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The changing geography of deprivation in Britain: exploiting small area census data 1971 to 2011

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Summary

This paper will describe the method being used to devise a time-series of area deprivation 1971 to 2011 using census data for all years harmonised to contemporary definitions of LSOAs / Datazones in GB. This involves identifying appropriate deprivation indicator variables from each census, converting data between boundary systems since these change over time and calculating deprivation such that change over time, rather than just cross-sectional deprivation, can be measured. Comparisons between censuses will be presented to show the degree of consistency or change in situation.

KEYWORDS: Deprivation; Area measures; Time-series; Census.

1. Introduction

Townsend (1987), defines deprivation as, "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs." To identify small area deprivation, a wide variety of indexes have been devised which provide a single score which summarises information from several variables that each indicate something relating to deprivation. Various deprivation schemes / indexes exist including: Jarman Underprivileged Area, Townsend, Carstairs, Breadline Britain, Index of Multiple Deprivation (IMD) (Norman, 2010).

Many policy-related and academic studies use deprivation scores calculated cross-sectionally. A recent example in the health literature is by Maguire et al. (2015) in 'Health & Place' who investigate the relationship between area deprivation and the food environment over time in a repeated cross-sectional study on takeaway outlet density and supermarket presence in Norfolk, UK, 1990–2008. To do this, they link food outlet locations to wards but, "due to changing electoral ward boundaries, we were only able to use 2001 deprivation rather than capturing deprivation at multiple time points across the study period" (p. 143). Stratifying a time-series of an outcome across a single time point of deprivation is a common and pragmatic approach (see Norman and Fraser 2014, for example). However, as noted by Maguire et al. (2015, p. 146), "this approach may have introduced some error into our estimates of outlet density, and so future studies should utilise data where this information has been captured at multiple time points."

Thus, it is useful to identify whether small areas have changed their level of deprivation over time and be able to assess the impact of area-based planning initiatives or determine whether a change in the level of deprivation leads to a change in health. However, the changing relationship with an outcome cannot be judged if the 'before' and 'after' situations are based on deprivation measures which use time point specific variables, methods and geographies. Changing deprivation is both a cause and a consequence of demographic change. As such, in areas with improving deprivation over time: infant mortality improves more than for other areas (Norman et al. 2008) and cancer survival improves more (Basto et al. 2014). In areas of persistent (dis-)advantage over time have the (worst) best self-reported health & mortality (Boyle et al. 2009; Norman et al. 2010; Exeter et al. 2011).

Identifying deprivation change presents various challenges. UK deprivation indexes (e.g. Townsend 1987; Carstairs & Morris 1989) have traditionally been at ward scale and predominantly based on census variables as indicators of relative conditions between areas. In recent Indexes of Multiple Deprivation (IMD) alternative geographies and input variables have been used (Nobel et al. 2006). A drawback with the IMDs is they should only be used for individual countries in the UK. A drawback with ward schemes is the uneven population sizes compared with the Lower Super Output Areas (LSOAs) and equivalents

used in the IMDs. Any cross-sectional scores are not comparable over time and geographical boundaries are liable to change.

This paper will describe the method being used to devise a time-series of area deprivation 1971 to 2011 using census data for all years harmonised to contemporary definitions of LSOAs / Datazones in GB. This involves identifying appropriate deprivation indicator variables from each census, converting data between boundary systems since these change over time and calculating deprivation such that change over time, rather than just cross-sectional deprivation, can be measured. Comparisons between censuses will be presented to show the degree of consistency or change in situation.

