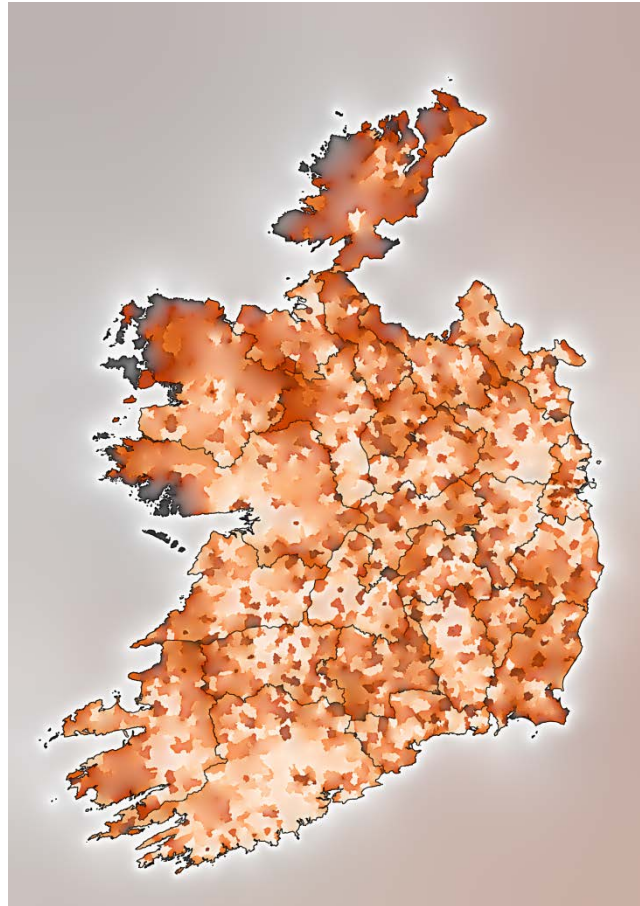# The Trinity National Deprivation Index for Health and Health Services Research 2016

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Foreword

This report describes the national deprivation index for Ireland, following the methodology of the index developed by Dr Alan Kelly. Alan was based in Trinity College Dublin for over 20 years, following spells at the United Nations in Geneva and the Food and Agriculture Organization of the UN in Rome. Over several decades he was involved in national and international in collaborative research programmes. Much of his research had a direct or indirect implication for regional and national policy in the health sector.

In the mid-1990s, Alan established the Small Area Health Research Unit (SAHRU) at Trinity College Dublin. In early 1997 SAHRU was commissioned by the Directors of Public Health in Ireland to produce the first national small area deprivation index for health and health services research. The index based on the 1991 Census and report was placed in the public domain. Subsequent reports provided the indices computed using the 1996, 2002, 2006 and 2011 Census outputs. The index has been widely used in health services research in Ireland, as well as to support decision making regarding resource allocation.

Alan was a generous colleague, always willing to give advice on biostatistical matters to the research community. He supervised and mentored countless MSc and PhD students and offered advice willingly to all researchers who sought his support, and was frequently consulted by senior researchers from other universities. Since his passing in 2015, Alan has been greatly missed by his friends and colleagues. The deprivation index combined his interests in spatial analysis and health inequalities, and featured widely in his work. The Trinity Deprivation Index is a continuation of the SAHRU deprivation index in both content and spirit.

Contents

Previous deprivation reports:

- Kelly A, Sinclair H. A national deprivation index for health and health service research. SAHRU, Dublin. 1997
- Kelly A, Teljeur C. A new national deprivation index for health and health services research. SAHRU, Dublin. 2004
- Kelly A, Teljeur C. The National Deprivation Index for Health & Health Services Research. SAHRU, Dublin. 2007
- Kelly A, Teljeur C. The National Deprivation Index for Health & Health Services Research – Update 2013. SAHRU, Dublin. 2013

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Abbreviations

CSO	Central Statistics Office
ED	Electoral Division (census output area)
IQR	Inter-quartile range
LA	Local Authority housing (deprivation indicator)
NC	No car (deprivation indicator)
PCA	Principal components analysis
SA	Small Area (census output area)
SAHRU	Small Area Health Research Unit
SC	Low social class (deprivation indicator)
SD	Standard deviation
UE	Unemployment (deprivation indicator)

Background

Peter Townsend stated that "individuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities and have the living conditions and amenities which are customary, or are at least widely encouraged or approved, in the societies to which they belong."[1]

In Townsend's definition, people are labelled according to what resources they do not possess, rather than those they do possess. The resources need not only be income, education or good social support – but might include household goods such as a washing machine or television, clothes, an adequate and nutritious diet, and access to a social life. This definition places poverty in terms of what resources and amenities the average individual expects to have access to, making poverty a relative measure. This definition of poverty is, in effect, a definition of deprivation – a state of being deprived of that which one should have access to according to the norms of society.

Deprivation indices

Deprivation indices are composite indices that combine several measures of socio-economic status or material deprivation. Since the early 1970s, there have been attempts to generate composite indices to identify small areas of adverse social conditions. Work by Jarman in the UK resulted in the underprivileged areas score which identified small areas that are likely to have an increased primary care workload.[2] There followed small area deprivation indices for the Northern region of England by Townsend[3] and for Scotland by Carstairs and Morris.[4]

Deprivation measures are typically area-based rather than individual-based. Although it cannot be assumed that all individuals in an area experience the level of deprivation found for that area as a whole, it has been shown that when deprivation indices are calculated for reasonably small areas, the deprivation score for an area is predictive of deprivation for individuals living in that area.[5]

A suitable index of deprivation must be based on an appreciation of the functional role of the index. This requires that a distinction be made between an index of material deprivation and other potential at-risk indices. The index of material deprivation provides information

about the level of economic strain in an area relative to all other areas in the country. An at-risk index, such as a health at-risk index, directly measures the risk of poor outcomes by including them in the index. A firm conceptual basis allows for the selection of the relevant individual indicators, subject to their availability in small area population statistics.

Deprivation and health

Like single variable measures of socioeconomic status, such as occupation or income, composite deprivation measures have also shown strong correlations with a range of morbidity, mortality and health outcome measures. However, associations that apply at an individual-level do not necessarily apply at an area-level and vice versa.

As an area-level measure, it could be anticipated that associations between lower socioeconomic status and health might be less apparent. An area-level measure is in effect a mean: the presence of very deprived individuals may be moderated by the presence of some affluent individuals resulting in a medium deprivation score. Furthermore, for most associations it is not assumed that the link is causal – for instance, area deprivation does not cause irritable bowel syndrome, but it is a good predictor of elevated incidence rates. For measures such as neighbourhood crime rates and the associated increased stress levels, they are linked to area characteristics for which deprivation is a more direct measure. In these instances, a causal relationship may well exist. For example, higher rates of obesity in deprived neighbourhoods have been linked to a greater density of fast food outlets in deprived areas.

Deprivation and health service utilisation

Provision of services and, to some extent, access to those services is tied in to resource allocation. The underprivileged areas score developed by Jarman was specifically developed to identify areas with a predicted high primary care workload.[6] Practices in underprivileged areas could then be targeted for increased funding to compensate for the higher workload. The benefit of using socioeconomic indicators rather than health outcomes such as mortality to predict workload is related to the notion of identifying the at-risk populations – a deceased person is not necessarily a good predictor of future health care need. However, not all forms of morbidity are correlated with deprivation so resource allocation based on deprivation alone might not be a sensible approach. Furthermore, no deprivation index will

perfectly identify the areas of highest need for resources, and so local knowledge should support decisions made using a deprivation index.

The Trinity Deprivation Index for Ireland

The SAHRU deprivation index was originally developed in 1997 to be similar in design to the widely regarded Carstairs and Townsend indices employed in the UK, with certain modifications in view of differences in definition and scope between census variables in the UK and Ireland. The SAHRU index has been used widely in health and health services research in Ireland.

This report updates the former SAHRU Deprivation Index using the outputs of the 2016 Census. The data are also presented for the 2006 and 2011 SAHRU indices, along with an exploratory analysis of changes over time.

Methods

The methodology used to compute the index reflects the methodology that has been used in previously published SAHRU indices. Some minor revisions have been made over time to the included indicators and their definitions.

Data

The deprivation index is published at the Electoral Division (ED) level. Although there are 3,444 EDs nationally, some EDs with small populations are merged with neighbouring EDs to protect anonymity or respondents. The changing grouping of EDs can pose issues for cross-time comparisons for some areas, although since 2006, data have been provided for a consistent set of 3,409 EDs. The 2011 deprivation index was also provided at the CSO's newly-defined Small Areas (SA) level. There are 18,641 SAs which are defined as subsets of EDs, and the data provide detail on smaller neighbourhoods, particularly in urban areas. To avoid issues with anonymity, some EDs with small populations are not further subdivided, and hence the ED and SA definition is the same in those areas.

Indicators

Townsend described deprivation as a state of "observable and demonstrable disadvantage relative to the local community to which an individual belongs".[7] The idea has come to be applied to conditions (i.e. physical and social circumstances) rather than resources or income and thus can be distinguished from the concept of poverty, although the two are closely related. This conceptualisation can explain why people can experience deprivation without necessarily living in poverty.

The following four indicators are included in the present deprivation index:

1. Unemployment (UE)

   Unemployment reflects lack of access to earned income and the facilities of employment. It may also impose other pressures on individuals through loss of self-esteem, and on families through the associated problems and tensions generated.

   The 'unemployment' indicator is defined as:

> Proportion of the economically active population (15 years or older) unemployed or seeking a first time job.

2. Low social class (SC)

The Irish Social Class Scale is an ordinal scale from 1 (higher professional) to 6 (unskilled manual). It is based on the concept of groups whose members possess capacities for the generation of income through their occupations, not the status/prestige associated with particular occupations. A social class code of seven is assigned to people who cannot be assigned to any of the other six groups. Being in a low social class - i.e. class 5 (semi-skilled manual occupations) and class 6 (unskilled manual occupations) - reflects earnings at the lower end of the income scale. Low income limits access to material resources and the ability to make choices in life.

The 'low social class' indicator is defined as:

> Proportion of population (social classes 1 to 6 only) in social class 5 or 6.

3. Local Authority rented housing (LA)

Non-owner occupation has been suggested as a surrogate for income in the long term. Taken together with car ownership these two indicators are likely to provide a fairly good reflection of income levels in different areas.

The 'rented accommodation' indicator is:

> Proportion of persons living in permanent private households rented from a local authority.

4. No car (NC)

Car ownership has been suggested as a surrogate for current disposable income. Apart from the cost of purchasing a car there are the necessary expenses of licensing, insurance, fuel, maintenance and repair costs. Car ownership also confers benefits in terms of access to other resources. In urban areas, with good access to public transport services, owning a car is arguably not a necessity. However, despite the availability of public transport ownership of a car appears to be the societal norm.

This may be a reflection of the inconvenience and/or limited scope of public transport as well as the prestige associated with owning a car. In rural areas car ownership is more of a necessity and its value as a discriminator between affluent and deprived areas may be diminished.

The following 'no car' indicator has been used:

> Proportion of permanent private households with no car.

Shrinkage

As deprivation indices are generally computed at a small area level where the denominator population may be quite small, a small fluctuation in the numerator may translate into a relatively large change in the observed proportion. A large deviation from the mean could therefore be a genuine difference or merely be a reflection of uncertainty, which should be taken into account in computing the deprivation score.[8] The purpose of shrinkage is to move indicator values based on very small numbers closer to the mean for that indicator. The degree of shrinkage is related to the standard error associated with the small area. The standard error is, in turn, related to the population of that small area such that a large population equates to a small standard error and vice versa.

The technique of shrinkage is analogous to smoothing in that it reduces random fluctuations in the data. Although various methods of shrinkage are available which produce similar results (e.g., empirical Bayes,[9] Noble logit,[10] and Longford[11]), we found that the Longford method was most applicable to deprivation indicators.

Principal components analysis

A number of methods of dimension reduction have been used to combine deprivation indicators into a single or small number of indices. The most common techniques have been principal components analysis (PCA) and factor analysis (FA).

Both PCA and FA develop weights associated with each variable based on how it correlates with the other variables. As a consequence, no prior knowledge of which indicators are more or less important is required. A possible drawback to FA is that it assumes that there are underlying factors in the first place. PCA does not make such an assumption - it merely combines the indicators into new variables. This fact leads to a further problem with FA

which is that the results are dependent on the choice of the number of factors and the method of rotation used. Two researchers working with the same dataset could potentially find evidence to back up two quite different theories based on how they extracted the factors.

