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Drivers of Wellbeing Inequality

Inequality in Life Satisfaction across Local Authorities in Great Britain

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ABSTRACT

The literature on the drivers of wellbeing inequality is growing, however, analysis so far has focussed almost exclusively on wellbeing inequality at a national level. This is the first paper to explore what drives wellbeing inequality at the local authority level in Great Britain.

This analysis uses inequality in life satisfaction as the main dependent variable. This measure is univariate, measuring overall inequalities in life satisfaction within a local authority, independent of any other variable such as ethnicity or income. It is calculated using four years of Annual Population Survey data for over 200 local authorities. Using multilevel modelling, we find that higher deprivation, unemployment, and rurality are associated with higher inequality in life satisfaction, whereas higher median income, female life expectancy, engagement in heritage activities and use of green space are associated with lower inequality in life satisfaction.

INTRODUCTION

Wellbeing inequality was included in the World Happiness Report for the first time in 2016[1] and the literature on the drivers of wellbeing inequality is growing. However, analysis so far has focussed almost exclusively on wellbeing inequality at a national level, partly due to the lack of datasets large enough to look below the national level.[2]

Engagement with local community stakeholders through the Community Evidence Programme of the What Works Centre for Wellbeing, as well as previous dialogues as part of the ESRC project 'Making Wellbeing Count'[3] revealed an appetite for a better understanding of wellbeing inequalities locally, and what can be done at local level to reduce them.

This exploratory analysis of the drivers of wellbeing inequality in local authorities in Great Britain begins to address this local area knowledge gap.

WHY DOES WELLBEING INEQUALITY MATTER?

Inequality is widely seen as one of the defining challenges of the twenty-first century. Inequalities in people's objective circumstances - particularly economic, but also in other areas such as health and education outcomes – have been widely studied.[4] As important as these analyses are, they fail to describe inequalities in peoples' actual experience of their lives. If measures of inequality are partly intended to help us gain a deeper understanding of society, then this is an important omission.

While there may be different views about the relative importance of increasing mean wellbeing versus reducing wellbeing inequality, many people agree that improving the wellbeing of those at the bottom of the scale is of more value than improving the wellbeing of those who are already living happy and fulfilling lives. By looking only at average wellbeing scores, we fail to acknowledge and so to address experienced inequality.

Work being undertaken by the Community Evidence Programme of the What Works Centre for Wellbeing has identified a need to complement existing literature on individual wellbeing, typically atomised and individualised, with the notion of 'community wellbeing.'[5] Knowing how personal wellbeing is distributed socially and geographically can help us explore this idea, and shed light on issues of inclusivity and social justice that may form part of community wellbeing.

Exploring the distribution of wellbeing across a population provides a richer and more valuable picture of how society is faring than averages alone. Figures 1 and 2 describe life satisfaction distributions in Lambeth and Sunderland. Both local authorities have similar mean scores, but while Lambeth is ranked amongst the ten most equal local authorities in Great Britain according to its standard deviation of life satisfaction (1.55), Sunderland is ranked amongst the ten most unequal (2.04) – a statistically significant difference.[6] By looking at the whole distribution, we can see that in Sunderland a sizeable minority of people report very low life satisfaction, lagging well behind the rest of the population.

Figure 1 Distribution of life satisfaction scores in Lambeth, 2014-15

Figure 2 Distribution of life satisfaction scores in Sunderland, 2014-15

EXISTING LITERATURE ON THE DRIVERS OF WELLBEING INEQUALITY

The existing literature on wellbeing inequality has focussed on national-level inequalities. This literature is largely cross-sectional and cross-country with no review-level evidence. Studies have found the following:

- Higher economic growth (GDP) seems to be associated with lower wellbeing inequality, at least in rich countries.[7-8]
- Unemployment is associated with higher wellbeing inequality, over and above the effects of GDP.[9]
- 'Better' governance is associated with lower wellbeing inequality, at least in rich countries. Governance indicators measuring the quality of regulation, voice and accountability, government effectiveness, control of corruption and political freedom are associated with lower wellbeing inequality. These associations do not hold in poorer countries. [10-12]
- In rich countries, higher levels of government consumption, transfers and subsidies seem to be associated with lower wellbeing inequality. These associations do not hold in poorer countries. [13-15]
- The evidence is inconclusive on the association between income inequality and wellbeing inequality.[16-22]
- There are mixed results on the role of economic freedom in relation to wellbeing inequalities. The findings vary according to the indices of economic freedom used, the inclusion of rich or poor countries, and the wellbeing measures used. [23-24]

THE FOCUS OF THIS STUDY

Earlier this year, the New Economics Foundation, as part of the Community Wellbeing evidence programme of the What Works Centre for Wellbeing published the *Wellbeing Inequality in Britain*.[25] The report included wellbeing inequality scores for over 200 local authorities[i] in Great Britain using four years of data from the Annual Population Survey.[26] It was the first calculation of wellbeing inequality at the local authority level in Great Britain.

This study builds on *Wellbeing Inequality in Britain* to analyse the drivers of one element of wellbeing inequality – inequality in life satisfaction. We chose just one measure of wellbeing for ease of communication and interpretation. Our research question is:

- What is associated with inequality in life satisfaction in local authorities in Great Britain?

This is the first study to address this research question, and is therefore exploratory. We hope that it lays the ground for local actors to begin further exploration of wellbeing inequalities in their area, as well as producing insights worthy of further research.

METHODOLOGY

Our analysis uses the data produced as part of the *Wellbeing Inequality in Britain* report that includes measures of wellbeing inequality for local authorities across Great Britain over four

[i] A full list of local authorities is included in the appendix of Abdallah, S., Wheatley, H. & Quick, A. (2017) Wellbeing Inequality in Britain

years, 2011-2015. Where possible, each independent variable was also measured at each time point over the four years.

To account for the covariance between the four data points for each local authority, we used a first-order auto-regressive repeated measures model.[ii] Repeated measures models are a subcategory of multi-level models.

The methodology and variables were chosen *a priori*, blind to the results and peer reviewed by academic advisers to the What Works Centre for Wellbeing. A series of robustness checks were carried out to test the methodology used. The results of these robustness tests as well as the subsequent adjustments to the methodology are given in Appendix II.

DEPENDENT VARIABLES

Our dependent variables were:

- Standard deviation (SD) of life satisfaction scores within local authorities (primary dependent variable)
- Average of the bottom 40% of life satisfaction scores within local authorities (secondary dependent variable)
- Average life satisfaction scores within local authorities (for comparison)

Standard deviation is a measure of the average distance of individual observations from the sample mean. It was chosen as it is the most commonly used measure of wellbeing inequality in existing literature. However, the question of which measure of wellbeing inequality is most appropriate has been woefully under-explored. Whereas for income, some would argue that we should take money from the richest in order to reduce economic inequality, the same is not argued for wellbeing: no-one wants those who are living fulfilling lives to become less happy in order to reduce wellbeing inequality. This throws into question whether standard deviation – as a measure of variance – is measuring what really matters when it comes to wellbeing. Technical questions also remain about how susceptible measures are to various biases.

Research is currently being undertaken on wellbeing inequality measurement by the New Economics Foundation, the What Works Centre for Wellbeing and the Office for National Statistics. In light of this uncertainty, *Wellbeing Inequality in Britain* reported standard deviation as the primary measure of wellbeing inequality, but also published seven different indicators for each local authority to support researchers to undertake further exploration of how the different measures perform.