2. Methodological background

The development of methods to analyse demographic change in the face of small boundary change is relatively recent. Norman (2002) and in subsequent publications estimated a set of population related resources for GB and the UK through the development of methods: for geographical harmonisation when small area boundaries change (Norman et al. 2003; Norman 2006); of populations by age and sex, the estimation of the past (Rees et al. 2004; 2005; Norman et al. 2008) and projection of the future (Norman et al. 2010; Rees et al. 2010, 2011 & 2012); of the calculation of changing area deprivation (Norman, 2010a); and of the analysis of demographic change (Tromans et al. 2008; Norman 2010b; Norman 2011). The resources relate to the period 1981 to 2001 with very full detail (relevant to the purposes) though with less detail from 1971 to 1981 and after 2001. Various datasets have been deposited at the UK Data Archive (study numbers 5850, 6045 & 6777).

In applied work, these resources were used for health related research of; infant mortality (Norman et al. 2008), all cause mortality (Rees et al. 2003; Norman et al. 2011), cause specific mortality (Exeter et al. 2011); limiting long-term illness and incapacity benefit (Bambra and Norman 2006; Norman & Bambra 2007) and of children with life limiting conditions (Fraser et al. 2012; Norman & Fraser 2014). Further topics include small area analyses of local democracy (Norman et al. 2007), environmental equity (Mitchell & Norman 2012), traffic accidents (Lyons et al. 2009) and fire risk (Corcoran et al. 2007).

The examples above are *area* based; about whether aspects for small populations vary over space and time. Parallel to this, has been research which seeks to determine whether for *individuals*, there are different experiences for people who live in different kinds of places over time. As above, the focus is on health, particularly for persons: who move between levels of deprivation (Boyle et al. 2002; Norman et al. 2005) at different ages (Norman & Boyle 2014) or between urban and rural areas (Riva et al. 2011); who do not move residence (Boyle et al. 2004); or who are social mobile (Boyle et al. 2009); and where linkages to residential areas need estimation when specific locations are unclear or names of places have changed (Norman & Riva 2012).

The resources and methods have been applied in studies of general cancer (e.g. van Laar et al. 2010, 2012& 2013); specific cancers (Basta et al. 2014; Blakey et al. 2014; McNally et al. 2012 & 2014), coronary heart disease (Bajekal et al. 2013a&b; Scholes et al. 2013); diabetes (Harron et al. 2010 &2011) asthma (Hoskins et al. 2011 & 2012) and sensory impairment (Dawes et al. 2014; Dawes et al. 2015).

The resources and applicability of previous decisions on which boundaries to use have become dated. More recent data are now available (both census and demographic births and deaths events) but with the inevitable boundary and data definitional changes which were resolved in the previous work. There is a need then to update, to redefine and to ensure the resources are fit-for-purpose for long run time-series analysis from 1971 to 2011 and by contemporary geographies (2011 definitions). The latter ensures that interpretations are relevant to current applications. Thus there is an overall aim to produce for small area subnational areas in England, Wales and Scotland various datasets which comprise:

- 1971-2001 annual time-series of populations by five years age-groups and sex;
- Population density for the census years, 1971, 1981, 1991, 2001 and 2011;
- Deprivation scores and quantiles for the census years, 1971, 1981, 1991, 2001 and 2011;

- Sociodemographic variables (the inputs to deprivation measures and others).

To create the above requires data to be converted from their original geographies of dissemination (different at least once per decade) to the small area geographies for which the 2011 Census data were released: i.e. Super Output Areas in England and Wales and Datazones in Scotland. (Unfortunately, a lack of data over this time-frame precludes widening out the geographical coverage to include Northern Ireland but *some* data will be made available for 1991, 2001 and 2011.) Given that the National Statistician stated that there should be greater use of administrative data, comparisons will be made with schemes which characterise area deprivation using administrative data (Abejon & Norman, 2015: D'Silva & Norman, 2015)

This paper provides interim results on progress to date and reports on the calculation of changes in deprivation in England from 1971 to 2011 by the 2011 definition of the Lower Super Output Areas.

3. Deprivation by LSOAs in England, 1971 to 2011

The specification of the work here relates to a time frame of the census years: 1971, 1981, 1991, 2001 and 2011. The coverage of this initial study is England and the small areas used are the 2011 definitions of the LSOAs. The variable inputs obtained from the decennial censuses are the inputs to the Townsend deprivation scheme which relate to unemployment, non-home ownership, lack of car access and household overcrowding. Deprivation is then calculated which is comparable over time, rather than being just for a census year cross-section.