For both PCA and FA, components or factors are derived from a transformation of the correlation or covariance matrix. Indicators associated with higher correlations will receive higher weights than those associated with lower correlations. As such, if two variables are included which are opposites of the same measure (e.g., high social class and low social class), they will have a high negative correlation which is likely to increase their weight relative to other variables. Furthermore, including large numbers of variables is likely to increase noise and create difficulties in understanding which variables may be contributing to the deprivation score for an area.

The deprivation index here is computed using PCA with an assessment of how many components are required based on the percentage variance explained by each component. Our previous experience is that only a single component is required to meaningfully represent the four included indicators. We present the score, which is a continuous variable with a mean of zero: negative values imply less deprived than the national average; positive values represent areas that are more deprived than the national average. We also divide areas into deciles each containing ten percent of areas. Decile 1 represents the least deprived 10% of areas, and decile 10 represents the most deprived 10%. It should be noted that ten percent of areas does not imply ten percent of the population.

Cross-time comparison

The deprivation index is a relative measure calculated at a point in time and the scores for two different time periods cannot be meaningfully compared. The weights applied to each indicator vary over time and within the computation of the PCA the variables are standardised to the mean for that year. In previous reports, we have focused on EDs that have changed by more than one decile as a measure of substantial change in deprivation.

To allow for a cross-time analysis of scores, we have used the indicator weights generated for 2016, and standardised 2006 and 2011 indicators based on the 2016 means and standard

deviations. On this basis, scores can be compared across time. We have also investigated where ED scores have experienced a substantially different shift than the national average.

Results

Between 2011 and 2016, the national population increased by 3.8% from 4,588,252 to 4,761,865. At the county council level, the largest population increase was in Dun Laoghaire-Rathdown, where the population grew by 7.0%. In Donegal, Mayo and Tipperary South Riding, the population decreased marginally. At an ED level, some areas grew in population by as much as 67.7%. The largest absolute increase in population (2,837) was in Blanchardstown-Blakestown in Fingal. A total of 1,330 (39%) of EDs experienced a population decrease between 2011 and 2016.

Indicator values

The data for 2006, 2011 and 2016 show some apparent trends in terms of a decreasing proportion in low social class, an increasing proportion of people renting local authority housing, and a decreasing proportion of households with no car (Table 1). Unemployment increased substantially between 2006 and 2011, but has shown a subsequent decrease. It is apparent that the distributions of the indicators are right-skewed, as can be seen by the difference between the mean and median values.

There is substantial variation across county councils in terms of the average indicator values. Limerick City has the highest proportions for unemployment (0.134), low social class (0.275), and no car (0.383). Waterford City has the second highest values for unemployment (0.125) and low social class (0.265), and the highest value for local authority housing (0.190). The lowest proportions for unemployment (0.044) and low social class (0.076) were observed in South Dublin.

Correlation between indicators

Figure 1 gives the correlation coefficient between each pair of indicators following shrinkage. All of the correlation coefficients are positive and range from 0.42 (between Low Social Class and No car) to 0.70 (between Unemployment and Local Authority Housing). All of the pairwise comparisons are highly significant with $p < 0.0001$.

Table 1. Summary statistics (proportions) over time for constituent variables

Indicator		Year		
		2006	2011	2016
Unemployment	Mean (SD)	0.045 (0.026)	0.110 (0.039)	0.071 (0.033)
	Median (IQR)	0.039 (0.027; 0.055)	0.105 (0.082; 0.132)	0.065 (0.049; 0.087)
Low social class	Mean (SD)	0.191 (0.070)	0.182 (0.064)	0.181 (0.063)
	Median (IQR)	0.183 (0.145; 0.230)	0.176 (0.140; 0.218)	0.175 (0.141; 0.216)
Local Authority housing	Mean (SD)	0.049 (0.072)	0.052 (0.072)	0.055 (0.076)
	Median (IQR)	0.023 (0.005; 0.068)	0.025 (0.006; 0.072)	0.027 (0.008; 0.077)
No car	Mean (SD)	0.148 (0.116)	0.127 (0.112)	0.107 (0.113)
	Median (IQR)	0.115 (0.079; 0.170)	0.093 (0.064; 0.141)	0.070 (0.044; 0.117)

Notes: data refer to raw indicator values (i.e., prior to shrinkage).

Abbreviations: SD, standard deviation; IQR, inter-quartile range.

Figure 1. Correlations between the four deprivation indicators
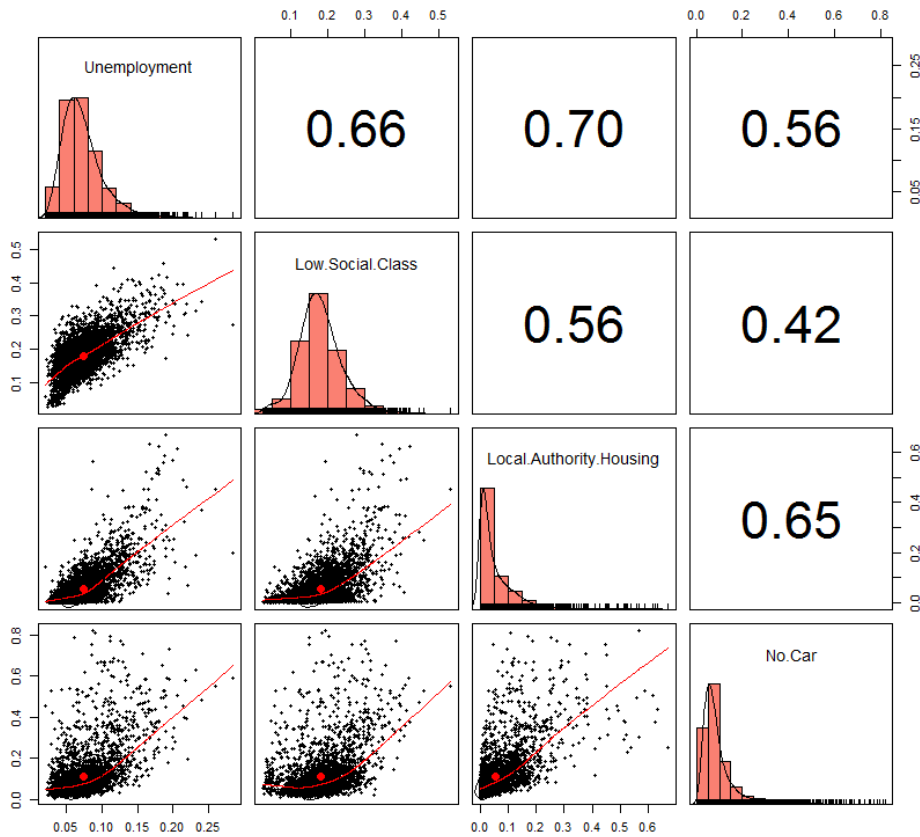
Figures based on shrunken indicator values (as used in analysis).

Shrinkage

The application of shrinkage transforms indicator values at the ED-level, taking into account the standard error of the indicator estimates. The indicator value for a large ED will be almost unchanged, whereas the value for an ED with a very small population will be shrunk towards the national mean. It can be seen from the plots in Figure 2 that most EDs retain values close to the original non-shrunken values. As a consequence, the application of shrinkage has a minimal impact on the estimated deprivation score for most EDs.

Figure 2. Impact of shrinkage on indicator values
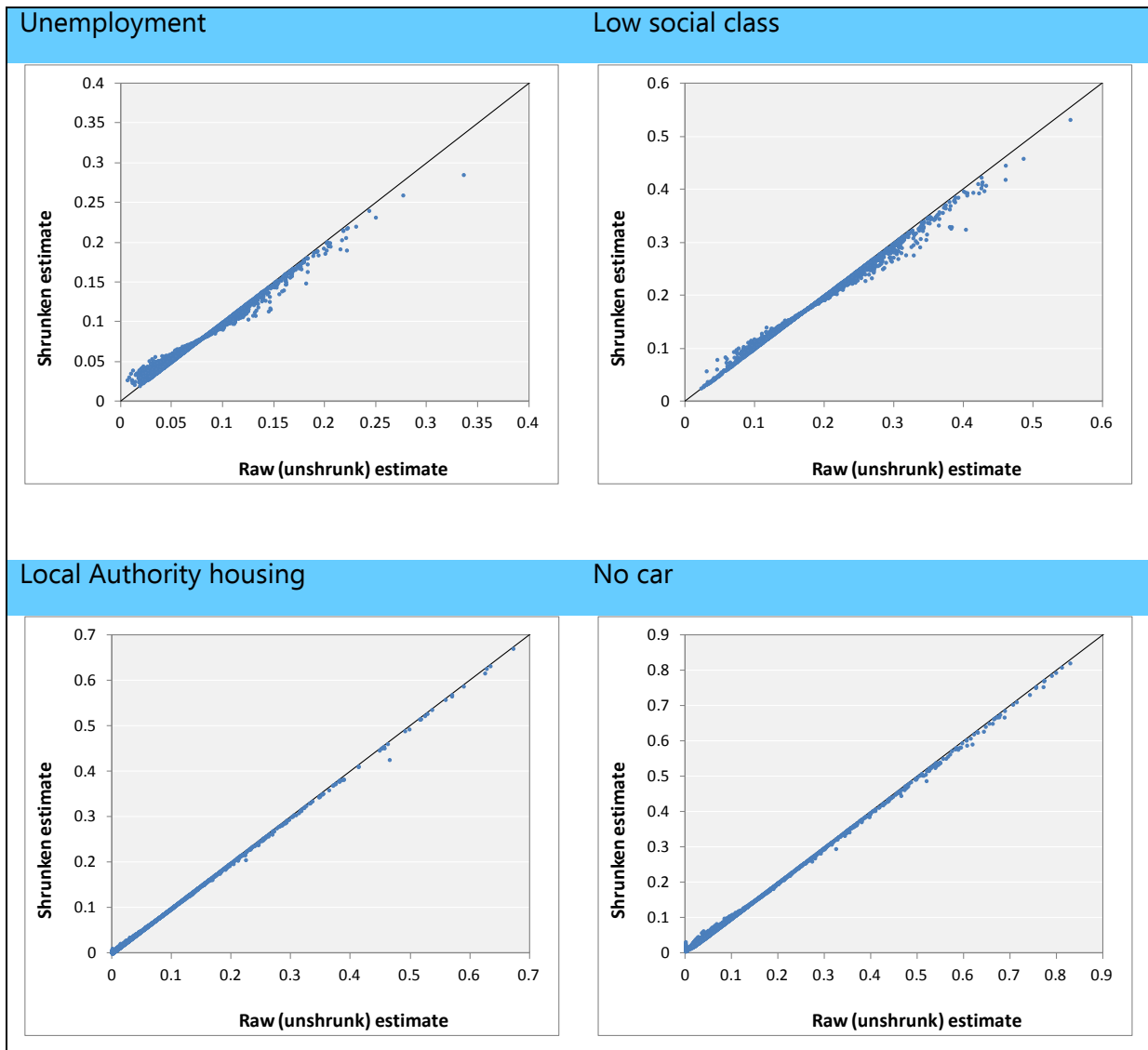
Principal components analysis

The first principal component had a standard deviation of 1.67, explaining 69.7% of the variance. The second component had a standard deviation of 0.78. Therefore, only the first component was required and it explained an acceptable percentage of the variance.

The application of PCA generated indicator weights similar to those for the 2006 and 2011 data (Table 2).

Table 2. Indicator weights

Indicator	Year		
	2006	2011	2016
Unemployment	0.527	0.514	0.529
Low social class	0.474	0.501	0.472
Local Authority housing	0.507	0.520	0.527
No car ownership	0.491	0.463	0.469

The distribution of deprivation scores is right-skewed (Figure 3). The impact of the skewness is that the range of deprivation scores in the most deprived 10% of EDs is much wider than for any other decile. In other words, the difference between two EDs within the most deprived 10% may be much greater than the difference between two EDs across several deciles in mid-range scores.