We did test alternative measures of wellbeing inequality in this study, the results of which are discussed in *Box 1: Alternative measures of wellbeing inequality.*[iii] In order to give particular

[ii] A repeated measures model acknowledges and controls for the covariance between data points for any given local authority and thus helps avoid false positives. For example, a local authority that has consistently high unemployment and consistently high inequality four years running should not add as much statistical power as if there were four separate local authorities that had high unemployment and high inequality. We used a first order auto-regressive repeated measures model, which specifically recognises that there is a pattern in the covariance between the four data points for a local authority and that the figure for 2011 is likely to correlate more with that for 2012 than it does for 2013 or 2014.

[iii] To avoid data dredging, however, these measures were stated a priori.

weight to wellbeing at the bottom of the distribution this study included the average of the bottom 40% as a secondary dependent variable.[iv]

The only development from the figures reported in *Wellbeing Inequality in Britain* was to estimate values for 2011-12 for the metropolitan and London boroughs. The methodology used is explained in Appendix III.

The single measure of life satisfaction was used as the measure for wellbeing for ease of interpretation and communication.

CONTROL VARIABLES

The following variables were used as controls:

- % of the population self-identifying as Asian
- % of the population self-identifying as Black
- % of the population living in a rural context (available for local authorities in England only)
- Index of Multiple Deprivation score (available for local authorities in England only)
- Log of the local authority population
- Mean life satisfaction
- Year dummies

Control variables were chosen where there were reasons to believe that they might be associated with life satisfaction or inequality in life satisfaction as well our independent variables of interest. Ethnic composition, rurality, and log of the population are descriptive of the demography of a locality, and it is unlikely that policy or action (at least at local level) would aim to alter these.

By including the Index of Multiple Deprivation (IMD) in the base set of control variables, we were able to identify variables that are associated with inequality in life satisfaction above and beyond what would be expected for a given level of deprivation. The IMD, and its component parts are also considered as independent drivers (see below). Log of population was included as a way to address the fact that local authorities with larger populations are more likely to include pockets of wealth and deprivation and therefore more likely to display higher inequality in life satisfaction.

Given that inequality in life satisfaction is heavily correlated with the mean life satisfaction, we controlled for mean life satisfaction to show how local conditions are associated with inequality in life satisfaction over and above their association with average life satisfaction.

Finally, we included year-dummies for each year the data was available. This was to control for any effects on independent variables driven predominantly by a country-wide annual pattern (e.g. generally rising life expectancy). However, this did not control out the effect of time within each local authority.

[iv] Strictly, this is not an 'inequality' measure per se, but a measure of the wellbeing of those towards the bottom. However, for the purposes of this study we refer to it as 'wellbeing inequality' for simplicity.

INDEPENDENT VARIABLES

A number of the variables we wanted to test were only available for local authorities within England. We therefore split our analysis between Great Britain (GB) and England, including the relevant variables in each.

GB-wide:

- **Air pollution.** Total PM2.5 emissions, separated by cause (anthropogenic and non-anthropogenic)
- **Median income.** Median gross annual pay.[v]
- **Income inequality.** 80:20 ratio of gross annual pay
- **Life expectancy at birth.** Males and females separately.
- **Unemployment rate.**

England-only model:

- **Use of outdoor space** for exercise/health reasons.
- **RSA/HLF Heritage indices**. Assets Index (including listed buildings, monuments, museums, canals, parks and local nature reserves) and Activities Index (including rates of volunteering to help care for the environment, community groups and visits by the public to heritage) separately.
- **Index of Multiple Deprivation**, including scores for the six of the seven dimensions included in the IMD: Income Deprivation, Employment Deprivation, Education, Skills and Training Deprivation, Health Deprivation and Disability, Crime, Barriers to Housing and Services, Living Environment Deprivation. Employment deprivation was excluded as unemployment rate was already included.

These variables were chosen either because they are known to influence average life satisfaction, or because they had been shown to be associated with inequality in life satisfaction at the national level in existing literature. In addition, we limited variables to those most conducive to policy intervention. Data sources and further detail are given in Appendix I.

We used a rolling three-year average of life expectancy. We pooled 2010-12 average for 2011, 2011-13 for 2012 and 2012-14 for 2013. Unfortunately, there were no 2013-15 values for local authorities and we therefore estimated results for that year using the values for the countries of Great Britain (England, Wales, and Scotland). The same method was used as described for modelling life satisfaction figures for Metropolitan and London boroughs and can be found in Appendix III.

Repeated measures models consider the association between independent and dependent variables both between areas and over time. It is possible to split these two effects, producing two effect estimates and significance tests for each variable – one for its effect over time, and one for its effect between areas. However, it is only advisable to do this when there are *a priori* reasons to believe that the effects over time and between areas may be substantively different – as splitting effects doubles the number of significance tests and reduces statistical power. The

[v] We tested the logarithm of median income in models, but it lead to slightly weaker models than when using the raw median income score. Kurtosis for median income was 2.7, and skewness was 1.5 – these are both acceptable for treatment as a normal distribution.

only variable for which we chose to split effects was median income. This was motivated by the Easterlin paradox: the evidence that at a point in time, wellbeing varies with income, but over time, wellbeing does not increase when a country's income increases. [27]

To split the income effect, we first calculated the average of median income for a given local authority over the four years. This accounts for the between-area effect. Then, we calculated the difference between this average and the actual median income for each year for each local authority. This takes account of the effect of time.

MODELS

As mentioned before, some of the variables we wanted to test were only available for local authorities within England. We therefore split our analysis between Great Britain and England. In both cases we ran models for each of our three dependent variables: standard deviation of life satisfaction, average of the bottom 40% of life satisfaction and mean life satisfaction.

For GB-wide models all variables were included in one model, controlling for each other. The results therefore show the estimated association between each independent variable over and above any association with any of the other independent variables being tested at GB-wide level.

For England-only analysis, the large number of independent variables under consideration meant there would have been a high degree of multicollinearity amongst variables had they all been included in one model.[vi] We therefore ran separate models for each independent variable or cluster of variables, including the same base set of control variables in each. We also tested the base set on its own in a single model.

Supplementary models were used as robustness checks. See Appendix II for details.

Repeated measures models were conducted using SPSS Statistics. Significance was set at 0.05.

RESULTS

The main results are shown in Tables 1 and 2 below. The tables include the parameter estimates (standardised beta coefficients) and the p-values, which indicate the likelihood that the effect is due to chance. We ran further tests to explore some of these associations, the results of which are explained in the discussion.

In both the GB-wide model and the England-only model, higher average life satisfaction was significantly associated with lower standard deviation in life satisfaction. This was the largest effect size in both models.

In the GB-wide model, the next largest significant effect size was for median income between areas. Differences in median income between different local authorities were significant for both our measures of life satisfaction inequality; local authorities with higher median income had lower life satisfaction inequality, over and above any impact on mean life satisfaction. This

[vi] The SPSS Mixed model that we used does not provide the option of testing multi-collinearity, so we tested it in a simple linear regression model. There, 11 of the 40 variables would have had tolerance levels below the recommended 0.1 level.

was also a large and significant finding in the England-only model. Change in median income over time was *not* associated with life satisfaction inequality.

