

# UK indices of multiple deprivation – a way to make comparisons across constituent countries easier

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## Abstract

### Background

Deprivation is multi-dimensional, and as such can be challenging to quantify. In the UK, each of the four constituent countries measures deprivation using their own distinct index of multiple deprivation (IMD), designed to facilitate targeting of policies within that particular country. Although these four IMD scores are not directly comparable, there are circumstances where comparison across the whole of the UK may be desirable.

### Methods

A method of generating a UK-wide IMD score was developed using publically available data. An adjusted IMD score was generated using the employment and income domains of the individual country IMD scores, along with the coefficients and residual values from a linear regression of employment and income on the overall IMD score.

### Results

The Scottish IMD was used as a baseline to generate an adjusted UK-wide score. The proportion of variance explained for the Scotland model was 0.972. The rank correlation coefficient (Kendall's tau) for the association between adjusted and original IMD was 0.97, 0.98 and 0.94 for England, Northern Ireland and Wales respectively. The absolute change in Welsh and English IMD scores

was relatively small, although there was a considerable change in ranking in Wales. In contrast, the adjusted IMD score was considerably higher than the actual IMD score for Northern Ireland, but with minimal impact on the ranking within Northern Ireland. Overall, 4.9 per cent (1606), 2.6 per cent (23) and 10.3 per cent (196) of areas were reclassified into different quintiles using the adjusted score for England, Northern Ireland and Wales respectively.

## **Conclusions**

An adjusted IMD score generated using this method might be used for UK-wide policy decisions, and allow tools developed for one country to be applied elsewhere.

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## Introduction/ Background

Deprivation is considered to be a multi-dimensional problem, encompassing a range of domains such as financial, health, education, services or crime (Townsend, 1987; Whitehead and Dahlgren, 1991; Venkatapuram and Marmot, 2009). The four constituent nations of the UK have each developed their own index of multiple deprivation (IMD). These have been developed to identify small area concentrations of deprivation, and are based on methodology developed at the University of Oxford Social Disadvantage Research Centre (Noble *et al.*, 2006). However, although the underlying methods for the four countries is similar, they are nonetheless distinct and designed to facilitate the targeting of policies and resources within disadvantaged communities in that particular constituent nation.

As such, the domains used to construct the four IMD scores vary between country, as do the weightings of these domains and the various indicators used to construct a particular domain. However, there are two domains – income and employment – which are common to all four national IMDs. These are both major drivers of deprivation, and contribute around half the weight of each IMD. Furthermore, they use similar indicators, and the untransformed scores of these domains are a simple percentage of individuals receiving one or more income or employment benefits (Box 1), and therefore relatively comparable across countries (Office for National Statistics, 2010). The source and year of the data used to construct the indicators may differ more in other domains (Box 2) (Department of Communities and Local Government, 2011a; Northern Ireland Statistics and Research Agency, 2010a; OCS, Scottish Government, 2010; Welsh Assembly Government, 2009a). For instance, the Living Environment domain has a weight of 9.3 per cent within the English 2010 IMD. This is calculated from measures of housing in poor condition, absence of central heating, air quality and road traffic accidents. The same domain only has a weight of 5 per cent within the Northern Irish 2010 IMD (correctly referred to as Multiple Deprivation Measure, MDM). It is calculated from four different indicators – decent home standard, housing health and safety rating system, homelessness acceptances, and a local area problem score.

<b>Box 1 Components of IMD income and employment domains</b>				
	England 2010	Northern Ireland 2010	Scotland 2009	Wales 2008
<b>Income</b>				
Income Support	✓	✓	✓	✓
Pension Credit	✓	✓	✓	✓
Jobseeker's Allowance	✓	✓	✓	✓
Tax Credits	✓	✓	✓	✓
Housing Benefit		✓		
Asylum seekers support	✓			✓
Income-based ESA*		✓		
<i>Weighting of domain</i>	22.5%	25%	28%	23.5%
<b>Employment</b>				
Unemployment-related benefits	✓	✓	✓	✓
ESA*	✓	✓		
Incapacity Benefit	✓	✓	✓	✓
Severe Disablement Allowance	✓	✓	✓	✓
Carer's Allowance		✓		
New Deal participants	✓	✓	✓	✓
<i>Weighting of domain</i>	22.5%	25%	28%	23.5%

Comparison of different components comprising income and employment domains across different UK countries. \*A major change in the benefits system involved the introduction of Employment and Support Allowance (ESA) in October 2008, replacing incapacity benefit and income support. Differences exist in the precise definitions used between countries, and readers are referred to the respective official technical reports for details (see references).

