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Socio-demographic diversity and unexplained variation in death rates among the most deprived parliamentary constituencies in Britain

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ABSTRACT

Background There is considerable unexplained variation in death rates between deprived areas of Britain. This analysis assesses the degree of variation in socio-demographic factors among deprivation deciles and how variables associated with deaths differ among the most deprived areas.

Methods Death rates 1996–2001, Carstairs' 2001 deprivation score and indicators, population density, black and minority ethnic group (BME) and population change 1971–2001 were calculated for 641 parliamentary constituencies in Britain. Constituencies were grouped into Carstairs' deciles. We assessed standard errors of all variables by decile and the relationship between death rates and socio-demographic variables with Pearson's correlations and linear regression by decile and for all constituencies combined.

Results Standard errors in death rates and most socio-demographic variables were greatest for the most deprived decile. Death rates among all constituencies were positively correlated with Carstairs' score and indicators, density and BME, but for the most deprived decile, there was no association with Carstairs and a negative correlation with overcrowding, density and BME. For the most deprived decile multivariate models containing population density, BME and change had substantially higher R^2.

Conclusions Understanding variations in death rates between deprived areas requires greater consideration of their socio-demographic diversity including their population density, ethnicity and migration.

Keywords geography, mortality, socio-economics factors

Introduction

A strong relationship between rates of deprivation and death in areas of Britain has been demonstrated in numerous studies.[1–3] Analyses of the relationship between area deprivation and death rates commonly group together areas with 'similar' levels of deprivation into quintiles and deciles of deprivation. However, several studies have indicated that among the most deprived group of areas in Britain, there is considerable unexplained variation in death rates.[4–16]

This variation in death rates raises questions regarding how similar the most deprived areas are to one another, whether different factors underlie death rates in deprived areas and less deprived places and whether factors other than deprivation are important to understanding health in the most deprived areas. This study explores the hypotheses

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that the large variation in death rates between deprived areas in Britain reflects their socio-demographic diversity and that there are differences in the associations between socio-demographic characteristics and death rates among these areas compared with less deprived places.

Methods

Areal units

This study analyses death rates in the 641 Westminster parliamentary constituencies in Britain, as at 1997–2001. Constituencies were used in the analysis as their populations are similar in size and sufficient to allow the calculation of death rates (~89 100 on average in the 2001 Census) and boundaries which fragment urban areas.

Deprivation deciles

The Carstairs 2001 deprivation index, selected to measure deprivation in this study, is one of the most widely used deprivation indices in analysis of deprivation and health.[17] The index is based upon four measures from the 2001 Census: the proportion of economically active males aged 16 and over unemployed, residents in households with no car, residents in households with an economically active head of household in social classes IV–V (approximated from NS-SEC) and residents in households with one or more persons per room. The *Z*-scores of each indicator were combined to create the Carstairs scores. Constituencies were grouped by Carstairs score into deciles containing equal numbers of areas (64–65).

Socio-demographic variables

The socio-demographic variables were Carstairs score, the Carstairs component deprivation indicators, population density (persons per hectare), proportion of the population in a black and minority ethnic group (BME) and proportion change in population 1971–2001. These variables were based upon 2001 Census data from the Office for National Statistics (ONS) and the General Register Office for Scotland (GROS) and 1971 Census data from the Linking Censuses Through Time (LCT) website.

The Carstairs component indicators were selected as commonly used measures of deprivation and to allow further assessment of the operation of the Carstairs index. Preliminary analysis demonstrated that the association between overcrowding and death rates varied significantly between the most deprived decile and all constituencies combined. The variables population density, BME population and population change were selected because they were likely to be associated with overcrowding and death rates, to explore these relationships further.

Death rates

Death rates for constituencies were based upon death registrations from ONS and GROS. This data set includes year, age and postcode of residence at death. Average all-cause death rates were calculated for the time period 1996–2001 using denominators based on straight-line (linear interpolation) estimates from Census data for 1991 and 2001. 2001 Census data were obtained from ONS and GROS and 1991 Census data, 'corrected' for undercount, from LCT. Age- and sex-standardized death rates were calculated using age groups 0–4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–44, 45–59, 60–64, 65–74, 75–84 and 85 and over years.