Higher female life expectancy was significantly associated with lower standard deviation in life satisfaction in both the GB-wide (p=0.038) and England-only (p=0.002) models. This variable, which is widely used as an indicator of health, had the third largest effect size in both models. Male life expectancy was not significantly associated with inequality in life satisfaction in any of our models.

Testable only in the England-only model, the overall Index of Multiple Deprivation score had the second largest effect on inequality in life satisfaction for both our measures.

In terms of the broken down IMD variables, barriers to housing and services, which measures issues relating to access to housing such as affordability, presented a *negative* association with inequality in life satisfaction (-0.180, p=0.010). Local authorities with higher barriers to housing and services had lower inequality in life satisfaction. No other IMD variables were significantly associated with our primary measure of standard deviation of life satisfaction.

Rurality was associated with higher standard deviation of life satisfaction (p=0.016) and also higher average life satisfaction (p<0.001).

Testable only in the England data, higher proportions of people using outdoor spaces for exercise or health reasons was associated with lower standard deviation in life satisfaction (p=0.046) as was the amount of people undertaking heritage-related activities, such as volunteering to help care for the environment or visiting heritage sites (p=0.004).

Unemployment was associated with higher life satisfaction inequality in the GB-wide model (p=0.035). However, this was not the case in the England-only model (p=0.340).

The ethnic composition of local authorities was not associated with standard deviation in life satisfaction in the GB-wide model, although in the England-only model, a higher proportion of the population self-identifying as Black was associated with lower standard deviation in life satisfaction (p<0.001).

No significant associations were found between inequality in life satisfaction and the 80:20 income ratio. Neither anthropogenic, nor non-anthropogenic air pollution were associated with standard deviation in life satisfaction in the GB-wide model, although – surprisingly – higher levels of anthropogenic air pollution were significantly and negatively associated with standard deviation in life satisfaction in the England-only model (p=0.015).

Most of these results had a corresponding effect on average life satisfaction of the bottom 40%, our secondary measure of inequality in life satisfaction. However, there were some exceptions; use of outdoor space for exercise/health reasons and % of population in a rural context did not have an impact on average life satisfaction of the bottom 40%. The income component of the IMD emerged as significant, with greater income deprivation associated with lower average life satisfaction of the bottom 40%. The living environment component also emerged as significant, although in the opposite direction.

Income deprivation had one of the larger significant associations with average life satisfaction of the bottom 40% (0.079, p=0.024), comparable to the effect size of median income between

areas. This suggests that income deprivation may underlie the association between the IMD and life satisfaction inequality.

Table 1: Standardised coefficients between local variables and wellbeing inequalities in local authorities across Great Britain between 2011-2015: Results of repeated measure model

	Standard deviation of life satisfaction		**Average life satisfaction of the bottom 40%**		**Mean life satisfaction**	
Variables *Included in a single model*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Life satisfaction	**-0.568**	**<0.001**	**0.872**	**<0.001**		
Year-dummy 2012	-0.093	0.179	0.044	0.204	-0.050	0.452
Year-dummy 2013	-0.074	0.301	0.053	0.137	0.087	0.204
Year-dummy 2014	-0.040	0.604	0.043	0.260	**0.262**	**<0.001**
Median income (between areas)	**-0.249**	**<0.001**	**0.156**	**<0.001**	0.024	0.607
Median income (over time)	-0.005	0.818	0.004	0.737	-0.012	0.582
Income inequality (80:20 ratio)	-0.032	0.320	0.016	0.317	0.048	0.119
% population Asian	-0.001	0.065	0.000	0.256	0.000	0.585
% population Black	0.000	0.661	0.000	0.450	**-0.002**	**0.004**
Log population	-0.003	0.957	0.012	0.619	**0.131**	**0.004**
Life expectancy (male)	0.047	0.618	-0.050	0.280	**0.222**	**0.012**
Life expectancy (female)	**-0.196**	**0.038**	**0.123**	**0.009**	0.124	0.168
Pollution (PM 2.5 non-anthropogenic)	0.046	0.528	-0.030	0.405	-0.097	0.163
Pollution (PM 2.5 anthropogenic)	-0.015	0.813	-0.020	0.515	**-0.425**	**<0.001**
Unemployment rate	**0.087**	**0.035**	**-0.043**	**0.032**	**-0.172**	**<0.001**

Table 2: Standardised coefficients between local variables and wellbeing inequalities in local authorities in England only between 2011-2015: Results of repeated measure models

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%		Mean life satisfaction	
Models and related variables *New models indicated by a new heading*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Base set of control variables:						
Mean life satisfaction	**-0.575**	**<0.001**	**0.858**	**<0.001**		
Year-dummy 2012	**-0.126**	**<0.001**	**0.073**	**<0.001**	**0.083**	**<0.001**
Year-dummy 2013	**-0.111**	**<0.001**	**0.085**	**<0.001**	**0.213**	**<0.001**
Year-dummy 2014	**-0.108**	**0.002**	**0.095**	**<0.001**	**0.469**	**<0.001**
Log population	0.036	0.413	-0.020	0.396	0.032	0.404
% population in rural context	**0.134**	**0.016**	-0.050	0.078	**0.261**	**<0.001**
% population Asian	-0.001	0.224	0.000	0.592	0.000	0.302
% population Black	**-0.003**	**<0.001**	**0.001**	**<0.001**	**-0.002**	**<0.001**
Index of Multiple Deprivation score	**0.415**	**<0.001**	**-0.240**	**<0.001**	**-0.376**	**<0.001**
Median income split effects:*						
Median income (between areas)	**-0.199**	**0.001**	**0.123**	**<0.001**	0.000	0.999
Median income (over time)	0.009	0.667	0.005	0.595	**0.008**	**0.033**
Income inequality:*						
Income inequality (80:20 ratio)	-0.023	0.506	0.012	0.506	0.062	0.055
Life expectancy:*						
Male life expectancy	0.064	0.561	-0.078	0.159	-0.010	0.920
Female life expectancy	**-0.298**	**0.002**	**0.193**	**<0.001**	0.161	0.071
Use of outdoor space:*						
Use of outdoor space for exercise/health reasons	**-0.061**	**0.046**	0.023	0.124	-0.038	0.193
RSA/HLF Heritage Index:*						
RSA/HLF Index of Heritage Assets	-0.015	0.744	0.010	0.687	0.050	0.219
RSA/HLF Index of Heritage Activities	**-0.150**	**0.004**	**0.092**	**0.001**	0.077	0.087

Pollution:*						
Pollution (PM 2.5 non-anthropogenic)	-0.109	0.174	0.071	0.079	0.067	0.372
Pollution (PM 2.5 anthropogenic)	**-0.154**	**0.015**	**0.088**	**0.007**	-0.016	0.783
Unemployment:*						
Unemployment rate	0.044	0.340	-0.023	0.319	-0.062	0.163
Index of Multiple Deprivation categories:**						
Mean Income deprivation score	0.256	0.051	**-0.147**	**0.027**	**-0.281**	**0.020**
Mean Education, Skills and Training deprivation score	0.076	0.340	-0.042	0.301	-0.091	0.218
Mean Health Deprivation and Disability score	0.160	0.124	-0.096	0.066	-0.034	0.720
Mean Crime score	-0.013	0.894	-0.020	0.678	-0.019	0.827
Mean Barriers to Housing and Services score	**-0.180**	**0.010**	**0.079**	**0.024**	0.051	0.421
Mean Living Environment score	-0.106	0.054	**0.082**	**0.003**	0.007	0.897

**Controlling for all base set control variables, except for dependent variable mean life satisfaction where this is the dependent variable*

***Controlling for all base set control variables excluding IMD, except for dependent variable mean life satisfaction where this is the dependent variable*

DISCUSSION AND SUPPLEMENTARY ANALYSIS

KEY FINDINGS

Several headline findings emerge from our analysis.

