Measuring deprivation in England and Wales using 2001 Carstairs scores

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Carstairs scores, first calculated in the 1980s based on data from the 1981 Census, were designed as a summary measure of relative deprivation within small populations. They were based on four indicators from the census which were considered to represent material disadvantage, and have since been widely used to examine the relationship between deprivation and health. This article describes how Carstairs scores were calculated for England and Wales based on data from the 2001 Census and also presents the resulting geographical patterns of deprivation.

Introduction

The link between poverty and health is well established.[1–3] While there is a long tradition of measuring socio-economic inequalities in health using data for individuals, such as social class based on occupation, in recent decades area based measures have also been used to examine the relationship between relative deprivation and health. Deprivation measures have often been constructed to act as a proxy for data on personal/household income or wealth which have not routinely been collected in the UK census, the main source of socio-demographic information. Deprivation indices also help overcome difficulties of using social class, such as the poor recording of occupations for some groups. In mortality data, for example, these include some women and those who may not have worked for some years at the time of death. The elderly are also frequently excluded from socio-economic classifications and ONS does not code occupations or social class for deaths of those aged over 74.

In the 1980s Vera Carstairs and Russell Morris developed an index designed to be used for health analysis which would measure material deprivation in small areas.[4] The first set of Carstairs scores were based on results from the 1981 Census and were subsequently updated following the 1991 Census. Carstairs scores for wards in England and Wales have now been calculated by ONS,[5] based on data from the 2001 Census and these have been published on the National Statistics website: www.statistics.gov.uk/statbase/Product.asp?vlnk=14068&More=n

This article discusses the choice of a deprivation index for health analysis by ONS, describes the calculation of the 2001 Carstairs scores and presents patterns of deprivation across England and Wales.

Table 1	Variables from 2001 Census used in Carstairs Index

Unemployment	Overcrowding	Car ownership	Low Social Class
Unemployed males 16 and over as a proportion of all economically active males aged 16 and over.	Persons in households with one or more persons per room as a proportion of all residents in households.	Residents in households with no car as a proportion of all residents in households.	Residents in households with an economically active head of household in Social Class IV or V approximated from NS-SEC (see Table 3) as a proportion of all residents in households.

Choosing a deprivation index

Many deprivation indices have been devised since the 1980s and there has been a wide and ongoing debate in the literature on the input variables and methodologies used.[6] Besides Carstairs, a range of other indices are available including the Townsend Index and the Indices of Multiple Deprivation (IMD). The latter, based on a range of administrative data, have the advantage that as they are not based solely on census results they can be updated more than once every ten years. The IMD also cover a broad range of aspects of deprivation as the indices are made up of a number of constituent domains which cover topics such as income, employment, education, crime and health.

Townsend scores, like Carstairs, are based just on census results (which have the advantage of allowing objective results for the entire population) although the choice of components is slightly different.

The choice of deprivation score is governed by both conceptual and practical considerations. For example, a deprivation score may be suitable in conception for use for health analysis but not available at a geographic level which would allow its use in practice.

The IMD include a 'health' component which makes use of the overall scores in health analysis conceptually problematic. The 2004 Index of Deprivation for England, for example, includes a mortality measure in its health component (Years of Potential Life Lost). This means that any subsequent analysis may overestimate associations between deprivation and health.

Although individual components of the index can be selected for analysis, such as the 'Income' domain, there are also practical problems which may lead to an alternative index being used. The 2004 Index of Deprivation for England was issued for the first time at Lower Layer Super Output Area level (previous versions of the IMD had been at ward level).[7] These are areas with a mean population of 1,500 people, and are thus smaller on average than wards. Using them is an advantage in areas where ward populations are particularly large, such as Birmingham. Using smaller areas also increases the likelihood that populations will be homogenous – larger areas are more likely to group together populations which differ in levels of deprivation.