Figure 3. Distribution of deprivation scores (2016)
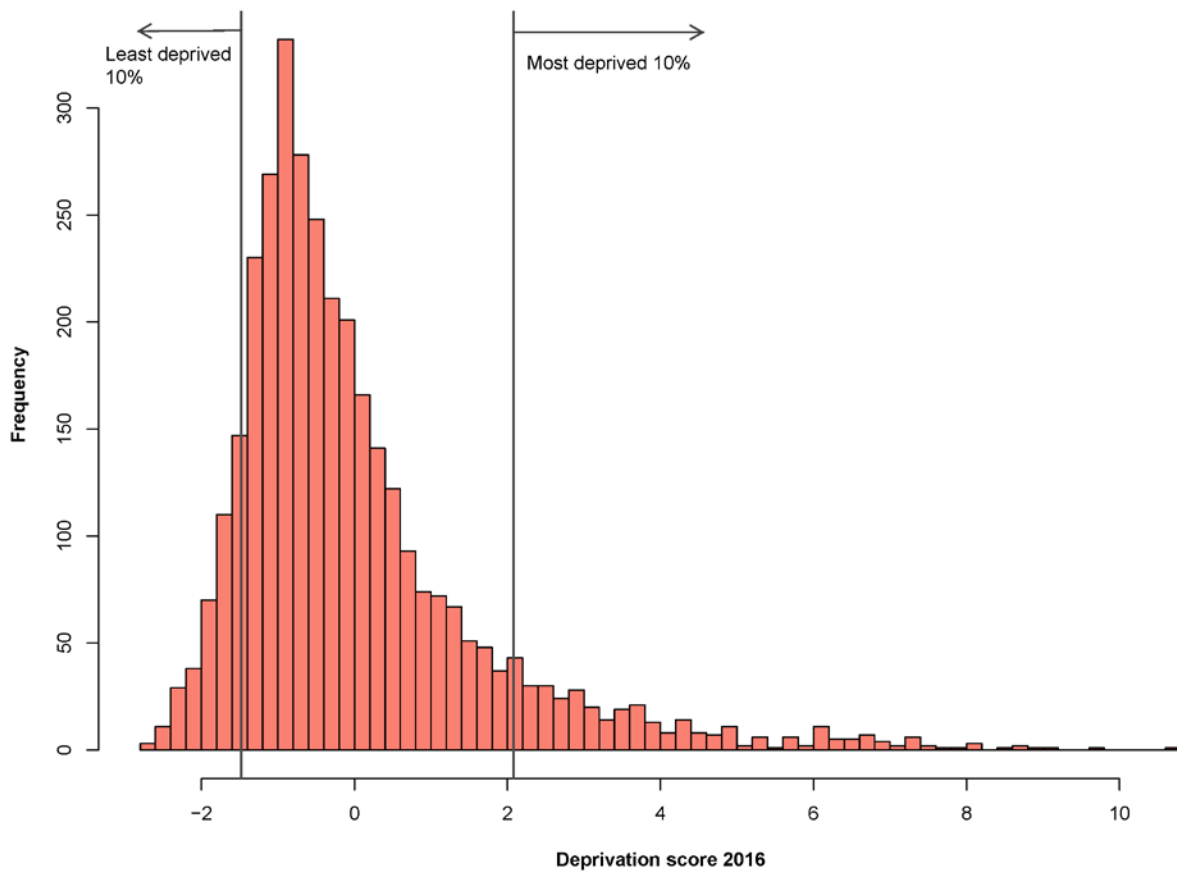
Deprivation deciles

Once grouped into deciles based on deprivation score, it is possible to compare across groups (Table 3). The population is not distributed uniformly across deciles, and it can be seen that almost a fifth of the population live in the most deprived decile. There exists a gradient of increasing values for all four indicators from deciles 1 to 10. However, it can also be seen that indicator values tend to be more extreme for the most deprived decile.

Table 3. Distribution of population and mean indicator values by deprivation decile

Deprivation decile	Population		Indicator values (mean proportion)			
	Total	(%)	UE	SC	LA	NC
1 – least deprived	539,460	(11.3%)	0.040	0.099	0.009	0.051
2	335,496	(7.0%)	0.050	0.136	0.013	0.052
3	322,817	(6.8%)	0.055	0.151	0.016	0.059
4	388,332	(8.2%)	0.060	0.162	0.020	0.066
5	300,854	(6.3%)	0.066	0.169	0.025	0.074
6	367,818	(7.7%)	0.070	0.184	0.035	0.080
7	426,081	(8.9%)	0.076	0.194	0.049	0.096
8	461,471	(9.7%)	0.083	0.209	0.073	0.114
9	712,192	(15.0%)	0.098	0.226	0.112	0.161
10 – most deprived	907,344	(19.1%)	0.134	0.275	0.212	0.344

Abbreviations: UE, unemployment; SC, low social class; LA, Local Authority housing; NC, no car.

Forty seven percent of EDs were in the same deprivation decile in 2011 and 2016 (Table 4), and a further 36% were within one deprivation decile of the previous Census. This indicates that the majority of EDs were relatively stable in their national ranking. However, 8.3% of EDs had disimproved by at least two deciles and 8.9% had improved by at least two deciles. Thus a minority of EDs experienced substantial shifts, some positive and some negative.

Table 4. Number of EDs by deprivation deciles for 2011 and 2016

		2011 decile									
		1	2	3	4	5	6	7	8	9	10
2016 decile	1	240	74	22	5	0	0	0	0	0	0
	2	64	125	77	48	16	10	1	0	0	0
	3	23	87	93	64	49	20	4	1	0	0
	4	9	36	82	97	71	32	13	1	0	0
	5	3	14	45	69	93	71	34	12	0	0
	6	1	5	14	36	78	110	71	23	3	0
	7	1	0	6	15	28	73	138	71	9	0
	8	0	0	1	6	5	21	74	175	59	0
	9	0	0	1	1	1	4	6	58	235	35
	10	0	0	0	0	0	0	0	0	35	305

Note: green cells mark EDs where the 2016 decile is at least 2 deciles lower than the 2011 decile. Red cells mark EDs where the 2016 decile is at least 2 deciles higher than the 2011 decile.

Figure 4. Deprivation Index 2016
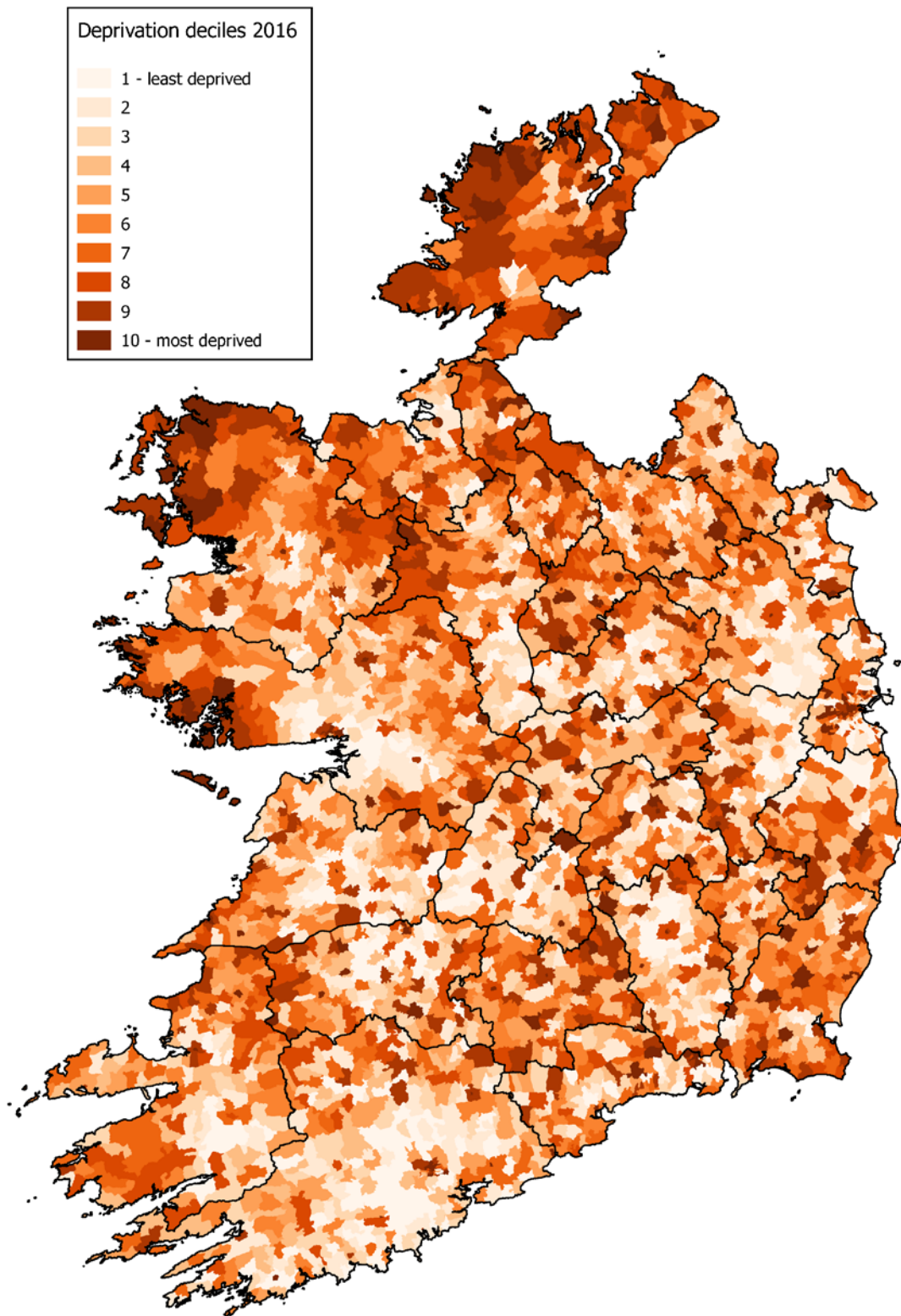
Figure 5. Deprivation Index 2016 - cities
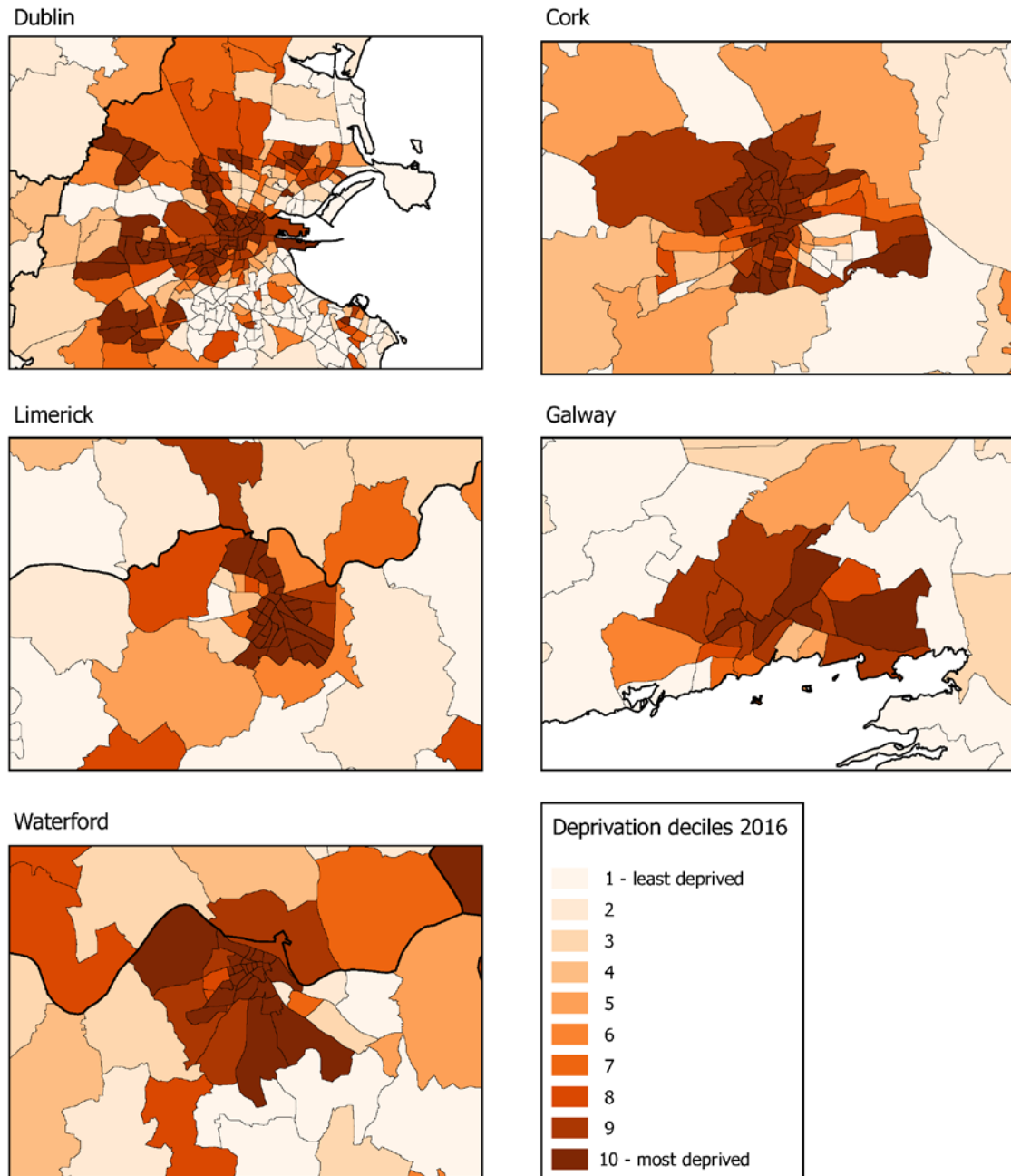
The map in Figure 4 shows the heterogeneity across areas in terms of the deprivation index. However, it is apparent that such heterogeneity is less in evidence in some of the city centre areas where there appears to be concentrated deprivation (Figure 5).