1. **Deprivation and lower median incomes are both associated with higher inequality in life satisfaction at local authority level. Unemployment is also associated with inequality in life satisfaction, though the effect is less consistent.**

The most consistent and significant finding in this study was that areas with lower median incomes have higher levels of inequality in life satisfaction. This was the case for both our measures of inequality in life satisfaction, across Great Britain as a whole, and in the England-only model.

Where it was available (i.e. England-only models), IMD was also a consistent and strong predictor of inequality in life satisfaction.[vii] Breaking the IMD down into categories, it seems that income deprivation underlies the association between the IMD and inequality in life satisfaction.

Unemployment rate also predicted inequality in life satisfaction in the Great Britain model, with higher levels of unemployment associated with higher inequality. However, the effect was less consistent. The fact that the effect failed to reach significance in the England-only model, may simply be due to the fact that our model also included the IMD – which itself includes unemployment rate. When we re-ran the model without controlling for IMD, we found a significant association between unemployment and standard deviation of life satisfaction ($p<0.001$) and mean life satisfaction of the bottom 40% ($p<0.001$).

However, when the model for Great Britain was run without income inequality, allowing a greater number of localities to be included, the effect of the unemployment rate on the standard deviation of life satisfaction just falls short of significance ($p=0.098$), although the effect on the mean life satisfaction of the bottom 40% remained significant ($p=0.031$). Furthermore the effect of the unemployment rate entirely disappears when one carries out a simple model only including those variables that were originally significant in the main Great Britain model.

One potential explanation for these inconsistent findings is that unemployment rate has a much stronger effect on inequality in life satisfaction in rural areas.

Further tests support this theory. We tested the main model, but splitting our data set into two: one for rural areas, and one for urban areas. The split file analysis found that unemployment was significantly associated with standard deviation of life satisfaction in rural areas ($p<0.001$), but had no effect on inequality in life satisfaction in urban areas ($p=0.584$).

This suggests that when the Great Britain model was run as a whole, the mixed effects for rural and urban areas balanced each other out to show no significant effect on standard deviation of life satisfaction. Further discussion of the implications of this finding for rural local authorities is discussed in the next section.

[vii] Indeed, in one of our robustness tests, which tested simultaneously all key predictors of wellbeing inequality in the England-only model, it appears that IMD dominates over median income.

These findings relating to deprivation, median income and unemployment add to the existing literature on the vital importance for wellbeing of ensuring that basic needs are met. This is – rightly – already a key priority for most local authorities and should continue to be so.

The association between median income and inequality in life satisfaction is particularly interesting given that median income was not associated with average life satisfaction. In other words, local authorities within Great Britain with higher median incomes do not generally have higher levels of wellbeing, but their wellbeing distribution is more equal, and those at the bottom of the distribution have higher levels of wellbeing. This rules out the most intuitive hypothesis to explain the association between median income and inequality in life satisfaction; that as median income rises, so does average life satisfaction, and this pushes up the distribution, reducing inequality in life satisfaction.

There are various hypotheses that could account for this association. Firstly, as median income rises, levels of low income reduce, and, to the extent to which these increases boost the wellbeing of those with low incomes, this would reduce inequality in life satisfaction.

Secondly, there may be a 'spill over' effect whereby higher average income in an area improves the wellbeing of everyone. This argument has been made at a national level on the basis that higher average incomes improve public expenditure, governance and health.[28] Similar mechanisms could be operating at a local level, including increased council tax revenue allowing higher levels of local expenditure, or increased local social action to improve the delivery of local services (e.g. campaigns for high quality local GP services, or 'pushy parents' improving standards in roles as school governors).

Thirdly, it could be that a 'relative income' effect is in operation. A wide body of literature suggests that relative income is more important than absolute income when it comes to wellbeing.[29] It is suggested that, once basic needs have been met, the positive relationship between income and wellbeing at the individual level is mostly due to the wellbeing benefit of having higher income than one's peers, rather than the effect of absolute income per se – at least beyond a certain level of income. According to the theory of post-materialism, as we become more prosperous, our values become less materialistic.[30] It is therefore possible that the relative income effect is operating more strongly in local authorities with lower median incomes, and therefore contributing to larger differences in wellbeing than in areas with high median incomes.

However, these hypotheses are speculative.

The finding that median income is not associated to inequality in life satisfaction is not surprising. Because of the relative income effect, there is often no relationship between income and wellbeing at the aggregate level.[31-32] Recent research also finds that, at the national level, economic growth 'evens out' happiness distributions, by allowing greater social expenditure, leading to better health outcomes and improving governance and rights.[33] Further work is necessary to determine what mechanisms are at play at the local level that lead to a similar pattern. Furthermore, it remains to be determined how the level of geographical aggregation affects these results. Might median income at the neighbourhood level, have a different effect on wellbeing and its inequality?

2. **Rural areas have higher inequality in life satisfaction than would be expected given their high average life expectancy scores.**

Rurality was associated both with higher life satisfaction and higher life satisfaction inequality in our models. This suggests that, although average life satisfaction is higher in rural areas, this is not being translated into lower inequality in life satisfaction; a rising tide does not seem to be lifting all boats. [viii]

This could be because it is easier for people to 'fall through the gaps' in rural areas. If someone is experiencing a difficult life event, such as bereavement or the loss of a job, the higher levels of geographic isolation, poorer connecting infrastructure and transport services and poorer access to amenities and services may mean they do not get the material or social support that could help to improve their wellbeing.

Alternatively, it could be that rural areas are more economically unequal, perhaps due to an elite of wealthy land-owners. These people may be more likely to report very high levels of life satisfaction, increasing inequality by pulling up the top of the life satisfaction scale.

We undertook further analyses to explore these hypotheses.

We tested the correlation between income inequality (80:20 income ratio) and the level of rurality in a local authority and found a statistically significant result – more rural areas do have higher rates of income inequality (0.305, $p<0.001$). However, given that income inequality itself was not associated with inequality in life satisfaction in the aggregate, this finding on its own is not a satisfactory explanation.

To explore the 'falling through the gaps' hypothesis, we undertook two tests. Firstly, we tested the main model, but splitting our dataset into two: one for rural areas, and one of urban areas. Secondly, we tested an interaction term to compare the effect sizes of unemployment on wellbeing inequalities in rural versus urban local authorities.

The split file analysis found that unemployment significantly predicted inequality in life satisfaction in rural areas (0.130, $p<0.001$), but was not associated with inequality in life satisfaction in urban areas (0.002, $p=0.584$). The interaction term was not significant for our primary dependent measure standard deviation of life satisfaction (0.006, $p=0.120$). However, it was significant for mean life satisfaction of the bottom 40% (-0.008, $p=0.019$) and mean life satisfaction (-0.009, $p=0.037$). [ix]

These findings are consistent with the hypothesis that the effect of unemployment hits the wellbeing of those living in rural environments hardest. However, as this analysis has been conducted with the local authority as the unit of analysis, it could suffer from the ecological fallacy, the assumption that the effects at an aggregate level also exist at the individual level. Our analysis cannot tell us whether respondents with low life satisfaction scores in a local authority, whose responses may have increased inequality in life satisfaction, were the same as those who

[viii] Although rurality is associated with higher life satisfaction SD when controlling for mean life satisfaction in our models, when mean life satisfaction is taken out, as in Table 10 in Appendix II, rurality is no longer significantly associated with life satisfaction SD (-0.000, $p=0.770$). It would not therefore be accurate to say that rural local authorities had higher inequality in life satisfaction than non-rural areas.

