definition	*Mean*	*Median*	*Standard deviation*	*Range*	*Minimum*	*Maximum*
Infant mortality rate: average 1975–7 of the numbers of children born alive dying under 1 year per 1000 live births (Source: OPCS)	14·7	14·5	2·2	12·4	8·9	21·3
Population proportion of large families: number of families with 3 or more children per 1000 population 1978 (Source: DHSS)	26·1	26·4	4·4	27·3	11·7	39·0
Population proportion of lone-parent families: number of lone-parent families per 1000 population 1978 (Source: DHSS)	7·1	6·7	1·4	7·1	4·7	11·8
Level of unemployment: number of persons unemployed per 1000 population 1976 (Source: Dept. of Employment)	24·6	22·2	10·2	57·6	9·7	67·3
Level of overcrowded housing: number of households with more than 1 person per room per 1000 households 1971 (Source: Census)	67·0	56·0	29·8	132·0	32·0	164·0

*The statistics cover 107 local authorities in England, the counties, metropolitan districts, and London boroughs. The City of London is excluded from the analysis because of its very small size.

Table 2 *Correlation matrix* of the infant mortality rate and the indicators used to examine variation in that rate*

	Infant mortality rate	*Population proportion of large families*	*Population proportion of lone-parent families*	*Level of unemployment*	*Level of overcrowded housing*
Infant mortality rate	1·00				
Population proportion of large families	0·38	1·00			
Population proportion of lone-parent families	0·49	0·39	1·00		
Level of unemployment	0·36	0·18	0·49	1·00	
Level of overcrowded housing	0·52	NS	0·62	0·66	1·00

*All correlation coefficients presented are significant at the five per cent level and are based on 107 cases.
NS not significant

Table 3 *Summary results of two regression analyses of the infant mortality rate*

	Increment in R^2 for each additional variable	*Unstandardised regression coefficient (B)*	*Standard error of B*	*F ratio*
	Regression of infant mortality rate on four social indicators			
Level of overcrowding	0·271	0·03	0·01	12·4
Large families	0·098	0·14	0·04	10·1
Lone parents	0·011	0·22	0·17	1·8
Unemployment	0·001	−0·01	0·02	0·1
Constant		7·7		
	Regression of logarithm of infant mortality rate on logarithms of two social indicators			
Log level of overcrowding	0·329	0·21	0·03	51·8
Log large families	0·063	0·20	0·06	10·7
Constant		0·52		

environmental characteristics of areas, and the same criticisms can be made of such comparisons of infant mortality. The regression analysis produces a model which describes how much of the variation in infant mortality can be ascribed to the chosen variables—the analysis of residuals shows how far an area deviates from the infant mortality rate which the model predicts. The model, in other words, provides an adjusted standard of reference which is more reasonable than simply taking the national average. It is possible to identify authorities which, given their characteristics, have relatively high or low levels of infant mortality. It would be too much to claim that all variation from the predicted level of infant mortality is purely the result of variations in the performance of health services. Not all the socioeconomic variables that could influence infant mortality have been incorporated into the regression analysis. Nevertheless, the analysis presents a fairer method of comparing local authority infant mortality rates than a simple league table.

Table 4 lists authorities by the size of the difference between their observed infant mortality rates and those predicted by the regression equation. Although

Table 4 *Local authorities listed by the size of the residuals produced by the regression analysis of the logarithm of infant mortality with the logarithm of the two social indicators*