Population figures are needed for many health analyses however, to allow the calculation of mortality rates for example. ONS has now published experimental population estimates for Lower Layer Super Output Areas for 2001–2003 but these have only been made available in broad age groups which make them unsuitable for the calculation of many health indicators.[8]

We therefore decided not to use the 2004 Index of Deprivation and to calculate a census based deprivation index at ward-level (for which population estimates are available), with the aim of conducting health analysis, e.g. examination of the association between deprivation and cause of death such as suicide[9] and poisoning due to antidepressant drugs.[10] Calculating a census based deprivation index had the additional advantage that scores could be calculated for both England and Wales. (The current IMD scores for England and Wales were calculated separately and are not comparable.)

A variety of research has demonstrated a strong relationship between health and deprivation.[11,12] Furthermore, when used for health analysis, different deprivation indices have shown a high degree of correlation.[13,14] Carstairs was selected for the calculation of 2001 scores because the index has been used for analysis in previous ONS studies,[15,16] as well as having widespread usage in much health research.[17–21]

Calculation of Carstairs scores

Carstairs scores are an unweighted combination of four census variables: unemployment, overcrowding, car ownership and low social class (Social Class IV and V).[4] The definitions used by ONS for the 2001 scores are included in Table 1. Each variable is standardised (z-scored) to avoid the score being unduly influenced by a high or low value for any one variable and to put each variable on the same scale, centred around zero. This is done for each variable by subtracting the mean of the observations for all wards in England and Wales from the value of that variable for each ward and dividing by the standard deviation for that variable. An example using 2001 values for Colindale ward is given in Table 2. The resulting values for each variable are summed to give a single score for that ward. The scores can be either positive (more deprived) or negative (less deprived).

The scores were calculated from 'raw' census data for England and Wales rather than published data which had been adjusted to prevent the inadvertent disclosure of information about identifiable individuals. The ONS results will therefore differ from Carstairs scores for England and Wales also calculated at the University of Manchester which were based on published 2001 Census data.[22] As the ONS index was based on unpublished census data, scores were not calculated for Scotland or Northern Ireland. A set of 2001 Carstairs scores for Scottish postcode sectors has been published but these are not comparable with the ONS scores for England and Wales, as they were standardised separately.[23]

One of the four Carstairs components in 2001 was not comparable to that used in 1981 and 1991, as in the 2001 Census the National Statistics Socio-economic Classification (NS-SEC) replaced social class. NS-SEC is based on occupation as defined by the Standard Occupational

Table 2	Calculation of 2001 Carstairs score for Colindale ward

Variable	Pecentage	Mean	Standard Deviation	z-score
No car	29.65	15.75	11.40	(29.65 - 15.75) ÷11.40 = 1.22
Overcrowding	30.74	9.02	6.27	(30.74 - 9.02) ÷ 6.27 = 3.46
Male unemployment	10.58	5.70	3.77	(10.58 - 5.70) ÷ 3.77 = 1.3
Social Class IV & V	13.51	13.70	6.71	(13.51 - 13.70) ÷ 6.71 = -0.03
Carstairs Score	-	0	3.41	(1.22 + 3.46 + 1.30 - 0.03) = 5.95

Table 3	Social Class linked to operational categories of the National Statistics Socio-Economic Classification (NS-SEC)

Social Class		NS-SEC Operational Categories
I	Professional, etc. occupations	3.1, 3.3
II	Managerial and Technical occupations	1, 2, 3.2, 3.4, 4.1, 4.3, 5, 7.3, 8.1, 8.2, 9.2
IIIN	Skilled occupations – non-manual	4.2, 4.4, 6, 7.1, 7.2, 12.1, 12.6
IIIM	Skilled occupations – manual	7.4, 9.1, 10, 11.1, 12.3, 13.3
IV	Partly skilled occupations	11.2, 12.2, 12.4, 12.5, 12.7, 13.1, 13.2, 13.5
V	Unskilled occupations	13.4

Classification, revised in 2000 (SOC2000) and details of employment status (e.g. whether an employer, self-employed or employee; whether a supervisor; number of employees at the workplace).[24] Using SOC2000, NS-SEC operational categories have been matched to social class, achieving a continuity level of 87 per cent.[25] Social Classes IV and V were therefore approximated using the NS-SEC categories listed in Table 3. Descriptions of the NS-SEC categories used are included in Table 4.