[ix] Controls: mean life satisfaction, year-dummies, median income (between areas), median income (over time), 80:20 ratio of income inequality, proportion of population Black, proportion of population Asian, log of population, male and female life expectancy, and air pollution.

are unemployed. Further analysis at the individual level is needed to explore this dynamic further.

3. **Greater engagement in heritage activities and the use of green space for health or exercise is associated with lower inequality in life satisfaction in local authorities, even though increased engagement in these activities is not associated with improved average life satisfaction at a Local Authority level.**

This finding may be counter-intuitive for some readers. We might expect that engaging in heritage activities and using green spaces are pastimes most enjoyed by those who are already more likely to be satisfied with their lives, and so would be more likely to increase average life satisfaction than decrease wellbeing inequalities. Indeed, there is evidence of inequalities according to health and socio-economic groups in engaging in green space activities.[34]

However, it is possible that, even if those with lower life satisfaction are less likely to engage in these activities, they yield greater wellbeing returns when they do. This study alone cannot demonstrate this association, but it does back up findings from other research. Studies have shown higher wellbeing benefits of using green space for those of lower socio-economic status or those with poor mental health[35] and that access to green space appears important in relation to health inequalities.[36] A HLF-funded study has also shown a positive correlation between heritage, volunteering and wellbeing – with greatest gains for those with lowest wellbeing[37].

Taken together, these results strengthen the case for increasing green space provision and addressing barriers for those with the lowest wellbeing to engage in heritage activities and use green space, indicating that this may support reductions in inequalities in wellbeing. Interestingly, rates of engagement in green space were not significantly associated with our secondary dependent variable, the mean life satisfaction of the bottom 40%.

An alternative explanation could be that the benefits of a high score on the RSA/HLF Index of Heritage Activities spills over to improve the life satisfaction of the whole local authority, not only people who participate in the activities. The index takes a broad definition of heritage and includes things like the number of people volunteering to help care for the environment, the number of civic societies, and the amount of public spending on heritage, tourism and open space. Spill over effects could operate where those with low wellbeing benefit indirectly from improved social cohesion or the condition of the local environment. This is another explanation worth investigating further.

4. **Higher female life expectancy is associated with lower inequality in life satisfaction.**

Across all four main models, female life expectancy was significantly associated with inequality in life satisfaction and mean life satisfaction of the bottom 40%, and the effect size was consistently large. Interestingly, male life expectancy did not have an association with inequality in life satisfaction.

The reverse pattern holds when it comes to *average* life satisfaction, which is associated with higher life expectancy amongst *males* in a local authority, but not females. Surprisingly, even when one does not control for average life satisfaction, there is still no relationship between

male life expectancy and inequality in life satisfaction, suggesting these two effects are orthogonal.

Further research is needed to un-pick these effects. One avenue to explore could be weather the effects are intra-sex. In other words, does male life expectancy only predict average *male* life satisfaction, or does it also predict average female life satisfaction? And does female life expectancy only predict inequality in *female* life satisfaction, or does it also predict inequality in male life satisfaction? A second question is whether female and male life expectancy are proxies for different sets of determinants that also determine life satisfaction and inequality in life satisfaction.[38]

DISCUSSION OF OTHER FINDINGS

Our study threw up several findings that are inconclusive or need further exploration.

Local authorities with a higher proportion of people self-identifying as black had lower mean life satisfaction in both GB and England-only models, as we would expect given existing individual-level evidence that BME populations have lower average life satisfaction.[39] More surprisingly, % black was associated with lower inequality in life satisfaction in our England-only model controlling for mean life satisfaction – i.e. areas with high proportions of people self-identifying as black had lower life satisfaction inequality than would be expected given its low average life satisfaction. This is a new and unexpected finding, and would benefit from further research to help get a fuller picture of the impact of ethnic composition on inequality in life satisfaction.

Higher levels of anthropogenic air pollution are significantly associated with *lower* inequality in life satisfaction on both our measures in the England-only model. Anthropogenic pollution covers all human-made sources of PM2.5, which includes emissions from vehicles, industrial emissions, the use of non-smokeless fuels for heating and bonfires. We controlled for rurality, so this finding is not just reflecting an urban effect. Understanding this finding requires more research.

Testable only in the GB-model, the 80:20 income ratio, our measure of income inequality, was not significantly associated with either of our measures of inequality in life satisfaction, or with average life satisfaction. This is not surprising given the mixed results on the association between income inequality and inequality in life satisfaction. One hypothesis is that the negative effects of income inequality are played out on a different geographical scale to this study. Thinking about the psychosocial effects, it may be that *national,* rather than *local,* living standards have a greater bearing on individual wellbeing.

Testable only in the England-only model, the IMD variable 'barriers to housing and services', which measures issues relating to access to housing such as affordability, was significantly associated with inequality in life satisfaction, but the direction of the relationship was surprising. Our results suggest that higher barriers to housing and services is associated with *lower* inequality in life satisfaction. This could be because barriers to housing and services are higher in more affluent areas. If these areas also have higher average life satisfaction they may have lower inequality in life satisfaction and indeed, median income and barriers to services are strongly correlated (0.404, $p<0.001$). For example, the affluent London borough Kensington and

Chelsea ranks 13th highest on barriers to housing and services, making it 13th worst local authority in the country on this measure.

To check this, we re-ran the initial model controlling for mean income and found that barriers to housing and services was still associated with lower inequality in life satisfaction (p=0.010). This suggests that the association between barriers to housing and services and inequality in life satisfaction goes beyond the fact that places with higher barriers tend to be more affluent.

LIMITATIONS

While this study did not intend to demonstrate causality, it suffers from many of the limitations of observational analyses associated with questions around cause and effect.

Important questions remain about covariance between a numbers of our independent variables. As this study was the first of its kind, it was necessarily exploratory in nature. We therefore chose breadth over depth, testing a number of independent variables, and in most cases included the same base set of controls for simplicity and comparability. This obscures some of the likely interactions between variables. A narrower research question focussed on a single driver could allow more in-depth analysis of the paths of causality and interactions between variables.

These issues are particularly challenging in the area of wellbeing where there is strong evidence of bi-directional relationships between wellbeing and other outcomes – for example, there is good evidence at an individual level that higher wellbeing may lead to higher productivity, earnings and more pro-social behaviour. Cross-lagged models – where the effect of independent variables at one time point is used to predict inequality in life satisfaction at a later time point – can help unpick some of these causal effects. As more years of wellbeing data become available, such methodologies will become more feasible.

As discussed above, there has been very little research into the comparative robustness of indicators of wellbeing inequality, or their relevance to policy. In particular, our primary measure – standard deviation – is a measure of overall variance, so that a policy that had no effect other than to increase respondents from e.g. a 9 to a 10 would increase standard deviation. While this finding would be an accurate response to our research question, it could be misleading to policy makers who may see a report of an increase in inequality and assume that was a bad thing.