Authority	*Observed infant mortality rate*	*Variation from predicted infant mortality rate (standardised residual)*	*Authority*	*Observed infant mortality rate*	*Variation from predicted infant mortality rate (standardised residual)*
Sutton	8·9	−3·02	Camden	19·0	+2·26
Islington	13·7	−2·02	Wolverhampton	21·3	+2·16
South Tyneside	13·0	−1·83	Salford	19·4	+1·87
Oxfordshire	11·5	−1·79	Rochdale	19·5	+1·78
Berkshire	12·2	−1·78	East Sussex	15·4	+1·76
Sunderland	13·4	−1·76	Oldham	17·4	+1·45
Barking	12·4	−1·68	Wakefield	17·3	+1·31
Harrow	11·0	−1·62	Stockport	15·6	+1·27
Bexley	11·0	−1·57	Doncaster	17·1	+1·24
Havering	11·6	−1·53	Warwickshire	16·2	+1·19
Bedfordshire	12·7	−1·35	St. Helens	17·0	+1·12
Haringey	13·7	−1·34	Manchester	18·7	+1·05
Kingston-upon-Thames	11·0	−1·27	North Yorkshire	14·6	+1·05
Liverpool	14·4	−1·26	Kirklees	17·7	+1·00
Tameside	12·9	−1·17	Bromley	15·0	+0·95
Knowsley	16·9	−1·16	Solihull	14·3	+0·95
Bury	12·5	−1·13	Lancashire	15·7	+0·95
Kensington & Chelsea	13·1	−0·89	Brent	18·8	+0·86
Sefton	13·3	−0·78	Derbyshire	15·2	+0·83
Suffolk	12·0	−0·78	Croydon	15·3	+0·82
Gloucestershire	13·0	−0·74	Leeds	15·7	+0·74
Essex	12·5	−0·71	Hackney	20·4	+0·73
Northamptonshire	13·0	−0·66	Staffordshire	15·6	+0·72
Southwark	16·0	−0·64	Hammersmith	16·9	+0·72
Norfolk	12·0	−0·61	Bolton	16·3	+0·67
Enfield	12·1	−0·60	Nottinghamshire	15·3	+0·60
Hertfordshire	12·7	−0·59	Westminster	15·0	+0·58
Northumberland	13·5	−0·58	Bradford	17·0	+0·56
Surrey	12·3	−0·56	Isle of Wight	13·3	+0·50
Ealing	15·1	−0·54	Richmond-upon-Thames	12·9	+0·48
Barnet	13·1	−0·51	Dorset	13·6	+0·45
Newham	15·8	−0·43	Cheshire	15·1	+0·44
Cornwall	12·7	−0·37	Dudley	14·3	+0·44
Hillingdon	12·9	−0·37	Birmingham	17·5	+0·42
Lewisham	15·4	−0·34	Humberside	15·2	+0·42
Somerset	12·7	−0·33	Cumbria	14·8	+0·39
Sheffield	13·5	−0·33	Merton	13·8	+0·39
Wiltshire	14·0	−0·24	Lincolnshire	14·2	+0·36
Newcastle upon Tyne	15·2	−0·23	Devon	13·4	+0·35
Hereford & Worcester	13·6	−0·17	Durham	15·6	+0·34
West Sussex	12·1	−0·17	Buckinghamshire	14·5	+0·29
Sandwell	15·8	−0·17	Wirral	14·7	+0·28
Rotherham	14·1	−0·16	Lambeth	17·2	+0·27
North Tyneside	15·0	−0·16	Avon	13·9	+0·19
Gateshead	15·6	−0·14	Cambridgeshire	13·8	+0·17
Coventry	15·8	−0·11	Salop	14·5	+0·15
Barnsley	14·7	−0·09	Wandsworth	16·7	+0·12
Trafford	13·9	−0·09	Redbridge	13·3	+0·12
Wigan	14·5	−0·09	Walsall	15·7	+0·10
Hounslow	15·0	−0·08	Cleveland	16·2	+0·10
Hampshire	13·8	−0·04	Kent	13·7	+0·04
Greenwich	14·7	−0·01	Leicestershire	14·4	+0·04
Tower Hamlets	17·3	−0·01	Waltham Forest	14·3	+0·03
Calderdale	20·2	+2·52			

the Table is self-explanatory it is worth drawing attention to certain features. For example, North Yorkshire has a higher infant mortality rate than that predicted on the basis of its characteristics, even though its infant mortality rate is below the national average. Liverpool, to give another example, has an infant mortality rate near the national average but considering its characteristics its rate is a relatively low one. Some authorities have high infant mortality rates both relative to the national average and to that predicted on the basis of their characteristics, including Calderdale, Camden, Wolverhampton, Salford, and Rochdale. There are certain authorities which, despite their social characteristics, have remarkably low rates, including Sutton, Islington, South Tyneside, Oxfordshire, and Berkshire.

These latter authorities are those which prima facie have been most successful in overcoming the social characteristics of their areas to achieve low infant mortality rates, and it is in these authorities that there is the best chance of finding patterns of health and social services that could provide an example for those authorities who are aiming to improve their services to reduce their high infant mortality rates. Some of the effects of socioeconomic deprivation can be overcome by adequate and accessible obstetric, paediatric, and community health and social services. Indeed, it appears they are being overcome in many areas of England, and this analysis has identified those authorities whose success might encourage others who still have much to achieve.

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