Boundary change. The small areas for which census data are disseminated change each decade by both terminology and by where they are placed. Older terminologies for the smallest areas are 'Enumeration Districts' (EDs) and newer are 'Output Areas' (OAs). At each census, these nest into electoral wards and / or Super Output Areas. The former have been the geography of choice for many deprivation schemes and the latter (particularly LSOAs) for official schemes and the release of administrative data since 2001. Even though they are designed to be frozen over time, even the LSOA boundaries have had some changes between 2001 and 2011.

The need here is to take original data as released for a geography relevant to a previous census (the 'source' geography) and convert to the contemporary geography of interest (the 'target' geography). Figure 1 shows the 1991 EDs (left) in Birmingham and the 2011 LSOAs (right). Whilst there are a few lines which correspond, the source and target geographies are very different.

Figure 1: 1991 ED and 2011 LSOAs in Birmingham

Since postcode distribution is a proxy for population distribution, the conversion between source and target geographies can be achieved for associating postcode points with the different geographies (Norman et al., 2003). The count of postcodes in the intersections of the boundary systems can be used to redistribute counts for the source geography into the target units. Figure 2 shows Sutton Coldfield in the northern part of Birmingham with the 1991 EDs and the 2011 LSOAs along with the postcode distribution (sized by address count). The less populous parts (including Sutton Park) have fewer postcodes than more densely populated areas.

Figure 2: 1991 ED, postcode distribution and 2011 LSOAs in Birmingham

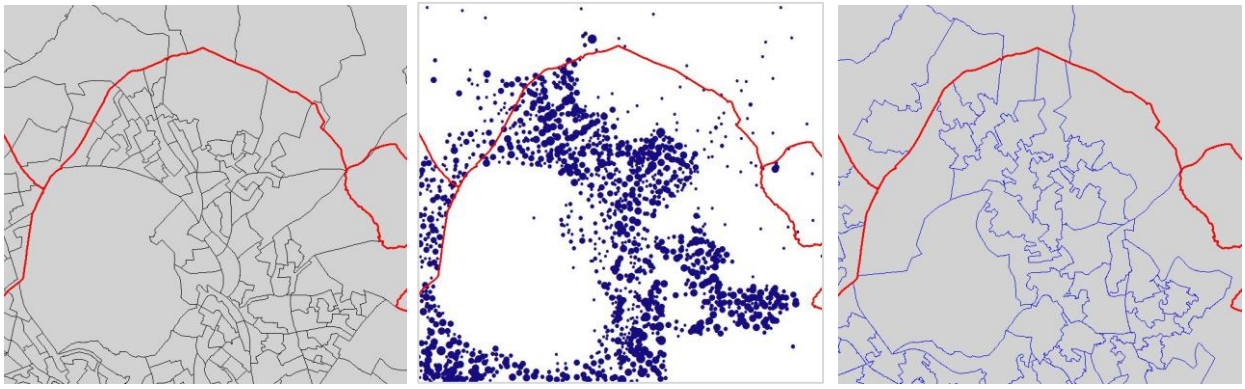


Table 1 shows the conversion weights between the 1991 EDs and the 2011 LSOAs. The weight is used to apportion the population counts, for 07CNGL05, for example, into the (four) LSOAs the area overlaps. The weights sum to one for each source area. The data are then aggregated across the target zones.