Table 4	National Statistics Socio-Economic Classification (NS-SEC) operational categories linked to Social Class

NS-SEC		Approximate Social Class
L11.2	Lower technical process operative	IV
L12.2	Semi-routine service	IV
L12.4	Semi-routine operative	IV
L12.5	Semi-routine agriculture	IV
L12.7	Semi-routine childcare	IV
L13.1	Routine sales and service	IV
L13.2	Routine production	IV
L13.4	Routine operative	V
L13.5	Routine agricultural	IV

Census Ward Boundaries

Carstairs scores were calculated for ward boundaries as used in the 2001 Census in England and Wales. These were the 8,800 Standard Table wards used to tabulate census outputs. The four Standard Table wards in the City of London were however aggregated together (to be consistent with the production of ward population estimates for 2001) and so scores were published for 8,797 areas.

(2001 Carstairs scores calculated by the University of Manchester have been published for 8,844 of the 8,851 Census Area Statistical wards in England and Wales.[22] This will also mean that the means, standard deviations and z-scores of these areas will differ from those used in the ONS results.)

After main census results had been produced a number of differences were discovered between draft and final ward boundaries which had not been available in time to use for the principal outputs. As a consequence of these corrections, ward population estimates for 2001 were revised for 23 wards (two each in Milton Keynes and North Norfolk and 19 in Monmouthshire).[26] Although Carstairs scores had already been calculated based on the original boundaries, it was decided to recalculate

them so that they would be consistent with the population estimates. These corrected scores should be used for analysis which is based on the amended ward boundaries. As most 2001 Census outputs were not produced again for the revised boundaries we considered that the original Carstairs scores may still be useful for users who wished to examine the relationship between deprivation and published census variables. Two sets of Carstairs scores were therefore published on the National Statistics website using both sets of boundaries.

Deprivation quintiles

Using the Carstairs scores wards can be divided into groups such as fifths (quintiles), by ranking areas from least deprived to most deprived. To analyse the Carstairs scores, wards were allocated to deprivation quintiles according to equal fifths of the population using 2001 experimental ward population estimates, published by ONS for 2001 Census wards.[27] One fifth of the total population of England and Wales were thus allocated to each deprivation category with Quintile One representing the fifth of the population of England and Wales living in the least deprived wards and Quintile Five representing the fifth living in the most deprived areas.

(Quintiles can also be created based on the number of wards so that each fifth has approximately the same number of areas rather than the same population. This method has been employed by the University of Manchester for the publication of their 2001 Carstairs scores.[22] Both methods are equally valid.)

Correlation coefficients between component variables were calculated for the 2001 scores. For each quintile of deprivation, the mean, median, standard deviation and range of scores were calculated. All analysis was done using Stata 8.2.

The impact of the ward boundary changes was also examined but no wards changed deprivation quintile between the two sets of results.

Results

Carstairs scores for the 8,797 Census wards in England and Wales ranged in value from -5.71 to 16.50, with a standard deviation of 3.41. Correlations between the components of the Carstairs score are shown in Table 5. Not owning a car was strongly associated with male unemployment and overcrowding, but less so with low social class. Male unemployment was moderately correlated with overcrowding and low social class. Overcrowding showed a little more modest correlation with low social class. Characteristics of wards grouped into quintiles of Carstairs scores are shown in Table 6. The similarity between the mean and median suggests that the scores are normally distributed within each quintile. For all quintiles apart from the most deprived the standard deviation was low and range of scores narrow.