Analytic strategy

Standard errors for death rates and the socio-demographic variables were compared between deprivation deciles groups. Then, Pearson's correlations between death rates and the socio-demographic variables were assessed for each of the deprivation decile groups and all constituencies combined.

Finally, four linear regression models were used to assess the relationship between the dependent variable, death rates and the independent socio-demographic variables for all of the constituencies combined and each of the decile groups separately. The independent variables were in the first model Carstairs score, in the second the component indicators of the Carstairs index, in the third the Carstairs score, population density, BME population and population change and in the fourth the component indicators of the Carstairs index, population density, BME and change.

Results

When the parliamentary constituencies were split into deciles by Carstairs score, the most deprived decile contained 18 London, 10 North West England, 10 Scotland, 10 Yorkshire and Humber, 8 West Midlands, 5 East Midlands and 3 North East England constituencies.

Figure 1 demonstrates that the relationship between age- and sex-standardized death rates and Carstairs score has a 'splaying pattern' among the most deprived constituencies. This illustrates the wider variation in death rates, Carstairs scores and the associations between them among the most deprived areas.

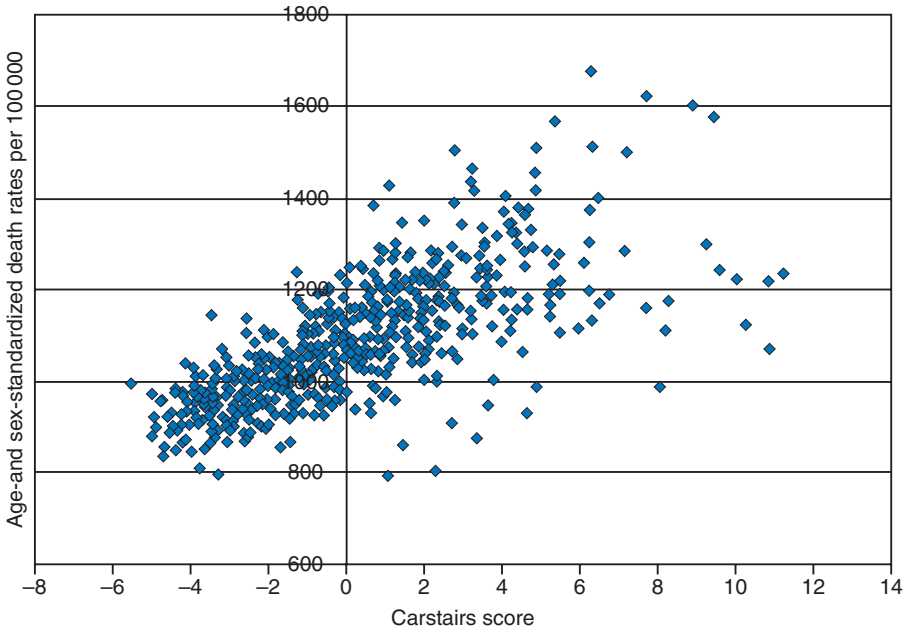

Fig. 1 Age- and sex-standardized death rates and Carstairs score.

Table 1 Standard errors of age- and sex-standardized death rates and socio-demographic variables by deprivation decile

Carstairs decile	*Age and sex standardized death rates (per 100 000)*	*Carstairs score*	*Male unemployment (%)*	*No car (%)*	*Social classes IV and V (%)*	*Overcrowding (%)*	*Population density (per hectare)*	*Black and minority ethnic group (%)*	*Population change (%)*
1—least deprived	6.22	0.06	0.08	0.43	0.19	0.03	1.22	0.35	2.27
2	7.39	0.03	0.09	0.36	0.23	0.05	1.22	0.44	2.10
3	7.64	0.02	0.10	0.49	0.24	0.06	1.51	0.55	5.12
4	8.27	0.03	0.10	0.51	0.32	0.08	1.73	0.83	1.85
5	8.46	0.03	0.10	0.50	0.26	0.08	1.62	0.72	2.69
6	8.98	0.03	0.14	0.70	0.34	0.10	2.46	0.95	2.16
7	13.23	0.03	0.14	0.69	0.37	0.13	2.81	0.96	2.26
8	12.53	0.04	0.17	0.82	0.45	0.20	2.90	1.70	2.03
9	14.98	0.06	0.18	0.61	0.36	0.20	2.41	1.60	1.53
10—most deprived	19.65	0.24	0.31	1.00	0.45	0.40	3.79	2.46	2.03

Standard errors

Standard errors by decile in Table 1 demonstrate that there is the greatest variation in death rates, Carstairs scores, Carstairs' component deprivation indicators, population density and BME population among the most deprived decile. However, standard errors for population change were similar in most of the decile groups.