If we rank county councils by deprivation score, we see that Limerick City is the most deprived and Dún Laoghaire-Rathdown the least deprived (Table 5).

Table 5. County councils ranked by population-weighted 2016 deprivation score

| County council	Population	Deprivation score		Proportion deciles 9 & 10	
		Mean	Rank	Mean	Rank
Limerick City	51,458	3.204	34	0.712	34
Waterford City	48,216	2.482	33	0.689	33
Cork City	125,657	2.105	32	0.643	32
Longford	40,873	1.840	31	0.465	22
Dublin City	554,554	1.747	30	0.546	27
South Tipperary	88,271	1.200	29	0.510	24
Louth	128,884	1.179	28	0.566	30
Carlow	56,932	1.158	27	0.553	29
Galway City	78,668	1.097	26	0.604	31
Donegal	159,192	1.067	25	0.552	28
Wexford	149,722	0.979	24	0.476	23
Offaly	77,961	0.917	23	0.522	25
Laois	84,697	0.788	22	0.525	26
Cavan	76,176	0.731	21	0.306	14
Westmeath	88,770	0.724	20	0.418	20
Monaghan	61,386	0.611	19	0.427	21
South Dublin	278,767	0.609	18	0.316	15
Sligo	65,535	0.603	17	0.383	19
North Tipperary	71,282	0.426	16	0.380	18
Mayo	130,507	0.395	15	0.324	16
Kerry	147,707	0.321	14	0.255	11
Leitrim	32,044	0.293	13	0.361	17
Kilkenny	99,232	0.269	12	0.283	13
Wicklow	142,425	0.213	11	0.272	12
Waterford	67,960	0.201	10	0.179	6
Roscommon	64,544	0.128	9	0.216	8
Clare	118,817	0.061	8	0.253	10
Galway	179,390	-0.143	7	0.237	9
Limerick	143,441	-0.201	6	0.168	4
Kildare	222,504	-0.206	5	0.206	7
Meath	195,044	-0.343	4	0.077	2
Fingal	296,020	-0.359	3	0.159	3
Cork	417,211	-0.409	2	0.177	5
Dún Laoghaire-Rathdown	218,018	-1.244	1	0.073	1

The ranks based on proportion population living in EDs in deciles 9 and 10 is also presented (Table 6). The ranks are broadly similar, particularly with respect to the most deprived county council areas. In Limerick City, over 70% of the population lives in EDs in deciles 9 and 10, in stark contrast to Dún Laoghaire-Rathdown where only 7% live in deciles 9 and 10. The average deprivation score in Dún Laoghaire-Rathdown is much lower than for the second ranked county council, Cork County.

Four of the five most deprived county councils are cities, pointing to the substantial burden of deprivation in urban areas. However, it can also be seen that some very rural counties, such as Longford and Donegal, also have a substantial burden of deprivation. In looking at regional patterns of deprivation it is important to appreciate that different indicators may contribute more to deprivation in rural areas than in urban areas. The manner in which deprivation may be associated with health outcomes may differ between urban and rural areas.

Cross-time analysis

The first step in the cross-time analysis was to calculate deprivation scores for the three time periods using the 2011 data as the reference point. Scores were then converted to deciles based on the cut-points for 2016. On that basis, ten percent of EDs fall into each decile in 2016. However, in 2011 a disproportionate number of EDs fall into the most deprived deciles (Figure 6). Sixteen percent of EDs in 2011 would be considered as being in the most deprived decile by 2016 standards. Conversely, in 2006 a disproportionate number of EDs fall into the least deprived deciles. In other words, in 2011 there were higher levels of deprivation than in 2016, and in 2006 there were lower levels of deprivation than in 2016. This is consistent with narrative of 2006 being pre-recession and coming after a period of sustained growth. In 2011 the effects of the recession were being fully felt, while 2016 reflects a period of gradual recovery.

Figure 6. Change in deprivation deciles over time
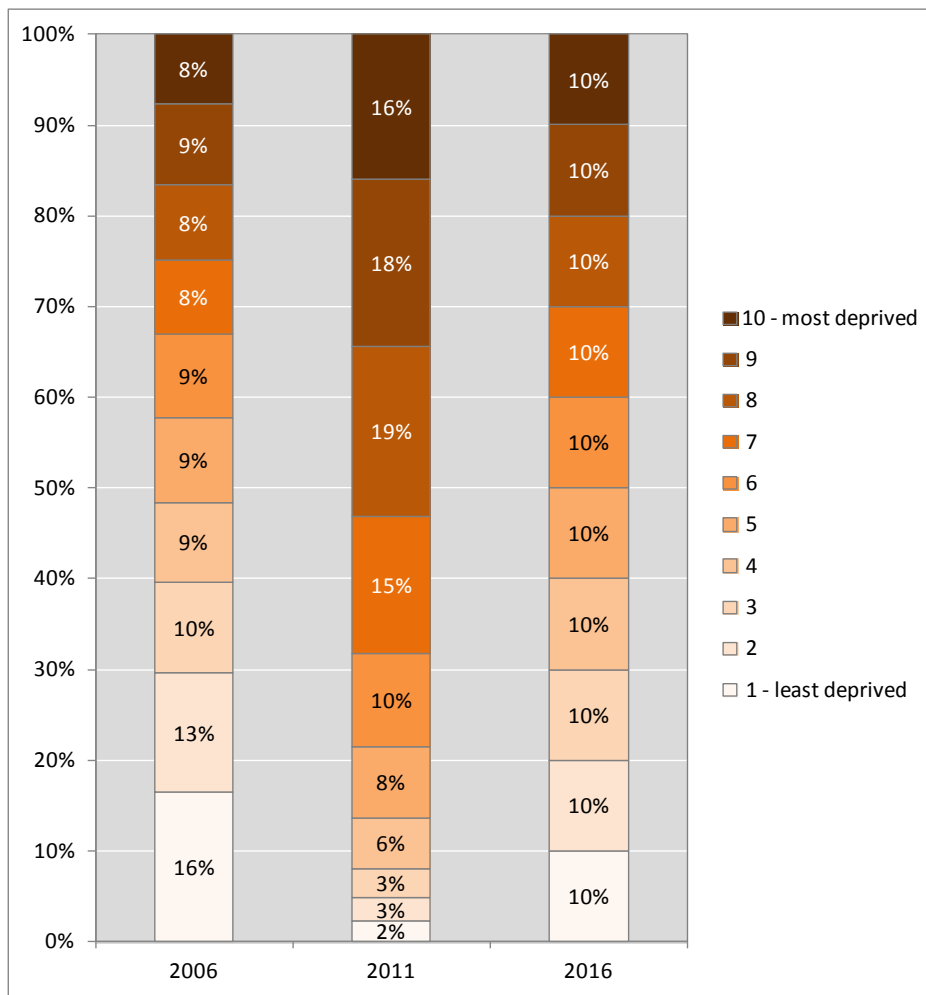
The difference between 2011 and 2016 deprivation scores is shown in Figure 7. While the scores display a similar shaped distribution, the mean deprivation is lower in 2016 than in 2011. It can be seen that the deprivation scores in a small number of EDs have shifted quite markedly between 2011 and 2016.
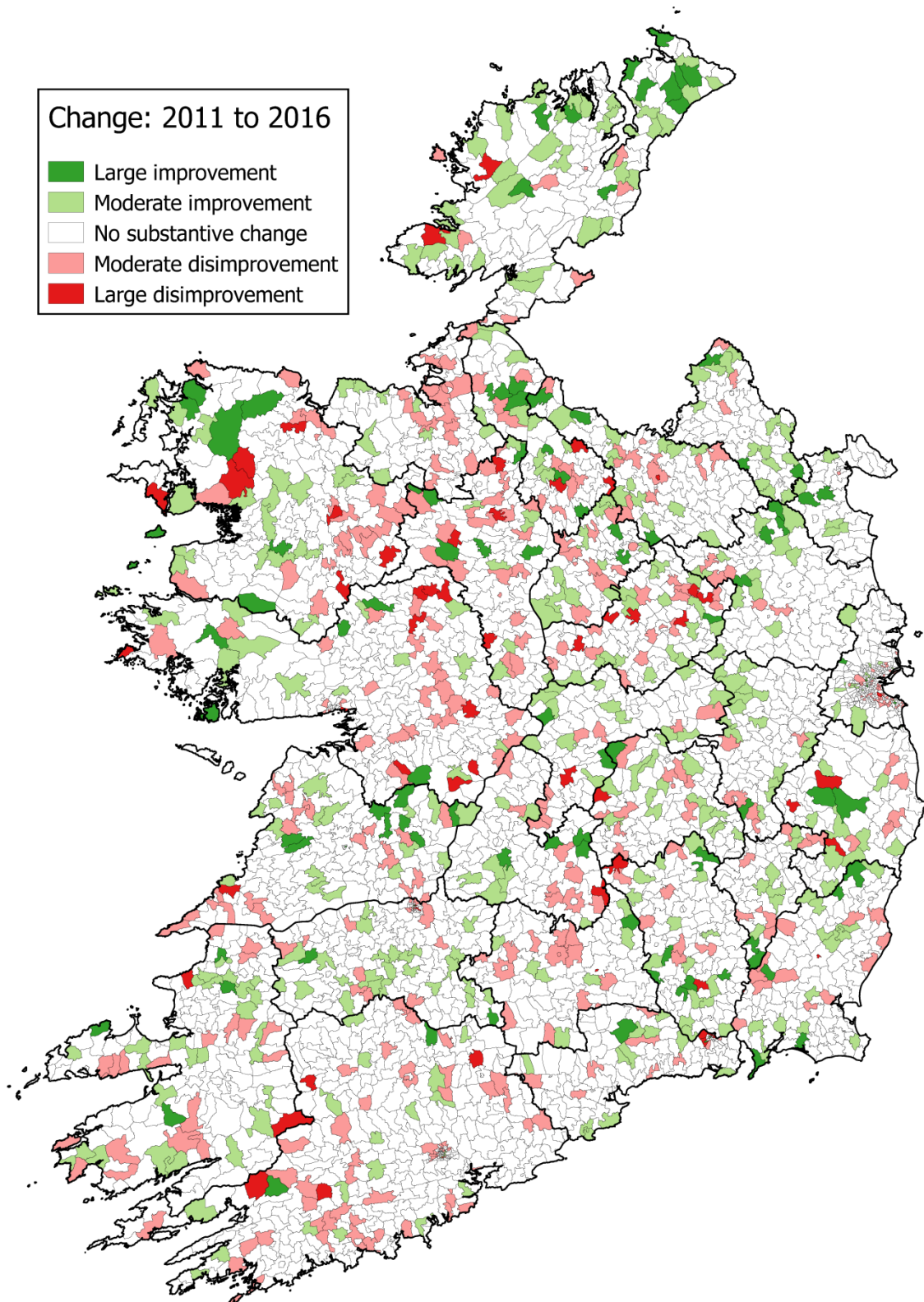
Figure 7. Deprivation scores in 2011 versus 2016
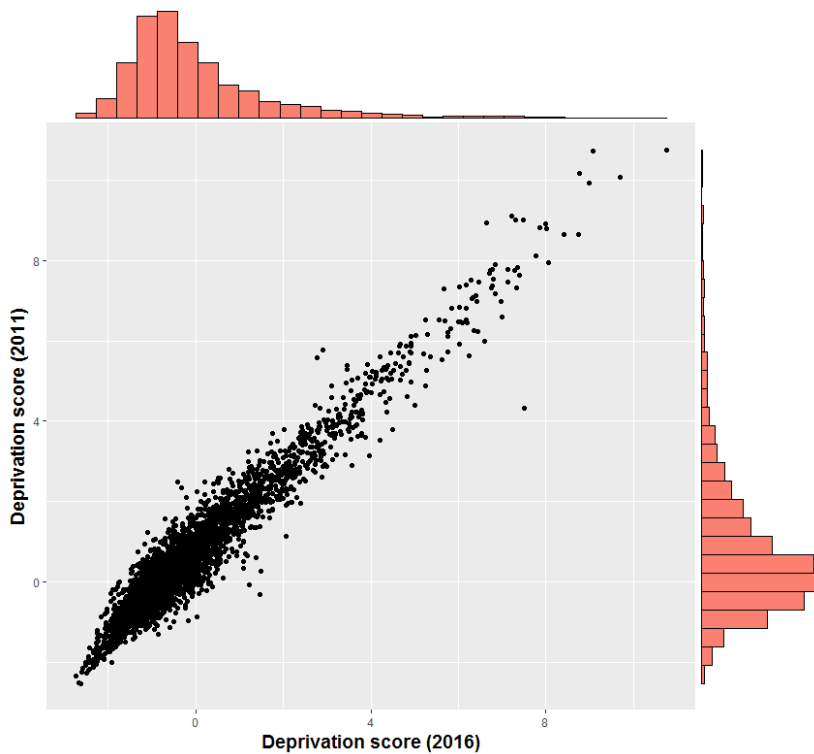
While deprivation increased on average between 2006 and 2011, and decreased on average between 2011 and 2016, that is not to say that all EDs experienced the same level of increase and decrease. Between 2006 and 2011, 123 EDs experienced a reduction in deprivation score. Between 2011 and 2016, only 134 EDs experienced an increase in deprivation score.