Table 5	Correlation between components of the 2001 Carstairs score

England and Wales

Component	Correlation			
	No car	Male unemployment	Overcrowding	Social Class IV and V
Carstairs Score	0.921	0.896	0.826	0.766
Social Class IV and V	0.567	0.573	0.471	
Overcrowding	0.717	0.627		
Male unemployment	0.855			

| Table 6 | | Mean, median, variance and range of 2001 Carstairs scores by quintile | | | | | |

England and Wales

	Quintile	Mean	Median	Standard Deviation	Lowest	Highest	Range
Least deprived	1	-3.30	-3.23	0.62	-5.71	-2.36	3.35
	2	-1.59	-1.62	0.48	-2.35	-0.69	1.67
	3	0.27	0.22	0.59	-0.69	1.37	2.05
	4	2.67	2.63	0.81	1.37	4.19	2.82
Most deprived	5	6.70	5.98	2.29	4.19	16.50	12.30
	Overall	0	-0.88	3.41	-5.71	16.50	22.20

Geographical distribution of deprivation in England and Wales

To consider how the most deprived areas are geographically distributed, the proportion of the total population in each deprivation quintile is illustrated in Figure 1 for each region of England and for Wales. This shows considerable diversity between areas. For example, 42 per cent of people in London lived in the most deprived fifth of wards compared to only 4 per cent in the South West. The East of England and South East both also had less than 10 per cent of their population living in the most deprived quintile. Conversely only 6 per cent of the population of London lived in the least deprived wards of England and Wales. The South East was the region with the highest proportion of its population living in the least deprived areas (39 per cent). The East Midlands had a distribution which was most similar to that for England and Wales with approximately one-fifth of its population in each deprivation quintile.

The distribution of deprivation within England and Wales is also presented in Map 1. This shows wards shaded according to their deprivation score with grey areas being the least deprived and coloured areas the most deprived. The map allows the identification of geographic patterns of deprivation within regions. In the South East for example, where only five per cent of the population lived in wards in the most deprived quintile, it can be seen that these areas are mostly clustered near the coast, while in the North West the most deprived areas were centred around the Liverpool and Manchester conurbations.

Maps showing the distribution of wards by deprivation quintiles were also included in the Decennial Supplement, Geographic Variations in Health.[16] These illustrated geographic patterns of deprivation within English regions, Wales and Scotland, using Carstairs scores calculated with data from the 1991 Census (rather than the 2001 Census).

The Carstairs scores for 2001 cannot be directly compared with those from 1991, partly because there have been changes to the ward boundaries used at each time point. Even if the boundaries were the same however it would not be possible to use the two sets of results to see if an area became more or less deprived between 1991 and 2001. This is because the Carstairs scores reflect relative deprivation. An area's score thus depends on the scores in all other wards. This can be seen in the results for 2001 where corrections were made to 23 ward boundaries. When the index was recalculated the scores not only changed for the areas affected – there were also subtle changes to the score of every ward in England and Wales.

Comparing the two sets of results from 1991 and 2001 shows that the broad geographical distribution of deprivation changed very little during this period.
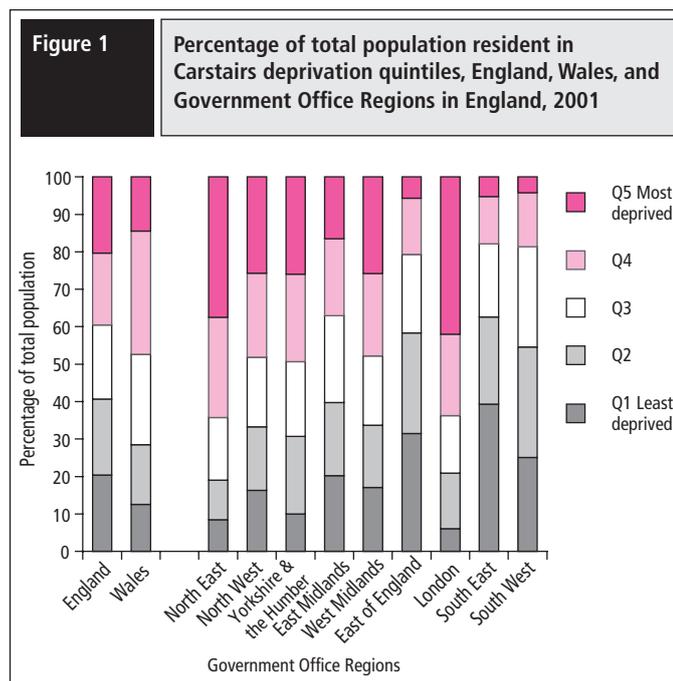
Discussion