Pearson's correlations

When correlations between death rates and Carstairs were assessed among constituencies of all levels of deprivation, a strong, statistically significant, correlation of 0.727 was found (Table 2). However, this relationship was not statistically significant among any of the decile subgroups, and for the most deprived decile, the correlation was close to zero.

There were significant positive correlations for all constituencies combined between the Carstairs component deprivation indicators of unemployment, no car, low social class and overcrowding of 0.723, 0.709, 0.465 and 0.283, respectively. Among the deprivation decile subgroups, a statistically significant positive relationship was found only for unemployment and no car for the most deprived decile and low

Table 2 Correlations between age- and sex-standardized death rates and socio-demographic variables for all areas and by deprivation decile

Carstairs decile	*Carstairs score*	*Male unemployment (%)*	*No car (%)*	*Social classes IV and V (%)*	*Overcrowding (%)*	*Population density (per hectare)*	*Black and minority ethnic group (%)*	*Population change (%)*
All deciles	0.727**	0.723**	0.709**	0.465**	0.283**	0.233**	0.105**	−0.483**
1—least deprived	0.070	0.003	−0.059	0.062	0.136	0.018	0.150	−0.167
2	0.057	0.245	0.136	−0.144	0.005	0.095	0.007	−0.245
3	0.065	0.211	−0.024	−0.085	0.042	0.074	0.018	0.047
4	0.182	0.167	0.240	−0.074	−0.079	0.130	−0.157	−0.337**
5	0.059	0.022	0.166	−0.036	−0.085	0.026	−0.126	−0.022
6	0.104	−0.057	0.350**	−0.151	−0.017	0.192	−0.068	−0.185
7	0.040	−0.067	−0.121	0.329**	−0.327**	−0.429**	−0.436**	0.171
8	−0.149	0.162	0.016	0.315*	−0.516**	−0.399**	−0.548**	−0.115
9	0.076	0.123	0.218	0.145	−0.263*	−0.379**	−0.500**	−0.475**
10—most deprived	0.007	0.375**	0.360**	0.109	−0.368**	−0.478**	−0.490**	−0.717**

*0.05 significance level.

**0.01 significance level.

social class among the seventh and eighth most deprived deciles. A statistically significant *negative* association was found between overcrowding and death rates among the 7th–10th most deprived deciles of −0.327, −0.516, −0.263 and −0.368, respectively.

Analysis of correlations between death rates and population density found that for constituencies of all levels of deprivation, there was a positive association of 0.233, but among the 7th–10th most deprived deciles, there was a statistically significant *negative* association of −0.429, −0.399, −0.379 and −0.478, respectively. A similar pattern was found when BME population was considered with a positive association of 0.105 among all constituencies but a statistically significant negative association among the 7th–10th most deprived deciles of −0.436, −0.548, −0.500 and −0.490, respectively. A statistically significant negative correlation was found between change in population 1971–2001 and death rates of −0.483 among all constituencies combined and −0.337, −0.475 and −0.717 among the 4th, 9th and 10th most deprived deciles, respectively.

Regression models

In the first linear regression model, examining the relationship between the dependent variable death rates and Carstairs score, when all constituencies were considered, there was a statistically significant coefficient of 0.727 (Table 3). However, when similar models were considered for separate deprivation deciles, the coefficients were low and not significant.

In Model 2, testing the association between death rates and the Carstairs component indicators, when all constituencies were considered, the coefficients for unemployment, no car and low social class were significant, positive figures of 0.218, 0.551 and 0.254, respectively, but the coefficient for overcrowding was a negative, significant figure of −0.242. In models for separate deciles, few or none of the deprivation indicator coefficients were statistically significant. In the most deprived decile, the coefficients for no car and overcrowding were statistically significant figures of 0.505 and −0.395, respectively.