Table 1: Conversion weights between source and target geographies

ED91	LSOA11-Code	LSOA11-Name	Add	Source	Weight
07CNGL05	E01009415	Birmingham 002A	126	223	0.5650
07CNGL05	E01009416	Birmingham 003A	27	223	0.1211
07CNGL05	E01009418	Birmingham 001B	30	223	0.1345
07CNGL05	E01009423	Birmingham 002C	40	223	0.1794
07CNGL06	E01009417	Birmingham 001A	37	247	0.1498
07CNGL06	E01009421	Birmingham 004A	210	247	0.8502
07CNGL07	E01009417	Birmingham 001A	112	264	0.4242
07CNGL07	E01009419	Birmingham 001C	152	264	0.5758
07CNGL08	E01009419	Birmingham 001C	260	260	1.0000

Input variables. For the census years: 1971, 1981, 1991, 2001 & 2011, the numerators and denominators of unemployment, non-home ownership, no car access, household overcrowding and persons have been obtained at ED and OA level as appropriate and converted to LSOAs for 2011.

Calculating comparable deprivation. The conventional way to calculate the cross-sectional (census time point) Townsend deprivation scores is to transform variable proportions to near normal distributions as necessary, to standardise as z scores and then to sum the four z scores, unweighted into a single score. Even when converted to the same geography, a change in deprivation score cannot be interpreted as an improvement or not. To calculate time comparable deprivation, stack the data for successive census years and calculate the z scores relative to the indicator and national level for both / all years. In Figure 3, area 1 based on just this one variable, would change (9% to 10%). In this way, the data for all censuses 1971 to

2011 have been stacked with deprivation calculated on that basis. Population weighted quintiles (20% population in each) over time have also been calculated.

Figure 3: Cross-sectional and comparable deprivation calculation

Cross-section: data for one year

Area	Variable	Z-score
1	9%	
2	11%	
3	11%	
4	14%	
…		
…	9%	
…	9%	
…	12%	
n	16%	

$$zscore = \frac{(Obs - Mean)}{SD}$$

Time comparable: data for more than one year

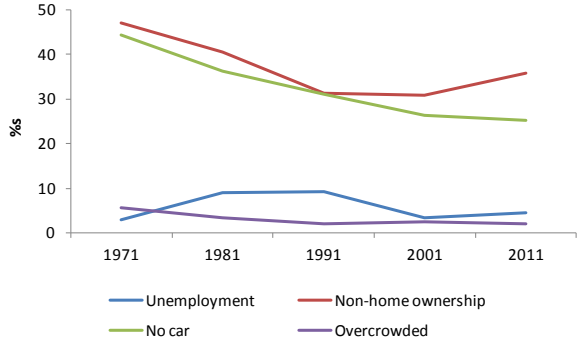
Area	Variable	Z-score
1	9%	
2	11%	
3	11%	
4	14%	
…		
…	9%	
…	9%	
…	12%	
n	16%	
1	10%	
2	12%	
3	9%	
4	16%	
…		
…	8%	
…	10%	
…	11%	
n	14%	

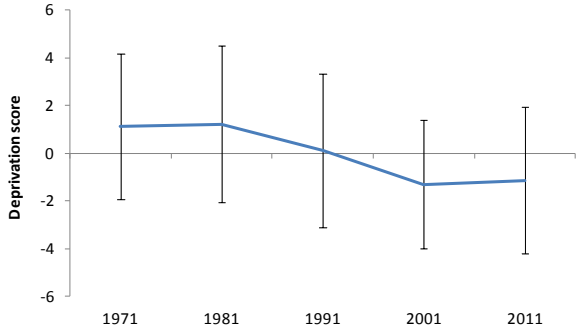
$$zscore = \frac{(Obs - Mean)}{SD}$$

4. LSOA deprivation change: England 1971 to 2011

Figure 4 shows on the left the average level of each of the four indicator variables over time. Lack of car access steadily decreases over time. Overcrowded households are rarer, reduce over time a little and seem to bottom out by 1991 through to 2011. Unemployment increases to 1981, is steady to 1991 and then reduces, staying at a similar level though a slight rise to 2011 (there is more change in the inter-censal periods, of course). Non home ownership is more intriguing with large reductions from 1971 to 1991, steady to 2001 and then a sharp increase to 2011. The average level of deprivation (figure 4 on the right) is higher in 1971 and 1981 and then reduces to 1991 and then 2001. To 2011 there is a small increase in deprivation driven by increases in non-home ownership and slight rise in unemployment.