This article has described the calculation of Carstairs scores from the 2001 Census and shown the considerable geographical diversity of deprivation in England and Wales.

When interpreting these results a number of limitations should be considered. One is that the Carstairs scores represent an average value for all people living in a ward. Wards however may clearly contain households or individuals with different levels of deprivation. Variability is more likely to occur in areas within the middle range of Carstairs scores as these may tend to result from a combination of more and less deprived households. Such heterogeneity may be further accentuated in rural wards as they tend to be geographically larger than urban wards. It has been argued that rural deprivation is frequently invisible because of the small sizes of communities.[28] Areas with very high or low scores are likely to be more internally similar.[23]

Interpretation of the values included in the Carstairs index may also vary significantly between rural and urban areas. Car ownership, for example, may be regarded as a necessity in remoter areas rather than as an indicator of wealth.[28]
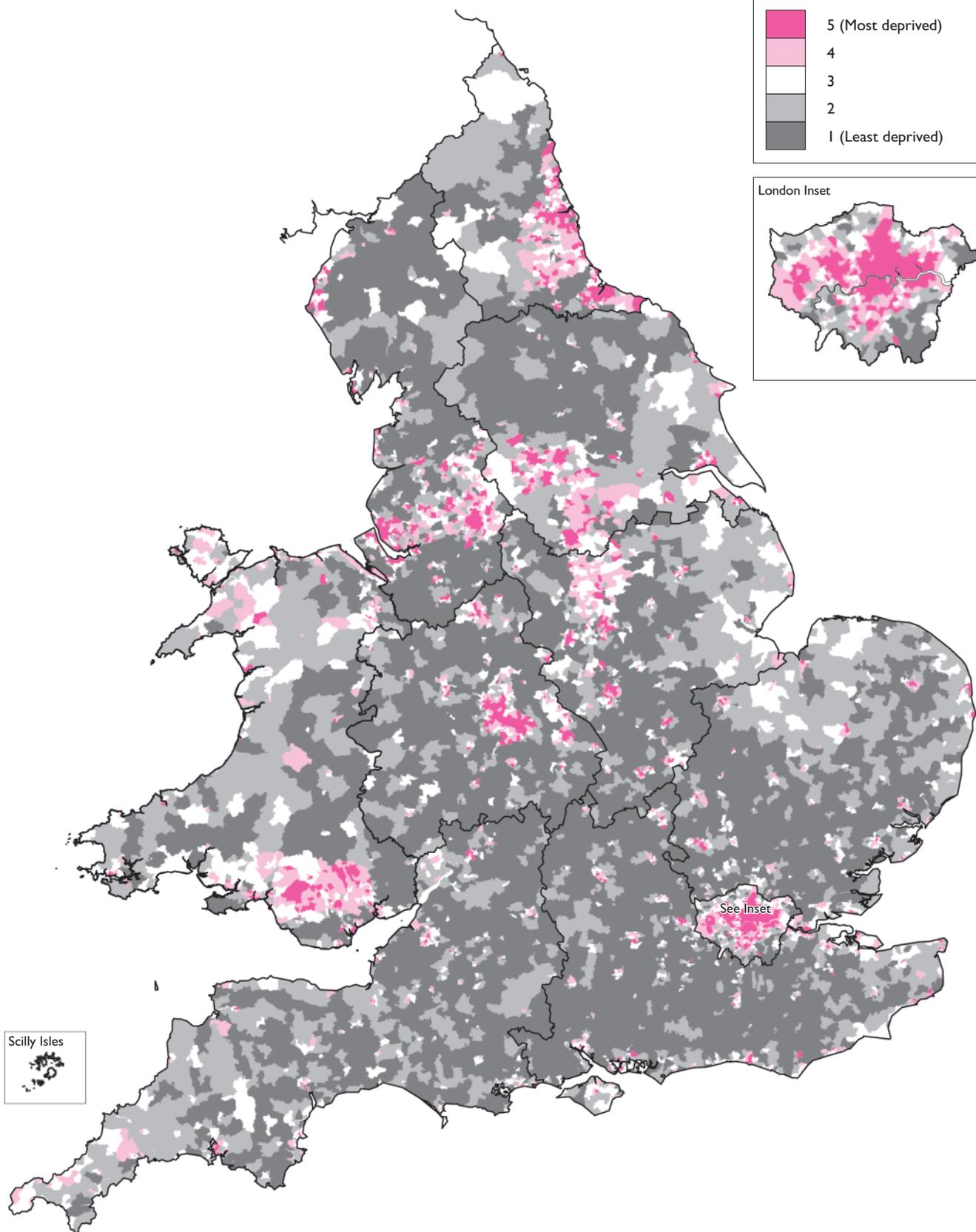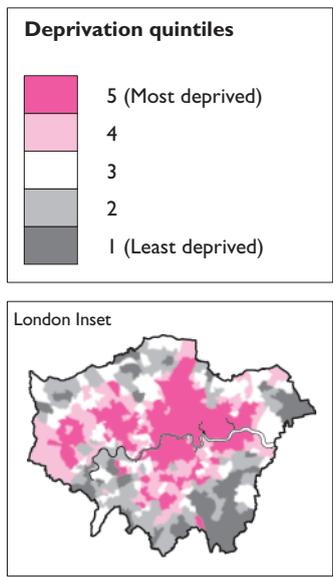
Many of the other potential limitations of deprivation indices, particularly in contrast to an individual based indicator such as social class, were addressed by Carstairs and Morris themselves. They argued that although Carstairs scores were subject to the implication that the population within an area shares the same environmental characteristics (the 'ecological fallacy'), that for an outcome such as mortality, there is an area effect in addition to a social class effect.[29] They also pointed out that social class