In Model 3 of the association between death rates, Carstairs, population density, BME and change, when all constituencies were considered, there was a statistically significant positive coefficient of 0.849 for Carstairs. Population density, BME and change had negative coefficients of −0.083, −0.311 and −0.166, respectively. In analysis of separate deprivation deciles, most coefficients in the models were not significant with the exception of the most deprived decile for which all variables were significant, a positive 0.281 figure for Carstairs and negative figures of −0.265, −0.259 and −0.532 for population density, BME and change, respectively.

In the fourth model, the relationship between death rates, the Carstairs indicators and the other socio-demographic variables were assessed. In analysis of all constituencies, all Carstairs' indicators, including overcrowding, had significant positive coefficients, the greatest for no car at 0.675, and the other socio-demographic variables all had significant

Table 3 Linear regression models for dependent variable age-and sex-standardized death rates, for all areas and by deprivation decile

Model	*Carstairs' decile*										
	All deciles	*1—least deprived*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10—most deprived*
Model 1											
Carstairs	0.727**	0.070	0.057	0.065	0.182	0.059	0.104	0.040	−0.149	0.076	0.007
Constant	1081.133	968.402	1002.363	1036.051	1087.001	1072.058	1092.784	1104.952	1243.160	1145.625	1264.303
Adjusted R^2	0.527	−0.011	−0.013	−0.012	0.017	−0.012	−0.005	−0.015	0.006	−0.010	−0.016
Model 2											
Male unemployment	0.218**	0.348	0.209	0.249	0.191	0.052	−0.147	0.127	−0.069	−0.041	0.135
No car	0.551**	−0.332	0.073	−0.070	0.477*	0.358	0.457	0.523	−0.046	0.377*	0.505**
Social classes IV and V	0.254**	0.176	−0.104	0.040	0.393	0.240	0.008	0.876	−0.165	0.299	0.188
Overcrowding	−0.142**	0.321*	−0.163	0.084	−0.022	−0.031	−0.221	0.138	−0.647*	−0.049	−0.396**
Constant	713.78	821.921	942.019	912.466	644.203	788.573	1016.388	236.677	1386.560	699.252	655.517
Adjusted R^2	0.624	0.013	0.013	−0.010	0.059	−0.009	0.115	0.115	0.221	0.075	0.358
Model 3											
Carstairs	0.849**	0.099	0.080	0.066	0.156	0.083	0.009	0.169	−0.071	0.051	0.281**
Population density	−0.083*	−0.256	0.212	0.144	0.162	0.144	0.422*	−0.236	−0.093	−0.280	−0.265**
Black and minority ethnic group	−0.311**	0.243	−0.288	−0.072	−0.424**	−0.214	−0.414*	−0.322*	−0.469**	−0.171	−0.259*
Population change	−0.166**	−0.153	−0.297*	0.085	−0.406**	−0.008	−0.114	0.035	−0.108	−0.431**	−0.532**
Constant	1127.711	982.287	1052.738	1030.739	1120.336	1077.794	1098.223	1090.779	1240.205	1192.887	1172.489
Adjusted R^2	0.643	0.001	0.034	−0.049	0.202	−0.028	0.072	0.204	0.271	0.359	0.613
Model 4											
Male unemployment	0.156**	0.124	0.185	0.272	0.124	0.067	−0.201	0.065	−0.079	−0.124	−0.099
No car	0.675**	−0.332	0.057	−0.109	0.206	0.353	0.279	0.756	−0.069	0.133	0.462**
Social classes IV and V	0.155**	0.518*	0.004	0.056	0.479	0.206	−0.244	0.633	−0.309	−0.098	−0.092
Overcrowding	0.183**	−0.112	0.028	0.165	0.277	0.144	0.192	0.410	−0.231	0.487*	0.266
Population density	−0.300**	−0.045	0.139	0.199	0.176	−0.018	0.071	−0.596	−0.185	−0.374	−0.728**
Black and minority ethnic group	−0.206**	0.633*	−0.312	−0.190	−0.462	−0.197	−0.674	−0.172	−0.428	−0.597*	−0.182
Population change	−0.095**	−0.304	−0.229	0.120	−0.436*	0.043	−0.129	0.105	−0.059	−0.437**	−0.369**
Constant	753.118	820.382	917.063	897.336	745.616	781.608	1175.818	290.489	1453.667	1226.705	1075.495
Adjusted R^2	0.666	0.079	0.010	−0.036	0.162	−0.051	0.129	0.243	0.239	0.459	0.688

*0.05 significance level.