One way to consider shifts in deprivation is using the ED-level change in score relative to the expected change based on the national average. Between 2006 and 2011, the average change in score was an increase of 0.998, with 96.4% of EDs experiencing an increase in deprivation score. Between 2011 and 2016, the average score decreased by 0.753, with 96.0% of EDs experiencing a decrease in deprivation score. We may consider a shift in deprivation within one standard deviation of the mean difference as no change (i.e., broadly in line with what was observed nationally). A shift of between one and two standard deviations from the mean may be considered as a moderate change, and a shift of more than two standard deviations can be considered a substantial change. When mapped, it can be seen that EDs experiencing moderate or large changes are distributed across the country (Figure 8).

Figure 8. Change in deprivation scores between 2011 and 2016

Change: 2011 to 2016

- Large improvement
- Moderate improvement
- No substantive change
- Moderate disimprovement
- Large disimprovement

On the basis of change in terms of standard deviations we can identify EDs where conditions have changed in a way that is not consistent with the national picture. Change in deprivation can be considered in terms of change in score or change in rank relative to all other EDs. Both analysis highlight different EDs, and reflect potentially different issues.

In terms of deprivation score, eleven EDs showed either a large disimprovement in both time periods or a large disimprovement in one and a moderate disimprovement in the other (Table 6). With the exception of Kilfearagh in Clare, all of the EDs are in decile 10 in 2016. Nine were in decile 10 in 2011 and six were in decile 10 in 2006. In other words, most of these EDs were already very deprived in 2006, and conditions worsened at each subsequent time point.

The same analysis can be used to investigate EDs that have experienced a large improvement in both time periods or a large improvement in one and a moderate improvement in the other (Table 7). It is interesting to note that four of the six EDs identified were in decile 10 at all three time points. So while they have experienced large improvements, they have not moved out of the most deprived 10% of areas. This again emphasises the skewed nature of the deprivation score and the very wide range of deprivation scores encompassed by decile 10.

A drawback of this type of analysis relates to the scope for change in an ED. For example, many EDs within Dublin experienced less of an increase in deprivation between 2006 and 2011 than was observed nationally. However, many of those same EDs experienced less of a reduction in deprivation between 2011 and 2016 than was observed nationally. While this may point towards resilience in those EDs, by looking at change over only one time period (e.g., 2011 to 2016), change in deprivation will not be placed in context.

Table 6. EDs experiencing a large disimprovement in deprivation score

Period of change		ED	ED name	County	Deprivation decile*		
2006 to 2011	2011 to 2016				2006	2011	2016
Large disimprovement	Large disimprovement	E24016	Gracedieu	Waterford City	7	10	10
		E20033	St. Laurence	Limerick City	8	10	10
		E20003	Abbey C	Limerick City	10	10	10
Moderate disimprovement	Large disimprovement	E32001	Cavan Urban	Cavan	10	10	10
		E24036	The Glen	Waterford City	10	10	10
		E14001	Enniscorthy Urban	Wexford	10	10	10
		E13041	Delvin	Westmeath	7	9	10
Large disimprovement	Moderate disimprovement	E16087	Kilfearagh	Clare	2	9	9
		E08044	Borris	Laois	8	10	10
		E32042	Belturbet Urban	Cavan	10	10	10
		E13090	Mullingar North Urban	Westmeath	10	10	10

* Based on deciles calculated relative to 2016 deprivation scores

**Table 7. EDs experiencing a large improvement in deprivation score**

Period of change		ED	ED name	County	Deprivation decile		
2006 to 2011	2011 to 2016				2006	2011	2016
Large improvement	Large improvement	E02004	Arran Quay D	Dublin City	10	10	10
		E02124	Merchants Quay F	Dublin City	10	10	10
Moderate improvement	Large improvement	E19127	Urlee	Kerry	9	9	5
		E29131	Clare Island	Mayo	10	10	8
Large improvement	Moderate improvement	E02097	Cherry Orchard C	Dublin City	10	10	10
		E02154	Ushers C	Dublin City	10	10	10

* Based on deciles calculated relative to 2016 deprivation scores

Large changes in deprivation score are more typically observed in EDs that are small in terms of population size (Figure 9). Although the application of shrinkage to deprivation indicators should to some extent protect against the impact of calculating proportions based on small numbers, there are still substantial fluctuations. These may be artefacts due to sensitivity to small changes, or they may be genuine fluctuations.

Figure 9. ED population and change in deprivation score 2011-2016
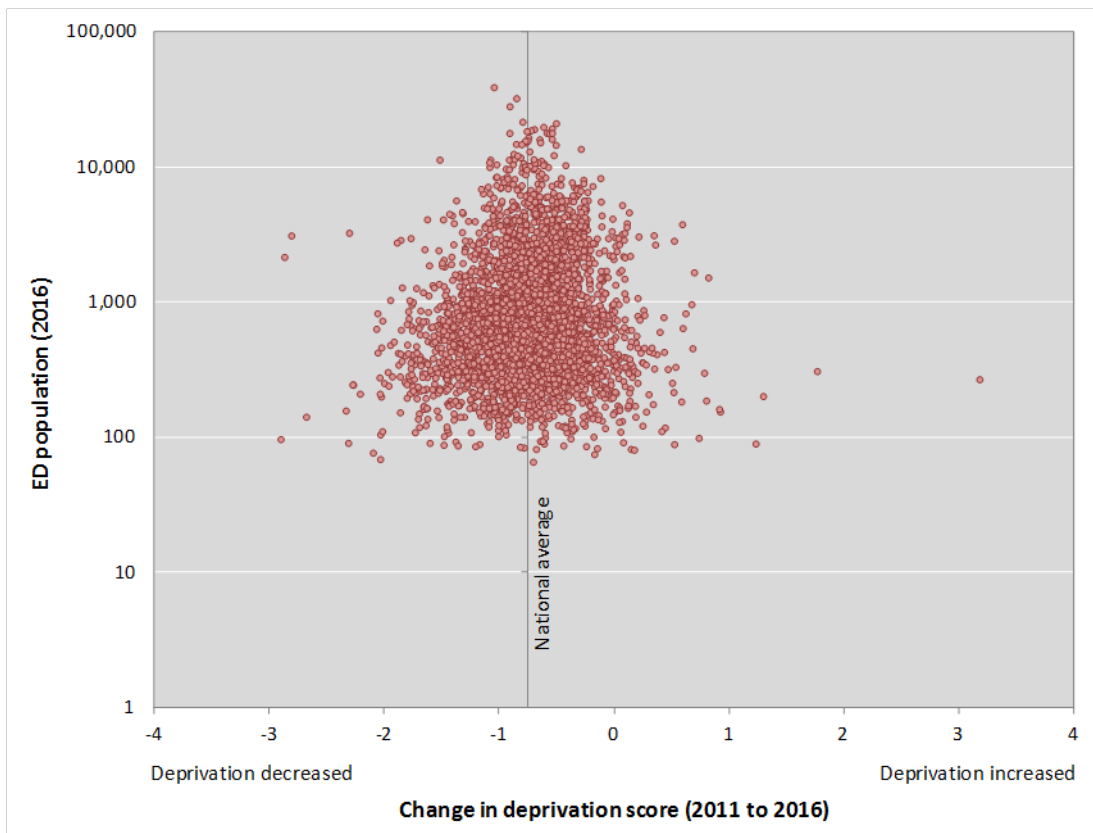
An alternative perspective is to consider EDs in terms of their ranking relative to other EDs, and to focus on EDs that had large increases in their rank between 2006 and 2011, and again between 2011 and 2016. As with change in terms of score, large shifts in ranking are typically observed in EDs with low population numbers (Figure 10).

Figure 10. ED population and change in ranking 2011-2016
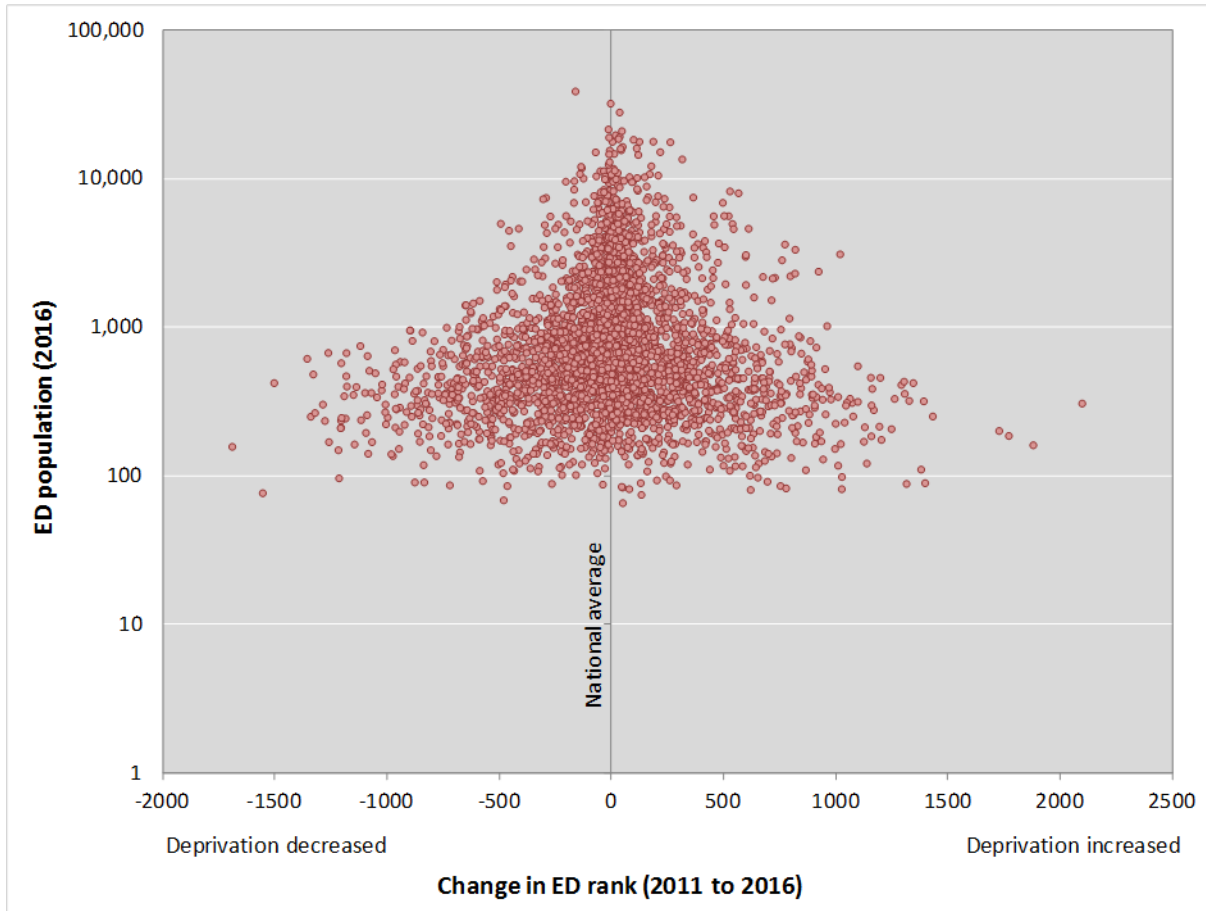
Ten EDs were identified that had a combination of large disimprovement in one time period and moderate disimprovement in the other time period (Table 8). All of the identified EDs were in deciles 1, 2 or 3 in 2006, indicating that these were all EDs with low levels of deprivation at that point. By 2016, seven of the EDs are in decile 7. These are EDs that have shown a marked shift in deprivation over time although not one is in the most deprived 20% of EDs in 2016. This may be highlighting areas that are at risk of further increases in deprivation.