Box 1: Alternative measures of wellbeing inequality

This report has focussed on inequality in life satisfaction. But the Annual Population Survey, from which the data has been derived, also includes three other questions intended to measure subjective wellbeing:

1. Overall, to what extent do you feel the things you do in your life are worthwhile?
2. Overall, how happy did you feel yesterday?
3. Overall, how anxious did you feel yesterday?

All of these questions are asked on 0-10 scales similar to the scale for life satisfaction, and can be used to calculate parallel measures of inequality – happiness inequality, anxiety inequality, and inequality in feeling that life is worthwhile. All these measures are available in the

wellbeing inequality data set, available at https://www.whatworkswellbeing.org/product/measuring-wellbeing-inequality-in-britain/

We tested parallel models to see what local level factors are associated with these different wellbeing inequality measures, and whether patterns differ from those found for life satisfaction inequality.

The results mostly confirmed the patterns we found for life satisfaction. For Great Britain as a whole, median income was strongly significant for all four wellbeing inequality measures. Unemployment rate lost significance for happiness inequality, but become more significant for inequality in feeling worthwhile.

For England, the IMD, median income, and female life expectancy all remained significant across all four wellbeing inequality measures. The indicator of heritage activities was significant for three of the four inequality measures. However, use of outdoor space does not retain significance, although the effect is in the same direction for all four measures.

For a fuller picture of wellbeing inequality we recommend that future analyses go beyond inequality in life satisfaction.

FURTHER RESEARCH

Further research should include:

- analysis of the association between inequality in life satisfaction and rurality to explore associations at an individual level
- analysis of area-level impacts of ethnic diversity on inequality in life satisfaction
- analysis of a wider range of indicators of the use and availability of green space and heritage activities at an area level and their potential to reduce inequality in life satisfaction
- analysis of drivers of between-group inequalities in wellbeing (for example according to age, ethnicity, socio-economic status)
- the use of cross-lag effects to explore associations over time, particularly local authority expenditure
- the use of quasi-experimental study designs in robust, nuanced evaluations that track the effects of specific local policy on inequality in life satisfaction
- exploration of the pathways that may underlie the relationship between median income and inequality in life satisfaction
- comparative analysis using alternative measures of wellbeing inequality as discussed in Box 1
- analysis to explore the intra- and inter-gender effects of life expectancy on life satisfaction and inequality in life satisfaction

CONCLUSION

This study used is the first to explore how local conditions shape inequality in life satisfaction in local authorities across Great Britain. Using a repeated measures model we found that:

- Deprivation, unemployment and lower median income are all associated with higher inequality in life satisfaction at local authority level.

- Rural areas have higher inequality in life satisfaction than would be expected given their high average life satisfaction scores.
- Greater engagement in heritage activities and the use of green space for health or exercise is associated with lower inequality in life satisfaction in local authorities, even though increased engagement in these activities is not associated with improved average life satisfaction.
- Higher female life expectancy is associated with lower inequality in life satisfaction at local authority level. This finding does not hold for male life expectancy.

Further analysis into the casual pathways in these findings would be valuable, including those using cross-lag models or quasi-experimental designs.

APPENDIX I: DATA SOURCES

Table 3: Predictor variables information: number of observations, sources and description

Variable	Source	Description	Ns (in relevant England-only model)	Ns (in GB-wide model)
Ethnic composition	2011 Census, Office of National Statistics & National Records of Scotland	Proportion of Asian residents (%) Proportion of residents self-reporting as: • Asian/Asian British: Indian • Asian/Asian British: Pakistani • Asian/Asian British: Bangladeshi • Asian/Asian British: Chinese • Asian/Asian British: Other Asian Proportion of Black residents (%) Proportion of residents self-reporting as: • Black/African/Caribbean/Black British: African • Black/African/Caribbean/Black British: Caribbean • Black/African/Caribbean/Black British: Other Black	600	703
Income inequality	Annual Survey of Hours and Earnings, Office for National Statistics	80:20 income ratio The income of someone at the eightieth percentile expressed as a proportion of the income of someone at the twentieth percentile. A greater ratio represents greater inequality.	523	703
Index of Multiple Deprivation	Department for Communities and Local Government	The Index of Multiple Deprivation (IMD) is an overall relative measure of deprivation constructed by combining seven domains of deprivation according to their respective weights. • Income Deprivation (22.5%) • Employment Deprivation (22.5%) • Education, Skills and Training Deprivation (13.5%)	600	N/A

	English Indices of Deprivation 2015	• Health Deprivation and Disability (13.5%) • Crime (9.3%) • Barriers to Housing and Services (9.3%) • Living Environment Deprivation (9.3%) The Income Deprivation Domain measures the proportion of the population experiencing deprivation relating to low income. The definition of low income used includes both those people that are out-of-work, and those that are in work but who have low earnings (and who satisfy the respective means tests). The Barriers to Housing and Services Domain measures the physical and financial accessibility of housing and local services. The indicators fall into two sub-domains: 'geographical barriers', which relate to the physical proximity of local services, and 'wider barriers' which includes issues relating to access to housing such as affordability.		
Inequality in life satisfaction	What Works Centre for Wellbeing, Community Wellbeing Evidence Programme	This paper uses three variables calculated for, and published in, *Wellbeing Inequality in Britain*[40]. The report included wellbeing inequality scores for over 200 local authorities in Great Britain using four years of data from the Annual Population Survey, 2011-15. Mean life satisfaction: The sum of life satisfaction scores in a given local authority divided by the number of respondents in the local authority. Standard Deviation of life satisfaction: The average difference from the mean for any individual within a local authority. Average of bottom 40%: Mean average life satisfaction of bottom 40% of respondents in a local authority.		
Life expectancy	Office for National Statistics & National Records of Scotland	Life expectancy at birth (years), males and females, by met counties and unitary and local authorities in England & Wales in England, 2009–2011 to 2012–2014.	600	703

Log Population	ONS	Mid-year population estimates (persons) Log of estimates of the usual resident population for each local authority as at 30 June of the reference year.	600	703
Median income	Annual Survey of Hours and Earnings, Office for National Statistics	Gross annual pay: median (£) Annual pay - Gross (£) - For all employee jobs (employees on adult rates who have been in the same job for more than a year) in the UK. Median - the median is the value below which 50% of jobs fall. It is ONS's preferred measure of average earnings as it is less affected by a relatively small number of very high earners and the skewed distribution of earnings. It therefore gives a better indication of typical pay than the mean.	598	703
PM2.5 Anthropogenic	Department for Environment, Food & Rural Affairs	Population-weighted annual mean PM2.5, anthropogenic sources Particulate matter (PM) is a term used to describe the mixture of solid particles and liquid droplets in the air. It can be either human-made or naturally occurring. PM2.5 means the mass per cubic metre of air of particles with a size (diameter) generally less than 2.5 micrometres (μm). Anthropogenic, or human-made, sources of PM2.5 contribute much more to the total concentration of PM2.5 than non-anthropogenic sources. Particulate matter is emitted during the combustion of solid and liquid fuels, such as for power generation, domestic heating and in vehicle engines. In urban areas, emissions of PM2.5 from road vehicles are an important source. In some places, industrial emissions can also be important, as can the use of non-smokeless fuels for heating and other domestic sources of smoke such as bonfires.	600	703
PM2.5 Non-anthropogenic	Department for Environment, Food & Rural Affairs	Population-weighted annual mean PM2.5, non-anthropogenic sources Non-anthropogenic sources of particulate matter. Some examples include dust, ash and sea-spray. These data are population-weighted annual mean concentrations (μg m-3) for each local authority.	600	703
RSA / HLF Heritage Index	The RSA in collaboration with Heritage Lottery Fund	No specific year defined, 2016 is the date the index was produced. The index combines over 120 metrics in 6 domains; historic built environment, museums, archives and artefacts, industrial heritage, parks and open space, landscape and natural heritage, cultures and memories, and general (infrastructure). Within these domains, indicators fit into activities (things done by people) and traditional physical assets.	600	N/A