**0.01 significance level.

negative coefficients, the greatest of −0.300 for population density. In models for separate deciles, few coefficients were significant except in the 9th and 10th deciles. In the model for the most deprived decile, the coefficient for overcrowding was also positive and coefficients were significant for no car, population density and change of 0.462, −0.728 and −0.369, respectively.

The R^2 for Models 1–4 for all constituencies combined was similar, at 0.527, 0.624, 0.643 and 0.666, respectively. Most of the R^2 for separate deciles were little above zero with the exception of the most deprived deciles. For the most deprived decile, the R^2 varied significantly with figures −0.016, 0.358, 0.613 and 0.688 for Models 1–4, respectively.

Discussion

Main findings

This study finds a greater variation in death rates, Carstairs deprivation scores and indicators, population density and BME population among the most deprived decile of constituencies in Britain compared with less deprived deciles. This study also finds that the socio-demographic factors that are correlated with death rates vary between constituencies of all levels of deprivation and the most deprived decile of areas. When the most deprived decile is assessed separately, death rates were not always associated with socio-demographic variables in the 'expected' ways. In particular, this analysis finds that Carstairs, a deprivation index developed through analysis of death rates,[18] is not correlated with death rates among deprived constituencies.

The analysis indicates that the lack of correlation between death rates and Carstairs scores among the most deprived decile results, in part, from the negative association between death rates and one of the component indicators of the index, overcrowding. This study does not suggest that overcrowded housing is beneficial to health in deprived areas but instead indicates that the negative correlation between death rates and overcrowding reflects the relationship between overcrowding and population density, BME population and population change.

Overcrowding, population density and BME are all positively correlated with death rates when all constituencies are compared but negatively correlated among the most deprived decile. In multivariate regression analysis, however, the direction of the associations between death rates and overcrowding, population density and BME are the same in models for all constituencies and the most deprived decile.

Among the most deprived decile, population density, BME and change were more strongly correlated with death rates than the deprivation indicators. The significance of population density, BME and change to death rates in the most deprived areas is also indicated by the multivariate model's R^2. Models for the most deprived decile which contained these variables had substantially greater R^2 than those containing only Carstairs' deprivation indicators.

What is already known

A number of previous studies have demonstrated that there is a significant variation in death rates between deprived areas of Britain.[4–16] Studies comparing countries and regions have found that areas in London have relatively better health and North West England and Scotland worse health than would be expected from their levels of deprivation.[5,8–12,14,19] Analysis of ONS' local authority classifications in England has also found that local authorities in 'mining, manufacturing and industry' and 'urban fringe' areas had lower life expectancies than their deprivation would predict,[11] while comparison of rural and urban wards in England and Wales have suggested that deprived rural areas have relatively low mortality.[20–22]

The substantial diversity in deprivation indicators among the most deprived areas has also previously been demonstrated in England and Wales at a ward scale.[17] This analysis found much greater variation in Carstairs' 2001 deprivation scores and indicators among the most deprived fifth of areas in comparison to less deprived quintiles. Deprived areas' diverse experiences of deprivation have however not commonly been focused upon as a cause of variations in their death rates; instead, these differences have often been presented primarily as a methodological problem.

Analysis in Britain has commonly defined deprivation using census-based deprivation indices, such as the Carstairs index, the Townsend index and, more recently, the Government's Index of Multiple Deprivation, based on census and administrative data.[17,23,24] It has been suggested that variables that comprise these indices may misrepresent deprivation in some types of areas. In particular, the proportion of households without a car may 'overestimate' deprivation in cities, especially inner London.[5,20]

Some researchers have also stressed that 'it's not "just deprivation"' that is important to understanding death rates in deprived areas in Britain.[16] Several studies investigating factors beyond the current degree of deprivation that may underlie health variations between deprived areas have considered population change[25–29] and ethnicity.[30,31] Other factors proposed include historical deprivation, spatial patterning of deprivation, selective migration, employment

structure, education, social capital, drink and drug cultures and local social policies.[4–16,19,20,32–34]

What this study adds

This analysis builds on previous studies by demonstrating that there is a greater variation not only in death rates and deprivation indicators but also in population density and BME among the most deprived parliamentary constituencies in Britain compared with less deprived areas. The greater diversity in socio-demographic characteristics found among the most deprived areas is likely to be an important part of the explanation for their greater variation in death rates.