We also identified eight EDs that had a combination of large improvement in one time period and moderate improvement in the other time period (Table 9). None of the eight EDs was in decile 9 or 10 in 2006.

Table 8. EDs experiencing a large disimprovement in deprivation ranking

| Period of change		ED	ED name	County	Deprivation decile		
2006 to 2011	2011 to 2016				2006	2011	2016
Moderate disimprovement	Large disimprovement	E06021	Johnstown	Kildare	1	4	7
		E15023	Lugglass	Wicklow	2	4	7
		E25003	Ballydurn	Waterford	2	3	7
		E23169	Kilmucklin	South Tipperary	2	3	7
		E23134	Inishlounaght	South Tipperary	3	4	7
		E30046/30048	Lisgarve/Mantua	Roscommon	2	3	6
Large disimprovement	Moderate disimprovement	E23177	Tipperary Rural	South Tipperary	3	6	8
		E16102	St. Martin's	Clare	3	6	7
		E23102	Cooleagh	South Tipperary	2	6	7
		E12009	Derrinboy	Offaly	1	3	5

Table 9. EDs experiencing a large improvement in deprivation ranking

Period of change		ED	ED name	County	Deprivation decile		
2006 to 2011	2011 to 2016				2006	2011	2016
Moderate improvement	Large improvement	E11062	Crosskeys	Meath	7	6	3
		E16064	Moy	Clare	6	4	2
		E21030	Bulgaden	Limerick	7	5	2
		E30078	Bumlin	Roscommon	6	5	2
Large improvement	Moderate improvement	E09032	Moatfarrell	Longford	7	4	2
		E18160	Gortmore	Cork	7	4	2
		E27108	Colmanstown	Galway	8	5	4
		E34043	Killynenagh	Monaghan	6	3	2

In any analysis of changes over time in ED deprivation, it is important to consider which of the indicators are contributing to changes in the deprivation score. For example, an ED may be experiencing a trend for increasing unemployment that is not following national trends. Understanding the underlying drivers of the deprivation score is critical to being able to explain changes. By way of example, it is useful to consider Johnstown ED in county Kildare (E06021) which was shown to have experienced increased deprivation across time (Table 8). The population of the ED was largely static over the ten years: 167 in 2006, 179 in 2011, and 172 in 2016. An examination of the deprivation indicator values shows that in 2006, the ED had lower than national levels for all four indicators (Figure 11) corresponding to the fact that it was in the least deprived decile. Between 2006 and 2011 all four deprivation indicators increased by more than observed nationally (in relative terms). By 2011 the ED had an above average proportion of people in low social class. Between 2011 and 2016, conditions improved nationally with reductions in unemployment, low social class and car ownership, and a modest increase in local authority housing. Within Johnstown ED, the reduction in unemployment was less than seen nationally, while the other three indicators increased. In other words, between 2011 and 2016 the ED did not see the experience the improvements observed nationally.

Figure 11. Change over time in deprivation indicator values in Johnstown ED (E06021)
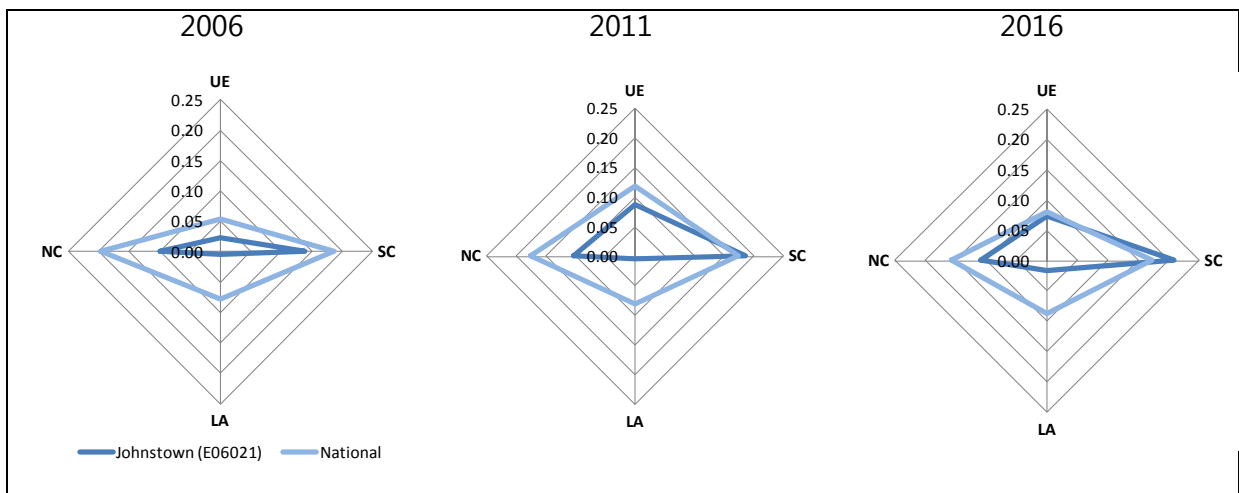
Regional inequalities

By classifying EDs into deciles, it is possible to look at the distribution of deprivation deciles within a region such as a county and characterise inequality using the Gini coefficient. As we expect 10% of areas to fall into each decile, there is inherently an expected level of inequality in areas. If there are exactly ten percent of EDs in each decile (as there is nationally), then the Gini coefficient is calculated as 0.3. If all EDs in a region were in the same decile, the Gini coefficient would be zero – indicating no inequality in that region.

As we expect a Gini coefficient of 0.3, it is worth concentrating on counties that have substantially higher figures. The highest Gini value is for Dún Laoghaire-Rathdown, with a coefficient of 0.475. This is substantially higher than the next county, Fingal, with a coefficient of 0.391. Other county councils with high levels of inequality are South Dublin (0.373) and Kilkenny (0.360). At the other end of the spectrum, county councils with very low Gini coefficients include Waterford City (0.109), Limerick City (0.119) and Donegal (0.125).

Having low levels of inequality does not imply average levels of deprivation across EDs in that area. In both Waterford City and Limerick City, for example, 70% of the EDs are in the most deprived decile.

Gini coefficient values for county councils are highly correlated between 2006 and 2011 (R^2=0.92) and again between 2011 and 2016 (R^2=0.96).

Urban-rural divide

It can be anticipated that deprivation may differ between urban and rural areas. Part of this is driven by the fact that rural areas are more sparsely populated, and hence the boundaries for an ED cover a larger geographic area than in an urban area. As a consequence, rural EDs tend to be more heterogeneous in terms of the characteristics of the population and hence more deprived neighbourhoods within an ED may be partly counterbalanced by less deprived neighbourhoods elsewhere in the ED.

By using a multi-dimensional measure of urban-rural status, it is possible to investigate differences in deprivation. The classification groups EDs into city, town, village, and rural, based on a number of ED characteristics.[12] Average indicator values vary quite substantially by area type, particularly for Local Authority Housing and no car ownership

(Table 10). For all four deprvation indicators, the lowest average proportions are found in rural EDs. It can also be seen that the average population is very substantially lower for rural EDs than for city or town EDs.

Table 10. Average indicator values by urban-rural area type

Class	Population	UE	SC	LA	NC
City	3,376	0.084	0.179	0.126	0.278
Town	4,953	0.099	0.202	0.114	0.174
Village	1,438	0.086	0.200	0.097	0.111
Rural	554	0.066	0.176	0.031	0.068
National	1,397	0.073	0.180	0.056	0.110

Abbreviations: UE, unemployment; SC, low social class; LA, Local Authority housing; NC, no car.

When considered in terms of deprivation scores, for all three Census years the lowest average deprivation scores were in rural EDs and the highest scores in city EDs (Table 11). It is interesting to note that the average increase in deprivation score from 2006 to 2011 was highest in town EDs and lowest in city EDs. The greatest improvement in deprivation scores between 2011 and 2016 was in rural EDs, and lowest in city EDs. However, the variation in change across area types was much larger between 2006-2011 than in the 2011-2016 period.

Table 11. Deprivation score urban-rural area type and Census year

Area type	Average deprivation score			Average change in score	
	2006	2011	2016	2006-2011	2011-2016
City	1.31	2.02	1.39	0.71	-0.63
Town	0.66	1.96	1.31	1.30	-0.65
Village	0.21	1.44	0.67	1.24	-0.77
Rural	-0.72	0.27	-0.52	0.99	-0.79
National	-0.25	0.75	0.00	1.00	-0.75

* Based on deprivation calculated relative to 2016 deprivation scores

Considering deprivation scores purely in terms of averages misses the fact that the least deprived EDs also tend to be found in city areas. The widest spread of deprivation scores is found in city EDs, and the narrowest spread in village EDs (Figure 12).

Figure 12. Distribution of deprivation scores by area type
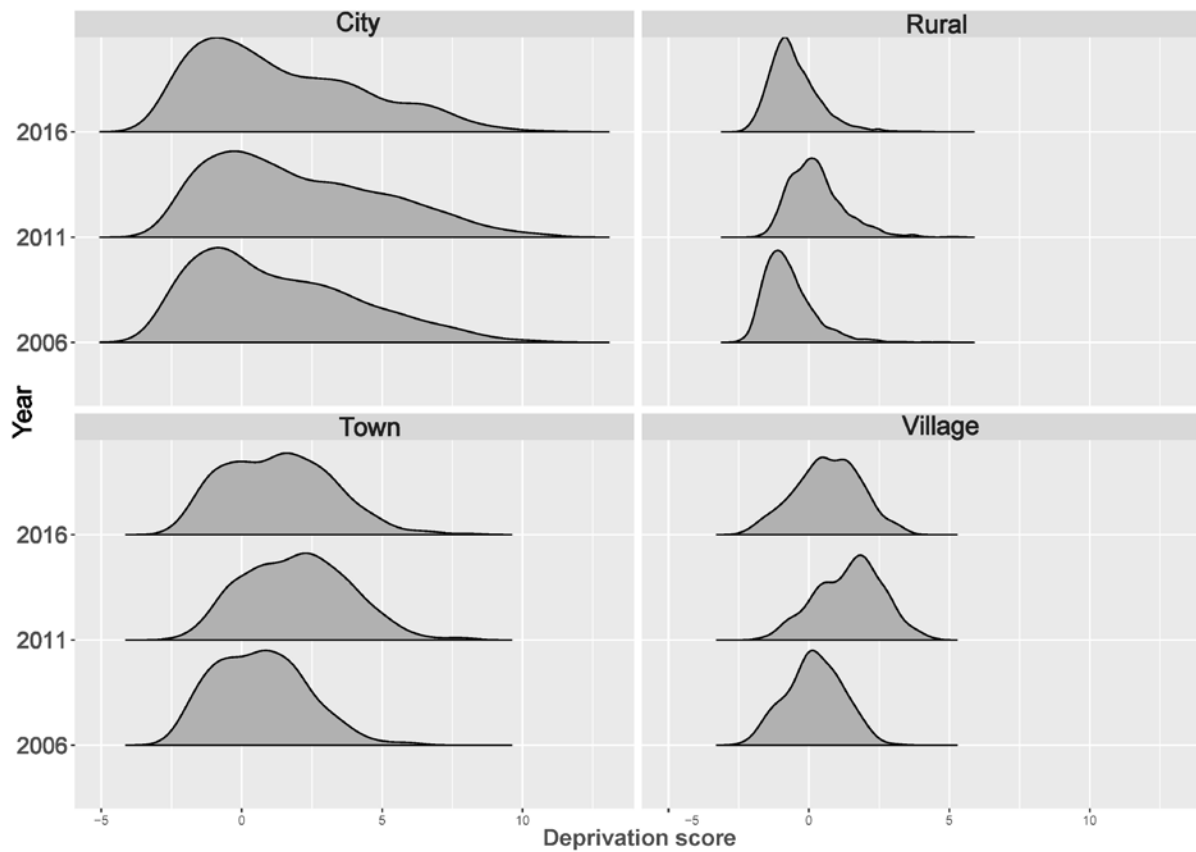
It is also useful to consider deprivation in relation to distance to the nearest urban centre. As shown above and in relation to counties, the highest deprivation scores tend to be found in city centre EDs. Urban areas have higher population density and can have highly deprived neighbourhoods that constitute all or most of an ED.