| Figure 1 | Percentage of total population resident in Carstairs deprivation quintiles, England, Wales, and Government Office Regions in England, 2001 |

| Map 1 | Deprivation by ward in 2001 showing Government Office Regions |

England and Wales

Deprivation quintiles

- 5 (Most deprived)
- 4
- 3
- 2
- 1 (Least deprived)

London Inset

See Inset

Scilly Isles

categories are not themselves homogenous, and are likely to contain people with widely differing occupations and incomes.

For an outcome such as low birthweight, Carstairs scores have been shown to perform better than individual social class in describing the extent of inequalities in the population, although it has been suggested that the use of an individual and an area-based measure together would better illustrate socio-economic inequalities.[30] Other commentators have also recommended that researchers should, where possible, measure both individual and area based measures of socio-economic position, as both appear to have an independent effect on health outcomes.[31]

For populations for which it is hard to assign an individual measure of socio-economic position, such as some women and the elderly, an area based measure can provide a valuable alternative as any record with a postcode attached can be allocated to a deprivation score.

While recognising its limitations, the Carstairs deprivation index has been shown to perform well in explaining variations in health measures and has been frequently used to illustrate health inequalities.

Key points

- In 2001 only 4 per cent of the population of the South West lived in the most deprived wards of England and Wales, while 42 per cent of people in London lived in the most deprived areas.
- In the South East 39 per cent of people lived in the least deprived areas of England and Wales, but in London this figure was only 6 per cent.
- Mapping allows patterns of deprivation to be easily identified and also shows that the broad picture of the geographical distribution of deprivation changed little between 1991 and 2001.

Acknowledgments

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