		RSA/HLF Index of Heritage Activities covers, for example, rates of volunteering to help care for the environment, community groups and visits by the public to heritage sites. It also includes investment in heritage by HLF and local councils. RSA/HLF Index of Heritage Assets includes, for example, listed buildings, monuments, museums, canals, parks and local nature reserves.		
% Rural	Department for Environment, Food & Rural Affairs, 2011	% rural and rural-related population The rural-related component is the resident population of hub towns, which have the potential to be centres of business and service provision for a surrounding rural area. Hub towns are built-up areas (from Ordnance Survey mapping) with a population of 10,000 to 30,000 (2011 Census) and a certain concentration of residential dwellings and non-residential establishments.	600	N/A
Unemployment rate	Annual Population Survey, via NOMIS	Unemployment rate - aged 16-64 (%) Proportion of those aged 16-64 unemployed, April-March.	600	703
Use of outdoor space	Natural England: Monitor of Engagement with the Natural Environment (MENE) survey	Utilisation of outdoor space for exercise/health reasons (%) The weighted estimate of the proportion of residents in each area taking a visit to the natural environment for health or exercise purposes over the previous seven days. Visits to the natural environment are defined as time spent "out of doors" e.g. in open spaces in and around towns and cities, including parks, canals and nature areas; the coast and beaches; and the countryside including farmland, woodland, hills and rivers. However this does not include: routine shopping trips or; time spent in own garden.	559	N/A

APPENDIX II: SUPPLEMENTARY MODELS AND ADJUSTMENTS TO PLANNED METHODOLOGY

A number of further models were carried out in order to provide further understanding of the main results, and to check for robustness. These models were identified *a priori*.

EXCLUDING YEAR DUMMIES

In our original methodology we had not intended to include year dummies in our primary model, but had included a robustness check using year dummies controlling for the effects on any predictor variables driven by a country-wide annual pattern (e.g. generally rising life expectancy). In the models without year dummies, all other aspects were the same as the main models for the GB-wide and England-only models as described in this paper. These results are shown in Tables 4 and 5 below.

When year dummies were not included, non-anthropogenic PM2.5 levels were significantly associated with higher inequality in life satisfaction. The fact that this effect entirely disappears when year dummies are included suggests that this was a spurious correlation i.e. that by chance, years with higher levels of non-anthropogenic PM2.5 were also years with higher levels of wellbeing inequality. Upon further research, we found that the most likely explanation is that, because of Iceland's volcanic eruption, pollution during our study period was gradually decreasing during a general decline in wellbeing inequalities.

Table 3: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities across Great Britain between 2011-2015 (no year dummies): Results of repeated measure models*

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%	
Variables *Included in a single model*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Life satisfaction	-0.444	**<0.001**	1.457	**<0.001**
Median income (between areas)	-0.000	**<0.001**	0.000	**<0.001**
Median income (over time)	0.000	0.984	0.000	0.537
Income inequality (80:20 ratio)	-0.012	0.429	0.014	0.355
% population Asian	-0.001	0.094	0.001	0.339
% population Black	-0.001	0.699	0.001	0.436
Log population	-0.001	0.894	0.004	0.704
Life expectancy (male)	0.004	0.631	-0.009	0.312
Life expectancy (female)	**-0.025**	**0.011**	**0.028**	**0.004**
Pollution (PM 2.5 non-anthropogenic)	**0.078**	**<0.001**	**-0.088**	**<0.001**
Pollution (PM 2.5 anthropogenic)	0.000	0.922	-0.002	0.644
Unemployment rate	0.004	0.093	**-0.005**	**0.029**

Table 4: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities in England only between 2011-2015 (no year dummies): Results of repeated measures models*

	Standard deviation of life satisfaction		**Average life satisfaction of the bottom 40%**	
Models and related variables *New models indicated by a new heading*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Base set of control variables:				
Mean life satisfaction	-0.507	**<0.001**	**1.486**	**<0.001**
Log population	0.009	0.436	-0.009	0.438
% population in rural context	**0.001**	**0.009**	**-0.001**	**0.029**
% population Asian	-0.001	0.214	0.000	0.550
% population Black	**-0.007**	**<0.001**	**0.008**	**<0.001**
Index of Multiple Deprivation score	**0.007**	**<0.001**	**-0.008**	**<0.001**
Median income split effects:*				
Median income (between areas)	**-0.000**	**0.001**	**0.000**	**<0.001**
Median income (over time)	-0.000	0.123	**0.000**	**0.026**
Income inequality:*				
Income inequality (80:20 ratio)	0.006	0.749	0.008	0.670
Life expectancy:*				
Male life expectancy	-0.004	0.679	0.003	0.814
Female life expectancy	**-0.028**	**0.007**	**0.035**	**0.001**
Use of outdoor space:*				
Use of outdoor space for exercise/health reasons	**-0.002**	**0.009**	**0.002**	**0.004**
RSA/HLF Heritage Index:*				
RSA/HLF Index of Heritage Assets	-0.018	0.785	0.020	0.773
RSA/HLF Index of Heritage Activities	**-0.213**	**0.005**	**0.256**	**0.001**
Pollution:*				
Pollution (PM 2.5 non-anthropogenic)	0.**082**	**<0.001**	**-0.100**	**<0.001**
Pollution (PM 2.5 anthropogenic)	**-0.011**	**0.032**	**0.013**	**0.011**

Unemployment:*				
Unemployment rate	0.004	0.105	**-0.006**	**0.012**
Index of Multiple Deprivation categories:**				
Mean Income deprivation score	0.715	0.071	-0.771	0.061
Mean Education, Skills and Training deprivation score	0.001	0.374	-0.001	0.371
Mean Health Deprivation and Disability score	0.038	0.131	-0.045	0.081
Mean Crime score	-0.005	0.880	-0.013	0.717
Mean Barriers to Housing and Services score	**-0.004**	**0.013**	**0.003**	**0.039**
Mean Living Environment score	-0.002	0.059	**0.002**	**0.005**

**Controlling for all base set control variables, except for dependent variable mean life satisfaction where this is the dependent variable*

***Controlling for all base set control variables excluding IMD, except for dependent variable mean life satisfaction where this is the dependent variable*

SUPPLEMENTARY MODEL: EXCLUDING ESTIMATED INEQUALITY IN LIFE SATISFACTION DATA

This model was the same as our main model, but excluding estimated inequality in life satisfaction data (we estimated inequality in life satisfaction for London and Metropolitan boroughs for 2011-12). Essentially a robustness check, so we only used our two primary dependent variables: standard deviation of life satisfaction and average life satisfaction of the bottom 40%. We did not test mean average life satisfaction.