Figure 4: Deprivation change: England 1971 to 2011





The correlations reported in Table 2 show strong consistencies between successive censuses and over time. Essentially, this suggests that there are not major changes in the geography of deprivation over time.

Table 2: Correlations between deprivation at each census: LSOAs in England 1971-2011

	towns81	towns91	towns01	towns11
towns71	0.88	0.84	0.79	0.75
towns81		0.93	0.87	0.84
towns91			0.94	0.92
towns01				0.95

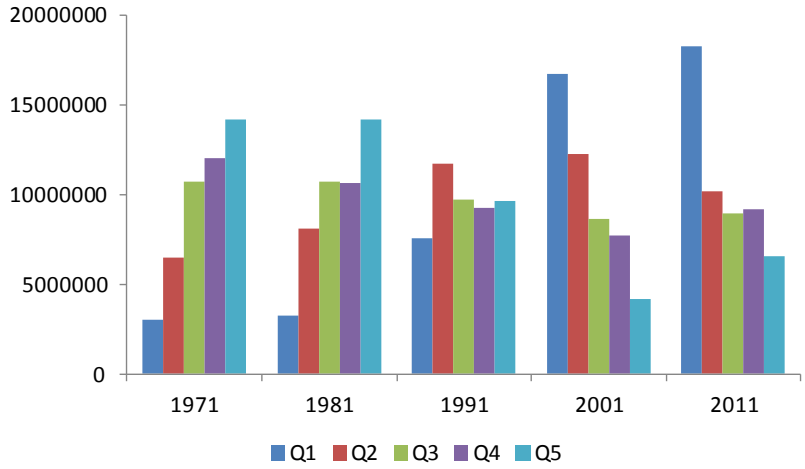
Using the quintiles of deprivation in 1971 and 2011, Table 3 shows that 28% of LSOAs are classified into the same quintile over time (the leading diagonal). 67% of LSOAs improve their categorisation of deprivation over time and 6% have a worse situation. These subsets can readily be used to analyse phenomena which might also have changed.

Table 3: Cross-tabulation of deprivation quintiles in 1971 and 2011

	Q1	Q2	Q3	Q4	Q5	Total
Q1	2047	271	86	37	8	2449
Q2	3582	967	339	142	20	5050
Q3	4133	2432	1104	403	53	8125
Q4	1515	2225	2556	1749	470	8515
Q5	272	490	1435	3272	3236	8705
Total	11549	6385	5520	5603	3787	32844
	Same	28	Better	67	Worse	6

Population change and deprivation change are linked by population migration and by people changing their attributes. Figure 5 shows how population is differently distributed across deprivation at each census. In 1971, the gradient shows fewer people living in less deprived areas through to more people living in more deprived areas. The extremes change little by 1981 but the mid deprived areas have changed. In 1991 there is little difference in population distribution across deprivation and by 2001 and 2011, population is redistributed such that more people are living in less, than more deprived locations.

Figure 5: Population distribution across deprivation quintiles: England 1971 to 2011



5. Further work

This work for England is soon to be extended to all of GB. A lack of data for Scotland until recently has held progress back. There will also be calculations of deprivation at different levels including MSOA and LA which will enable data relevant to those geographies to be analysed. Various health analyses will be carried out at LSOA and other levels including: infant mortality, all cause and cause specific mortality; being permanently sick / disabled. The variable inputs from censuses will also be broadened to enable tenure to be investigated as well as social class and education achievement. Population density will provide another area attribute.

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8. Biography

Paul Norman is a population & health geographer interested in time-series analysis of area and individual data from census, survey and administrative records. Paul did an MA GIS and PhD at the School of Geography, University of Leeds, was research fellow at CCSR before returning to Leeds as a Lecturer.