<b>Box 2 Number of indicators within IMD domains and relative weightings of domains</b>									
	England 2010		Northern Ireland 2010		Scotland 2009		Wales 2008		
	N <sup>1</sup>	Weight	N <sup>1</sup>	Weight	N <sup>1</sup>	Weight	N <sup>1</sup>	Weight	
Income	5	22.5%	6	25%	4	28%	5	23.5%	
Employment	5	22.5%	6	25%	4	28%	4	23.5%	
Health	4	13.5%	7	15%	7	14%	4	14%	
Education & training	7	13.5%	10	15%	5	14%	7	14%	
Access/barriers to services	7	9.3%	12	10%	8	9%	9	10%	
Living environment/ housing	4	9.3%	4	5%	2	2%	2	5%	
Physical environment	0	0%	0	0%	0	0%	4	5%	
Crime	4	9.3%	6	5%	5	5%	4	5%	

1. N is the number of indicators within domain. Readers are referred to the respective official technical reports for details of specific indicators (see references).

Because of these methodological differences, the four IMD scores are not directly comparable, despite being of a similar order of magnitude. However, there are circumstances when there may be a desire to apply a policy at a UK level, using a consistent definition of deprivation. Alternative measures such as the Townsend Index (Townsend *et al.*, 1988) or Carstairs Index (Carstairs and Morris, 1991) exist. These have the advantage of being able to be standardised across any geographical area. They are based, however, on infrequently updated UK Census data, and capture a different and narrower range of factors to that used by IMD scores. An example from health services is the use of deprivation scores in the estimation of cardiovascular risk, designed to address the inequalities in cardiovascular risk factor management across the socioeconomic spectrum. The Scottish ASSIGN score (ASSessing cardiovascular risk, using SIGN (Scottish Intercollegiate Guidelines Network) guidelines to **assign** potential patients to preventive treatment) is a tool developed for the clinical environment to enable cardiovascular risk stratification of patients. It is based upon sex-specific Cox proportional hazards models which incorporate the established risk factors of patient age, cholesterol, systolic blood pressure, smoking status, diabetes and family history of premature cardiovascular disease, in addition to deprivation. ASSIGN uses the Scottish IMD (SIMD), but as such it is difficult to apply this score to patients in other UK countries (Woodward *et al.*, 2007).

This paper describes the creation of a modified UK-wide IMD score. It is based on the Scottish IMD score and income/employment domains from each of the four countries, and was developed specifically to allow the ASSIGN score to be implemented across the UK using a web-based calculator. However, the methodology could equally be applied to create UK-wide scores based on the IMD score of a country other than Scotland.

## Methods

For each of the four UK countries, we obtained IMD scores for the lower layer super output area or equivalent. These geographical areas share similar populations of around 1500 persons, although the equivalent Scottish data zones are slightly smaller (500 to 1000 persons). We also obtained the raw income and employment domain scores (expressed as percentages) for each country. There are 32,482 lower layer super output areas for England and 1,896 for Wales; 6,505 data zones for Scotland; and 890 super output areas for Northern Ireland. The year of publication of each dataset is given in Box 1. Data is available from freely accessible online sources (Department of Communities and Local Government, 2011b; Northern Ireland Statistics and Research Agency, 2010b; Scottish Government, 2010; Welsh Assembly Government, 2009b). Statistical analysis was performed using PASW Statistics 18 (SPSS).

A linear regression model was computed for each country, with IMD as the dependent variable and income and employment as independent variables. Residuals were obtained using these models; the standardised residuals were considered equivalent between the constituent nations. By definition, the residual values will have a mean of zero for each country. The residuals essentially represent the unique contribution of 'other deprivation' to the overall IMD; in other words, that not explained by the income and employment domains. This is not the same as a weighted sum of the domain scores for these other domains, which will be correlated with the income and employment domain scores, and will have a non-zero mean. Using the regression equation for a specific

country, we can estimate IMD for another country based upon its income and employment score, and its corresponding residual value. This approach is demonstrated in Box 3.

We examined the effect of adding non-linear income and employment terms to the regression models. Although some of these coefficients were statistically significant, the magnitude of the effect size was very small in comparison to the linear term, and had minimal effect on the proportion of variance explained. We felt the benefits of having a simpler method outweighed the small improvement obtained from a more complex model.

Within-country deprivation quintile was calculated for both original and adjusted IMD (where quintile 1 is least deprived, and quintile 5 is most deprived) to examine what proportion of areas were reclassified using the adjusted IMD score.