For city EDs, deprivation scores tend to decrease with increasing distance from the city centre (Figure 13). However, for town, village and rural EDs, deprivation tends to increase with increasing distance from the nearest urban centre (whether measured as the nearest city centre, or as the nearest town or city). This clearly has implications for the most remote village and rural EDs, where high deprivation is combined with isolation and the likelihood of limited access to important amenities and services.

Figure 13. Deprivation score by distance to nearest urban centre
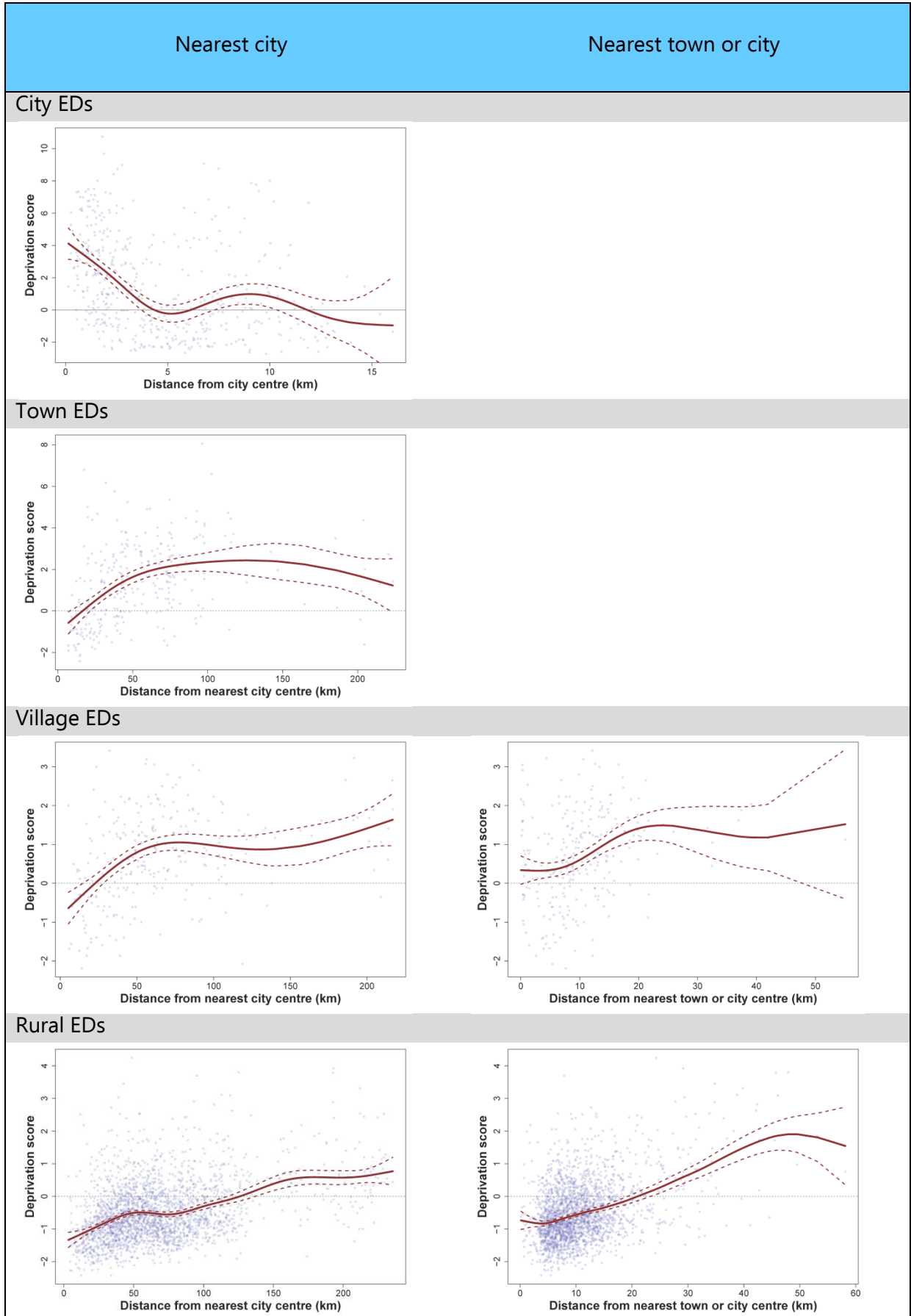
One final consideration regards the clustering of ED with high or low deprivation values. A cluster of EDs with high deprivation should be of concern, as it may represent a large geographic area of concentrated deprivation. A method for examining clustering is through measures of spatial autocorrelation, such as Moran's I. The global Moran's I is similar to the common R squared measure whereby a value of 1 is perfect positive correlation and -1 is perfect negative correlation. The Moran's I values for are 0.513 for 2006, 0.469 for 2011 and 0.473 for 2016. Thus there is positive correlation whereby deprived areas tend to be closer together, and further from less deprived areas.

An extension of the Moran's I is the local index of spatial autocorrelation (LISA). This approach can be used to identify clusters of areas of high or low deprivation. It can also be used to identify areas where EDs with high deprivation values border those with low values. In 2016, there were 258 very deprived EDs that were neighbouring other very deprived EDs (Table 12). The majority of EDs in this category (73%) are in decile 10. The locations of these EDs (very deprived adjacent to very deprived) is predominantly in the cities of Waterford (81%), Limerick (74%), Cork (57%), Dublin City Council (54%) and, to a lesser extent, South Dublin (24%) and Galway (18%).

Table 12. EDs by cluster type and Census year

| Cluster type	Number of EDs by census year		
	2006	2011	2016
Deprived ED beside deprived EDs	278	257	258
Affluent ED beside affluent EDs	441	434	442
Affluent ED beside deprived EDs	28	29	24
Deprived ED beside affluent EDs	61	54	58

Affluent EDs in this context may better be thought of as not 'very deprived' EDs. Clusters of affluent EDs are more common in Dún Laoghaire-Rathdown (62%), followed Cork County (36%), and South Dublin (31%).

Counties with contrasts, affluent EDs next to deprived EDs and vice versa are also of interest. Such heterogeneity may have important social consequences. These types of EDs are most common in Limerick City (11%), Dún Laoghaire-Rathdown (10%), North Tipperary (9%) and

South Dublin (8%). The proximity of such high and low deprivation areas may contribute to poorer social cohesion and ghetto-isation.

By looking at the distribution of deprivation clusters by distance to the nearest urban centre, it can be seen the clusters of high deprivation are closer to city and town centres than clusters of affluent EDs (Figure 14). However, it can also be seen that there are small clusters of deprived EDs at much greater distances.

Figure 14. Local index of spatial autocorrelation clusters by distance to nearest urban centre
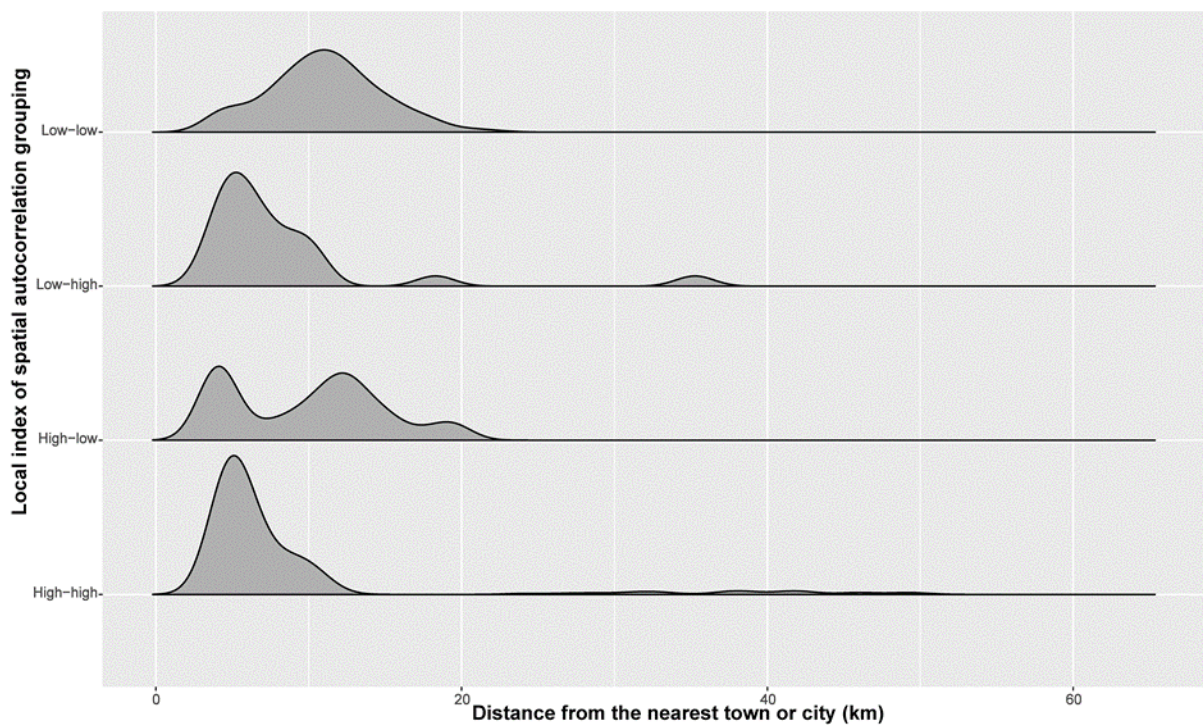
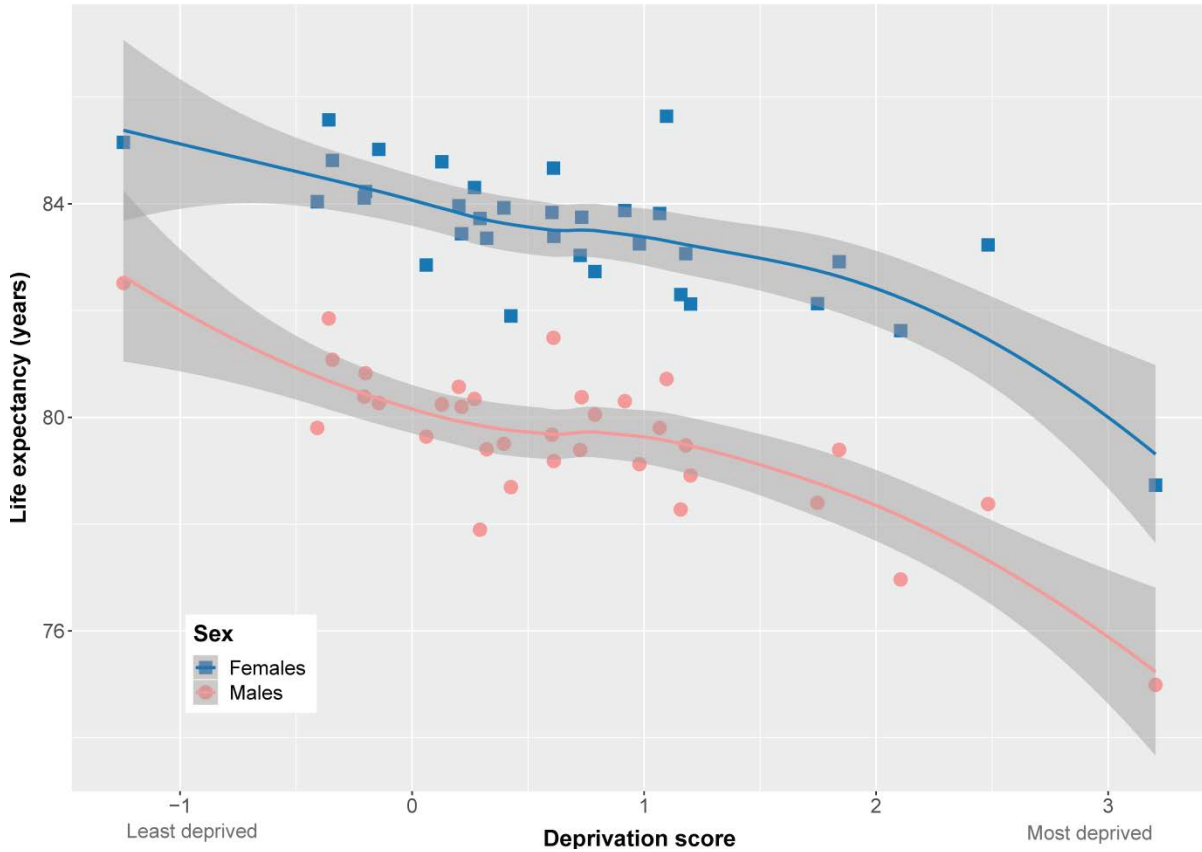### Deprivation and life expectancy

There is a substantial body of literature demonstrating the association between deprivation and a wide range of health outcomes. In Ireland there are limited sources of health outcome data available at a small area level. While alternative aggregations of small areas have been explored for research purposes,[13] data are not routinely published below county-level. When small areas are aggregated into larger areas, such as counties, there is a loss of heterogeneity: with increasing aggregation, areas tend towards the mean. As such, it is more challenging to identify associations.