This study also demonstrates that the correlations between death rates and socio-demographic characteristics differ markedly between the most deprived decile of constituencies and those with all levels of deprivation. The opposite direction of association is found for overcrowding, population density and BME. The negative relationship between death rates and overcrowding among the most deprived areas is a significant limitation of Carstairs, Townsend and other indices that use overcrowding as a measure of deprivation in analysis of health.[17,23,24]

Previous studies have found that population change in local authorities in Britain and small areas in Scotland was associated with death rates,[25–29] but some analysis has suggested this association is an artefact of deprivation effects.[27,28] This studies' multivariate analysis provides further evidence of an independent association between population loss and high mortality separate from area's contemporary socio-economic status.[25,29] The results also support previous research, suggesting that population change has a greater impact upon death rates in deprived areas.[29] Notably, this analysis finds a stronger correlation between death rates and population change than any other socio-demographic variable in the most deprived decile.

The results indicating that BME population is associated with lower death rates in deprived areas, in bivariate and multivariate analysis, also support earlier research in London that found wards with higher rates of New Commonwealth and Pakistan households have lower death rates after controlling for areas' socio-economic status.[30] However, the results contrast with research from the Netherlands that found deprived areas with lower death rates had fewer 'non-western immigrants'.[31]

The finding that low population density is also strongly associated with high death rates in deprived areas is novel. This contrasts with previous studies' findings of relatively better health in deprived rural areas.[20–22] Low population density may be related to risk of death directly because of its' strong association with motor vehicle traffic injury fatalities,[35] or could be an indicator of long-term economic decline and population loss.

The strong associations among deprived constituencies between death rates and population density, BME and change demonstrated in this analysis could be perceived as evidence that factors other than deprivation are more important to health in deprived places. Alternatively, this could be interpreted as indicating that traditional deprivation indices like Carstairs have limitations in describing the diversity of disadvantage in deprived places.

Paradoxically, two weaknesses of traditional deprivation indices may be their limitations in describing continuity and change. There is evidence that the historical geography of deprivation in Britain over time periods as long as a century affects contemporary death rates.[36,37] BME and population change may be indicators of prolonged deprivation as deprived areas that have failed to attract international immigrants and had significant population loss 1971–2001 are likely to have experienced long-term socio-economic disadvantage. Conversely, deprivation indices such as Carstairs, first developed with 1981 Census data,[17] may struggle to capture the diverse patterns of population mobility, affluence and ethnicity now found in deprived areas resulting from counter-urbanization, gentrification and international migration in recent decades. In this analysis, social class, traditionally central to measurement of socio-economic status in Britain, was only weakly associated with death rates in the deprived areas. Moreover, the deprivation indicator overcrowding now interacts with some of these population characteristics to obscure relationships with health.

While this analysis does not directly address the causes of unexplained variation in death rates between regions of Britain, the results suggest some possible explanations. Deprivation indices such as Carstairs may not capture the experience of long-term economic decline in ex-industrial cities such as Glasgow or the growth of multi-ethnic and gentrifying populations in London. Deprived areas in Glasgow may have relatively high death rates, in part, because of their high proportions of white population, low population density and population loss. Analysis comparing Censuses 1981–2001 indicates that over this period, Scotland, relative to England, experienced much larger falls in Carstairs' overcrowding while its mortality disadvantage, standardized for Carstairs score, increased substantially.[10] The decline in overcrowding, however, may have led to increasing 'underestimation' of the impacts of deprivation on health in Scotland. Longitudinal data that can describe both prolonged deprivation and how deprived areas have

changed may be an important part of understanding variations in death rates across Britain.

Limitations of this study

The results will be dependent upon the scale of units and reflect the degree of internal variability within the areas.[8,38,39] The regression models should be interpreted with considerable caution because of the significant co-linearity between variables. Previous research has found greater heterogeneity in causes of death among deprived areas in England and Wales.[40] Further analysis should assess death rates by cause and age.

Conclusions

There is much greater variation in death rates and socio-demographic characteristics among the most deprived group of constituencies in Britain than among less deprived areas. Understanding of unexplained variation in death rates between deprived areas may be supported by detailed assessment of their diverse populations and histories of deprivation.

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