### Box 3 Calculation of adjusted IMD

Using a linear regression model, original IMD for a specific country,  $C$ , and area,  $i$ , ( $IMD_{Ci}$ ) can be expressed as:

$$IMD_{Ci} = \beta_{C0} + \beta_{C1}I_i + \beta_{C2}E_i + \varepsilon_{Ci}$$

where  $I_i$  is rate of income benefits,  $E_i$  is rate of employment benefits,  $\beta_{C0}$ ,  $\beta_{C1}$  and  $\beta_{C2}$  are the model coefficients, and  $\varepsilon_{Ci}$  is the residual value. We then assume that any area  $i$  placed within the residual distribution of another country, would have the same standardised position that it would have in its own country, if the same regression approach was used for both countries. For example, the relationship between the residual for an area,  $i$ , on the Welsh scale ( $\varepsilon_{Wi}$ ) and the assumed residual for the same area,  $i$ , on the Scottish scale ( $\varepsilon_{Si}$ ) is given by:

$$\frac{\varepsilon_{Wi}}{\sigma_W} = \frac{\varepsilon_{Si}}{\sigma_S}$$

where  $\sigma_W$  and  $\sigma_S$  are the estimated standard deviations of the residuals for Scotland and Wales respectively. Therefore, using the regression equation for a particular country (in our case, Scotland), we can estimate IMD for other countries from their income and employment scores, and the corresponding residual values:

$$IMD_{ADJUSTEDi} = \beta_{S0} + \beta_{S1}I_i + \beta_{S2}E_i + \frac{\varepsilon_{Ci}\sigma_S}{\sigma_C}$$

For example, for English lower level super output area E01006287 (Wigan district), which has an income benefit rate of 4 per cent and employment benefit rate of 7 per cent, adjusted IMD (based on Scottish IMD) is calculated as follows (coefficients can be found in Table 1):

$$IMD_{ADJUSTEDi} = -1.491 + 0.831 \times 4 + 0.865 \times 7 + \frac{0.807 \times 2.779}{3.585}$$

where 0.807 is the residual value,  $\varepsilon_{Ci}$ . This gives an adjusted IMD score of 8.51, which compares with the original IMD score of 10.52.

## Results

The coefficients of the regression equations vary noticeably between countries (Table 1). Of note, the proportion of variance explained ( $R^2$ ) for the Scotland model was 0.972, suggesting that additional factors accounted for only 2.8 per cent of the variance in Scottish IMD beyond that explained by income and employment alone (Table 1).

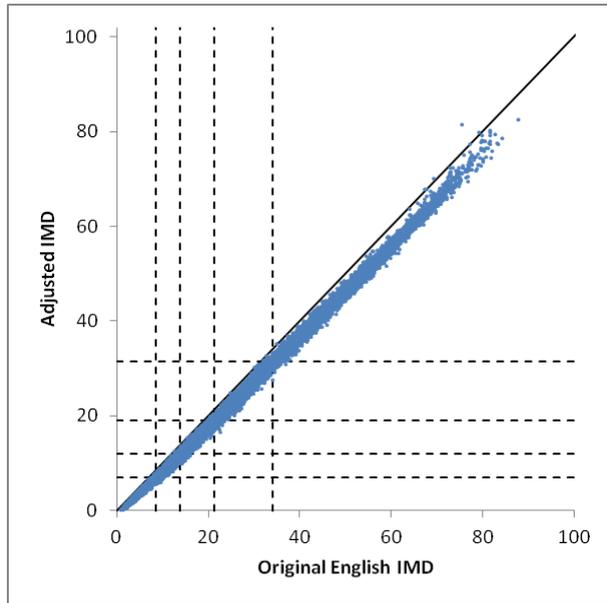
**Table 1 Relationship between IMD and income/employment**

	$\beta_{C0}$ (constant)	$\beta_{C1}$ (income)	$\beta_{C2}$ (employment)	$R^2$	$\sigma$
England	-0.190	0.849	0.930	0.947	3.585
Northern Ireland	-6.601	0.720	0.761	0.968	2.855
Scotland	-1.491	0.831	0.865	0.972	2.779
Wales	-5.252	1.282	0.662	0.924	3.973