Despite these limitations, we present an illustrative example of the association between deprivation and life expectancy at a city and county level. Life expectancy was calculated

using the average of three years data (2015 to 2017). The scatter plot is shown with smoothed lines estimated using a loess fit (Figure 15). It is apparent that life expectancy decreases with increasing deprivation.

Figure 15. Deprivation and life expectancy by county, 2016

The difference in life expectancy between the most deprived area (Limerick City) and the least deprived area (Dun Laoghaire-Rathdown) was 6.4 years for women and 7.5 years for men. There is a slight tendency for the gap between males and females to widen with increasing deprivation.

Deprivation and hospitalisation

In light of the association between deprivation and ill-health, it can be anticipated that there may be a correlation between rates of hospitalisation and deprivation. All inpatient and day case episodes in public acute hospitals in Ireland are recorded in the Hospital Inpatient Enquiry system in the HSE. As private hospital care is excluded, an analysis of hospital activity based on public hospital care alone may be misleading in some counties where there is significant capacity in the private system. However, that is likely to be less significant for emergency episodes as in most counties there is little or no capacity for emergency services in the private system.

Based on an analysis of emergency episodes only, there is an association between deprivation and the standardised hospitalisation ratio (SIR) (Figure 16). An SIR greater than 1 refers to a higher rate of hospitalisation than expected based on the age-sex distribution of the county population. Dublin appears to be a potential outlier – it has the lowest SIR value but this may reflect the wider availability of emergency departments at a number of private facilities.

Figure 16. Deprivation and standardised hospitalisation ratio by county, 2016
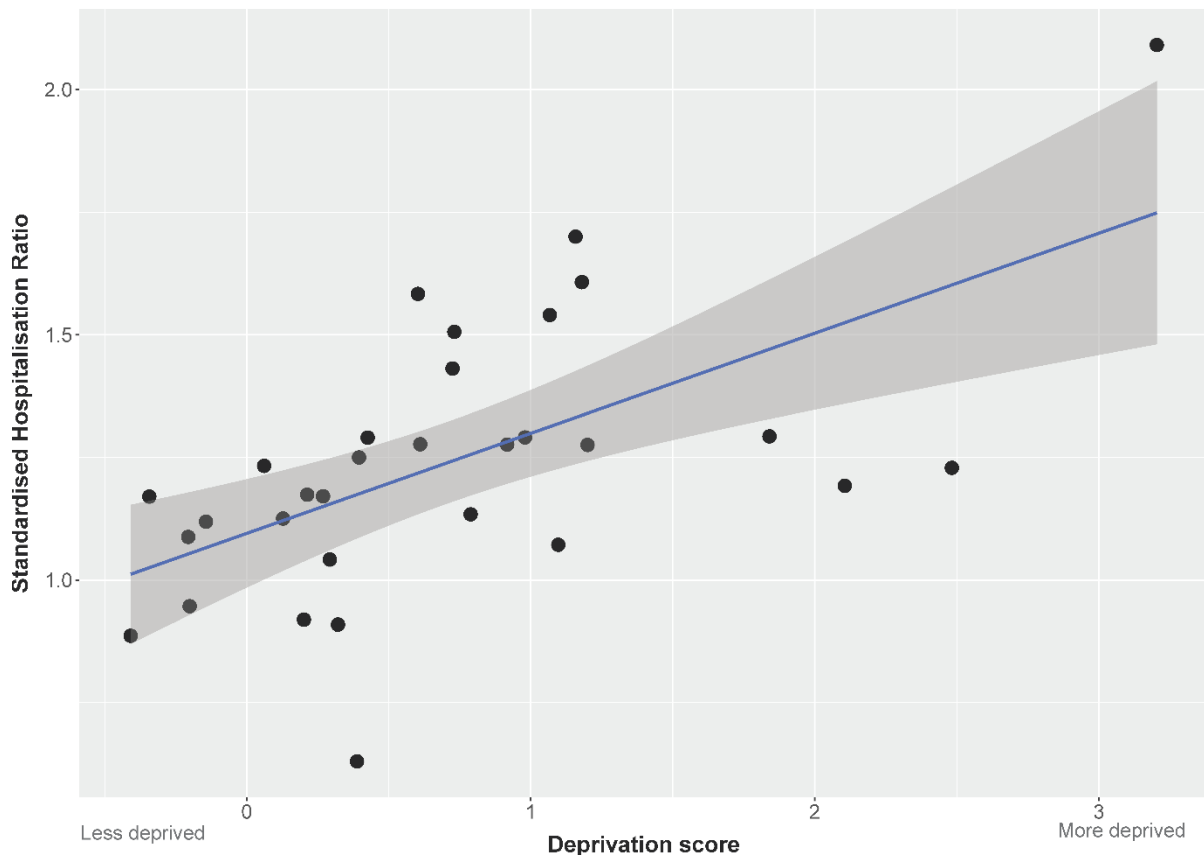
Discussion

This report presents the Trinity National Deprivation Index – an update of the former SAHRU Deprivation Index. The Index is presented for 2006, 2011 and 2016.

The EDs with the highest deprivation scores are in cities or in urban areas within predominantly rural counties. However, there are many rural EDs in deciles 9 and 10. In terms of policy formulation to address deprivation or its effects, it is important to acknowledge deprivation in both urban and rural areas. It is also essential when developing policy responses to deprivation to consider the factors contributing to deprivation locally, and whether a national or Local Authority-level policy will adequately address issues at a local level, where separate initiatives may be necessary to develop resilience against persistent deprivation.

By including data for three consecutive time periods, we were able to look at changes in deprivation over time. The majority of EDs are relatively stable in terms of what decile they are in. However, a small number of EDs have experienced quite large shifts in deprivation. Of most concern are EDs that have worsened repeatedly. Future study could be directed at assessing the impact of persistent and variable deprivation levels in health outcomes.

When using 2016 data as a baseline, we computed scores for 2006 and 2011 that could be directly compared. The average deprivation score increased between 2006 and 2011, but then decreased between 2011 and 2016. However, scores in 2016 are still higher than those for 2006. Some EDs observed an increase in deprivation between 2011 and 2016, despite the national trend for a decrease in deprivation.

Due to indicators included in the index, it should be noted that policy interventions can impact directly on the deprivation score. For example, increasing the local authority housing in an ED will lead to an increased deprivation score for that ED. Other initiatives, such as improved public transport to account for low levels of car ownership, may reduce the impact of deprivation but will not reduce material deprivation.

Using the Trinity Deprivation Index

The index is free for anyone to use and download. This report outlines the construction of the index, but we encourage anyone to get in touch if they have queries about it or would like advice on how to use it.

There are a number of important points to bear in mind when using the deprivation index in your research:

- Do not compare scores over time. The score is computed at a point in time and is relative to conditions at that point. If you wish to have a copy of the 2006 and 2011 scores computed relative to the 2016 baseline, please contact us.

- Do not try to calculate an interpolated score for a year that is between two censuses. It will usually be best to pick the deprivation index from before the year for which you have data on the outcome of interest. Matters are complicated if you have data for many years, although given the relative stability of ranking for most EDs it may be possible to pick a deprivation index from a year close to the mid-point for the data you are analysing.

- It is best to use the data at ED or SA level, but if you must aggregate for larger areas, such as counties, we recommend that you use a population weighted average of the scores.

- Do not try to calculate a mean or population-weighted mean decile for aggregates of EDs. For aggregations of EDs you can determine the proportion population living in EDs of deciles 9 and 10. It is worth noting that ranking counties on the basis of proportion in deciles 9 and 10 correlates better with ranking based on scores than using only decile 10.

- Do use the scores in preference to the deciles for modelling, such as calculating correlations. The score captures the skewed distribution of deprivation values.

- Do not assume that outcomes (such as mortality or morbidity) will be correlated with deprivation. In any modelling exercise where it is planned to include deprivation as a potential confounder – check whether this is an appropriate assumption and consider the plausibility. Sometimes it may be worth including the four constituent variables

rather than the aggregate score. Also consider how deprivation may interact with other confounders included in the analysis.

- Not everyone in a deprived ED is deprived and vice versa. The deprivation score and index are labels attached to areas – it provides information about an area as a whole and not specific individuals within that area.

- EDs can cover geographically large areas encompassing a diverse population. In urban areas, an ED may include neighbourhoods of high and low deprivation. If you are working with data coded to points, consider whether using the SA-level index may be more useful.

- Deciles of deprivation correspond to areas and not people – ten percent of EDs do not typically include ten percent of people.

- The deprivation scale is non-linear: individuals in decile 10 are not twice as deprived as individuals in decile 5.

- Two EDs with a very similar deprivation score may have very different indicator values. For example, one ED may achieve its given deprivation score predominantly due to high unemployment while another could achieve the same score predominantly through a high proportion of Local Authority housing.

- If your data are on individuals coded to EDs such that multiple individuals could be in the same ED, consider using hierarchical modelling or similar approach to account for the clustering of individuals.

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Appendix: Fifty most deprived EDs in the country in 2016

Note: all of these EDs are in decile 10, and were also decile 10 in 2011.

ED ID	ED Name	COUNTY	Population	Deprivation score
E20024	John's A	Limerick City	759	10.76
E20020	Galvone B	Limerick City	664	9.70
E02018	Ballymun D	Dublin City	2,458	9.07
E17039	Knocknaheeny	Cork City	4,044	8.99
E02016	Ballymun B	Dublin City	4,379	8.76
E20007	Ballynanty	Limerick City	2,891	8.74
E17046	Mayfield	Cork City	2,932	8.42
E09001	Longford No. 1 Urban	Longford	3,592	8.06
E24022	Larchville	Waterford City	944	8.02
E03033	Tallaght-Killinardan	South Dublin	3,958	8.00
E02081	Priorswood B	Dublin City	2,728	7.87
E03005	Clondalkin-Cappaghmore	South Dublin	2,581	7.78
E24013	Custom House B	Waterford City	269	7.51
E24034	Shortcourse	Waterford City	301	7.48
E02082	Priorswood C	Dublin City	4,854	7.39
E20023	Glentworth C	Limerick City	502	7.34
E02161	Wood Quay A	Dublin City	2,606	7.32
E20013	Custom House	Limerick City	736	7.30
E20027	Killeely A	Limerick City	1,467	7.29
E24001	Ballybeg North	Waterford City	2,757	7.23
E02119	Merchants Quay A	Dublin City	2,513	7.14
E17061	The Glen A	Cork City	2,466	7.12
E20003	Abbey C	Limerick City	602	7.00
E02145	Royal Exchange B	Dublin City	2,082	6.99
E02017	Ballymun C	Dublin City	6,112	6.85
E17036	Gurranebraher C	Cork City	1,053	6.85
E15006	Rathmichael (Bray)	Wicklow	2,415	6.80
E02009	Ballybough A	Dublin City	3,718	6.78
E20031	Prospect B	Limerick City	715	6.77
E24029	Newport's Square	Waterford City	543	6.76
E03030	Tallaght-Fettercairn	South Dublin	8,380	6.72
E20032	Rathbane	Limerick City	1,593	6.71
E04015	Blanchardstown-Tyrrelstown	Fingal	3,257	6.65
E32001	Cavan Urban	Cavan	3,770	6.60
E02073	Mountjoy A	Dublin City	5,389	6.47
E24036	The Glen	Waterford City	742	6.45

Trinity National Deprivation Index 2016

ED ID	ED Name	COUNTY	Population	Deprivation score
E24027	Morrisson's Road	Waterford City	490	6.41
E20025	John's B	Limerick City	952	6.40
E02071	Kilmore C	Dublin City	1,490	6.36
E02056	Finglas South C	Dublin City	2,645	6.33
E24028	Mount Sion	Waterford City	849	6.31
E02074	Mountjoy B	Dublin City	3,963	6.30
E20030	Prospect A	Limerick City	826	6.25
E17025	Farranferris B	Cork City	928	6.20
E24033	Roanmore	Waterford City	812	6.18
E24023	Lisduggan	Waterford City	993	6.18
E16002	Ennis No. 2 Urban	Clare	1,810	6.17
E20014	Dock A	Limerick City	2,339	6.16
E20028	Killeely B	Limerick City	821	6.08
E20035	Shannon B	Limerick City	925	6.05