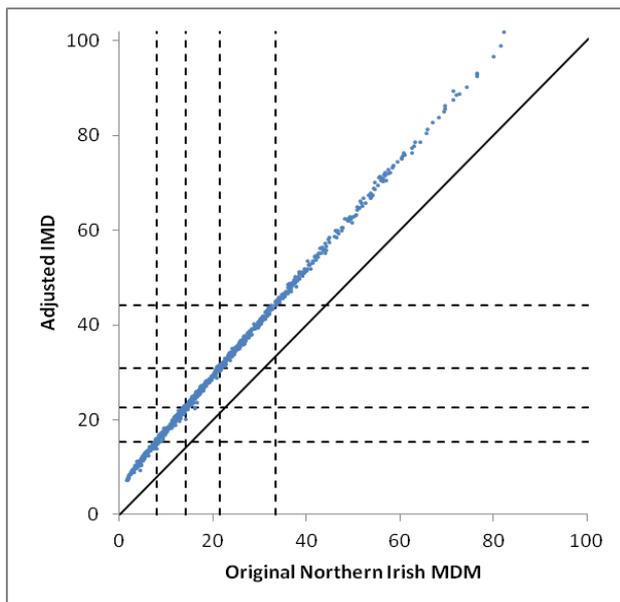
$\beta_{C0}$ ,  $\beta_{C1}$ ,  $\beta_{C2}$ , coefficients of regression equation;  $R^2$ , coefficient of determination;  $\sigma$ , estimated standard deviation of the residuals (that is based on N-3 degrees of freedom)

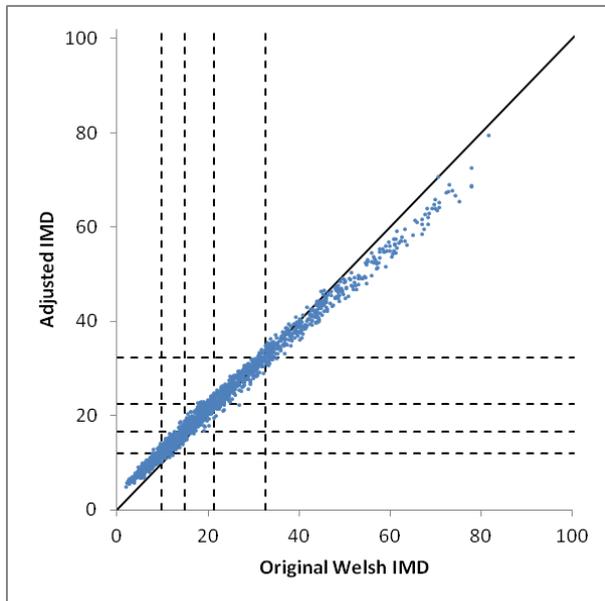
The relationship between the adjusted IMD, based on the Scottish regression coefficients, and the original IMD, for England, Northern Ireland and Wales, are shown in Figure 1.

**Figure 1a Adjusted IMD and original IMD for England**



**Figure 1b Adjusted IMD and original IMD for Northern Ireland**



**Figure 1c** Adjusted IMD and original IMD for Wales

Diagonal reference line is line of identity. Vertical reference lines indicate original IMD quintiles; horizontal lines indicated adjusted IMD quintiles. IMD, index of multiple deprivation. MDM, multiple deprivation measure.

Overall, the adjustment makes little difference to English IMD, with a tendency for the adjusted score to be slightly lower. For Wales, the adjustment results in a slightly higher IMD score for less deprived areas, and lower score for more deprived areas. For Northern Ireland, the adjusted score is considerably greater than the original MDM. Kendall's  $\tau$  for the association between adjusted and original IMD is 0.97, 0.98 and 0.94 for England, Northern Ireland and Wales respectively.

The reclassification of deprivation quintiles based on the new adjusted IMD score is shown in Table 2. The least change occurred for Northern Ireland, while the greatest change in ranking occurred for Wales. Overall, 4.9 per cent (1606), 2.6 per cent (23) and 10.3 per cent (196) of areas were reclassified into a different quintile using the adjusted score for England, Northern Ireland and Wales respectively.

**Table 2 Comparison of ranking of original and adjusted IMD**

		Adjusted IMD quintile					Percentage
		1	2	3	4	5	
Original IMD quintile							
England	1	96.7	3.3	0	0	0	
	2	3.3	92.5	4.2	0	0	
	3	0	4.1	92.7	3.1	0	
	4	0	0	3.1	95.1	1.7	
	5	0	0	0	1.8	98.2	
Northern Ireland	1	98.3	1.7	0	0	0	
	2	1.7	96.0	2.3	0	0	
	3	0	2.8	95.5	1.7	0	
	4	0	0	1.7	97.8	0.6	
	5	0	0	0	0.6	99.4	
Wales	1	91.3	8.7	0	0	0	
	2	8.7	84.7	6.6	0	0	
	3	0	6.6	86.1	7.4	0	
	4	0	0	7.4	89.4	3.2	
	5	0	0	0	3.2	96.8	

Table shows how percentage of areas within original IMD quintiles are distributed in new adjusted IMD quintiles. Rows may not total 100 per cent due to rounding. Quintile 1 is least deprived.

## Discussion

We have described a straightforward method of adjusting national IMD scores to improve the comparability between countries. When using the Scottish IMD as a baseline, this resulted in a sizeable change in the absolute IMD score for Northern Ireland, but minimal impact on the ranking within Northern Ireland. In contrast, the absolute change in Welsh and English IMD scores was relatively small, although there was a considerable change in ranking in Wales.

Individual countries' IMDs are, as has already been mentioned, constructed specifically to address the peculiarities and policy requirements of that particular nation. However, there may be circumstances where generalising a policy from a single constituent country is desirable. In the case of ASSIGN, the cardiovascular risk model was derived using Scottish data. Thus, the use of an actual English deprivation score (rather than the adjusted English score) may result in an overestimation of deprivation and a consequent higher estimate of cardiovascular risk. This may in turn lead to differences in risk factor management between countries, such as a tendency toward increased prescribing of preventative medicines in England compared with Scotland. Using an

approach such as the one described above to obtain adjusted IMD scores, reduces the impact of these issues.

When considering the validity of adjusting IMDs as we have done here there are two aspects of the construction of individual countries' IMDs which must be considered. Firstly, the individual countries' IMDs are based on different selections of domains and indicators and secondly, the weighting of these domains and indicators vary between the countries. It is this multi-dimensionality which underpins the entire concept of multiple deprivation.

Our adjusted score is principally based on income and employment. Nonetheless, these two domains are major drivers of deprivation, especially in the Scottish IMD score. Moreover, removing domains from the IMD score has been shown to have minimal effect on the overall deprivation ranking (Adams and White, 2006). We do still capture other facets of deprivation, defined by the set of domains and indicators specific to each country, but the validity of their influence depends on the implicit assumption that the measures of deprivation above and beyond the income and employment domains are somehow equivalent, or at least correlated, between the different countries (Box 2). Given the association between Scottish IMD and income and employment is very strong, calculating adjusted IMD using Scotland as the baseline is quite robust to this assumption; that is, the influence of the non income or employment component is small. However, doing so for Wales, where the association is weaker and the non income or employment factors have a larger influence, may be less good. We must also bear in mind that there are some differences in the indices used to construct the income and employment domains across countries, as detailed in Box 1, although the major benefits are consistent. It is worth noting that, if the adjusted IMD is based solely on the income and employment domains alone, and the residual values are excluded from the calculation, this results in a notably weaker correlation with original IMD (Kendall's  $\tau$  0.83, 0.88 and 0.82 for England, Northern Ireland and Wales respectively).

The change in ranking within countries is relatively small with our method; in particular, the change in the ranking of the most deprived quintile is minimal, although this is partly due to the greater spread of high deprivation scores compared to the more clustered nature of less deprived scores. This gives us confidence in the value of using the adjusted scores not only within countries, but also within the UK as a whole. Unfortunately, we are unable to further evaluate the accuracy of the adjusted scores across countries, as there is no UK-wide deprivation 'gold standard' against which to compare the adjusted scores. Using an alternative index such as Townsend or Carstairs is not necessarily appropriate, as these scores measure different aspects of deprivation to IMD. Thus, the differences between countries for Townsend, for instance, may not be consistent with the differences observed using IMD.

Are there alternative approaches that might be considered? An Office for National Statistics report from 2010 discussed why a single UK measure is considered inappropriate and the reasons why the separate national indices cannot be combined (Office for National Statistics, 2010). It highlighted the differences in domains, indicators, weighting and year of publication, in addition to geographical inconsistencies (Scotland's smaller datazones are more likely to have extreme pockets of deprivation). Three alternatives were proposed for dealing with situations where UK-wide policy was being considered: firstly, allocation of funds by country, then by inequality; secondly, allocation of funds using comparable regions within the different countries; and thirdly, by using a comparison of income or employment domains. Our method has the potential advantage of

taking into account two relatively comparable domains, with greater weight, in addition to accounting for other factors through the use of the regression residuals. An alternative approach might be to simply dispense with IMD, and use a score such as Townsend, which can be computed at a UK level. A further option is to include the Townsend score as a covariate in our own method, in addition to income and employment. The advantage would be the inclusion of an additional standardised and widely used measure of material deprivation which may explain further variance beyond the income/employment domains used. However, this has the disadvantage of requiring two separate datasets.

## **Conclusion**

In summary, we have shown how use of the individual employment and income domains of the IMD score may facilitate comparison of IMD across the constituent countries of the UK. This approach differs to, and may have advantages over, hitherto described methods, although important limitations remain. However, this approach may enable IMD to be used pragmatically for UK-wide policy decisions, and allow tools developed for one country to be applied elsewhere.

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