Excluding estimated data changed a number of the results for our primary dependent variable in the England-only model. Outdoor space now just fails to be significant ($p=0.052$), but mean income deprivation, health deprivation and disability and unemployment all gained significance in the expected directions. Deprivation in the living environment was, surprisingly, associated with lower SD in life satisfaction.

Table 5: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities across Great Britain between 2011-2015 (excluding estimated life satisfaction data): Results of repeated measure models*

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%	
Variables *Included in a single model*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Life satisfaction	**-0.524**	**<0.001**	**1.480**	**<0.001**
Year-dummy 2012	-0.024	0.316	0.024	0.310
Year-dummy 2013	-0.024	0.324	0.026	0.277
Year-dummy 2014	-0.006	0.812	0.012	0.626
Median income (between areas)	**-0.000**	**<0.001**	**0.000**	**<0.001**
Median income (over time)	-0.000	0.194	0.000	0.184
Income inequality (80:20 ratio)	-0.029	0.060	0.020	0.184
% population Asian	**-0.002**	**0.046**	0.001	0.072
% population Black	0.000	0.930	0.002	0.321
Log population	0.000	0.985	0.001	0.915
Life expectancy (male)	0.014	0.107	-0.016	0.067
Life expectancy (female)	**-0.031**	**0.003**	**0.031**	**0.002**
Pollution (PM 2.5 non-anthropogenic)	0.048	0.250	-0.042	0.305
Pollution (PM 2.5 anthropogenic)	-0.002	0.697	-0.001	0.860
Unemployment rate	**0.009**	**<0.001**	**-0.008**	**<0.001**

Table 6: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities in England only between 2011-2015 (excluding estimated life satisfaction data): Results of multi-level models*

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%	
Models and related variables *New models indicated by a new heading*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Base set of control variables:				
Mean life satisfaction	**-0.465**	**<0.001**	1.407	**<0.001**
Year-dummy 2012	**-0.039**	**<0.001**	0.044	**<0.001**
Year-dummy 2013	**-0.034**	**0.003**	0.052	**<0.001**
Year-dummy 2014	**-0.034**	**0.012**	0.059	**<0.001**
Log population	0.009	0.353	-0.010	0.332
% population in rural context	**0.001**	**0.008**	-0.001	0.052
% population Asian	-0.001	0.064	0.001	0.360
% population Black	**-0.007**	**<0.001**	0.008	**<0.001**
Index of Multiple Deprivation score	**0.008**	**<0.001**	-0.009	**<0.001**
Median income split effects:*				
Median income (between areas)	**-0.000**	**<0.001**	0.000	**<0.001**
Median income (over time)	-0.000	0.751	0.000	0.787
Income inequality:*				
Income inequality (80:20 ratio)	-0.015	0.380	0.013	0.463
Life expectancy:*				
Male life expectancy	0.014	0.192	**-0.022**	**0.046**
Female life expectancy	**-0.043**	**<0.001**	**0.053**	**<0.001**
Use of outdoor space:*				
Use of outdoor space for exercise/health reasons	-0.001	0.052	0.001	0.088
RSA/HLF Heritage Index:*				
RSA/HLF Index of Heritage Assets	-0.020	0.730	0.028	0.650
RSA/HLF Index of Heritage Activities	**-0.216**	**0.001**	**0.266**	**<0.001**

Pollution:*				
Pollution (PM 2.5 non-anthropogenic)	-0.080	0.082	**0.101**	**0.036**
Pollution (PM 2.5 anthropogenic)	**-0.016**	**0.002**	**0.018**	**0.001**
Unemployment:*				
Unemployment rate	**0.005**	**0.044**	-0.005	0.073
Index of Multiple Deprivation categories:**				
Mean Income deprivation score	**0.773**	**0.023**	**-0.849**	**0.018**
Mean Education, Skills and Training deprivation score	0.001	0.379	-0.001	0.462
Mean Health Deprivation and Disability score	**0.047**	**0.029**	**-0.060**	**0.008**
Mean Crime score	0.001	0.979	-0.023	0.447
Mean Barriers to Housing and Services score	**-0.004**	**0.009**	**0.003**	**0.033**
Mean Living Environment score	**-0.002**	**0.012**	**0.003**	**<0.001**

**Controlling for all base set control variables, except for dependent variable mean life satisfaction where this is the dependent variable*

***Controlling for all base set control variables excluding IMD, except for dependent variable mean life satisfaction where this is the dependent variable*

SUPPLEMENTARY MODEL: FULLLY SPECIFIED ENGLAND-ONLY MODEL.

In the England-only model, to avoid over-specification and excessive collinearity, we tested variables in separate models, individually (e.g. the RSA/HLF Activities Index), or in small groups (e.g. male life expectancy and female life expectancy). So as to check whether this had left any residual confounding, we therefore ran a fully-specified model, including all independent variables which had shown some significance in the main model in one go, rather than in separate models.

In our primary dependent variable, the only three changes were that the associations for RSA/HLF Activities and outdoor activities become non-significant (unsurprisingly given the likely collinearity between the two); and median income between areas lost significance.

Table 7: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities in England only between 2011-2015: Results of repeated measure models*

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%	
Models and related variables *New models indicated by a new heading*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Base set of control variables:				
Life sat mean	**-0.457**	**<0.001**	**1.388**	**<0.001**
Year-dummy 2012	**-0.046**	**<0.001**	**0.056**	**<0.001**
Year-dummy 2013	**-0.037**	**0.001**	**0.060**	**<0.001**
Year-dummy 2014	**-0.038**	**0.008**	**0.073**	**<0.001**
Log population	0.001	0.920	0.000	0.983
% population in rural context	**0.001**	**0.044**	-0.001	0.135
% population Asian	-0.001	0.363	0.000	0.757
% population Black	-0.003	0.052	0.003	0.077
Index of Multiple Deprivation score	**0.005**	**0.002**	**-0.007**	**<0.001**
Median income (between areas)	-0.000	0.380	0.000	0.224
Male life expectancy	0.014	0.236	**-0.027**	**0.020**
Female life expectancy	**-0.025**	**0.032**	**0.036**	**0.002**
Use of outdoor space for exercise/health reasons	-0.001	0.070	0.001	0.179
RSA/HLF Index of Heritage Activities	-0.131	0.080	**0.175**	**0.021**
Pollution (PM 2.5 anthropogenic)	-0.008	0.257	0.009	0.204

SUPPLEMENTARY MODEL: NOT CONTROLLING FOR MEAN LIFE SATISFACTION

Our main model controls for mean life satisfaction, thereby describing the association between our independent variables and inequality in life satisfaction over and above their association to mean life satisfaction. In practice, however, most people are interested in improving average life satisfaction and reducing wellbeing inequality. We therefore also tested a model which did not control for mean life satisfaction.

In the Great Britain-wide model, all those variables that had been significant for mean life satisfaction became significant for one or more of the inequality in life satisfaction measures, apart from male life expectancy.

The year dummy 2014 and anthropogenic PM2.5 became significant for both measures. The proportion of the population identifying as black and the log of population became significant for life satisfaction of the bottom 40%. All previously significant variables remained.

In the England-only model, median income over time and unemployment became significant for average of the bottom 40%. % population in a rural context lost significance for standard deviation of life satisfaction, but gained significance for average life satisfaction of the bottom 40%.

Proportion of the population identifying as black and anthropogenic air pollution both lost significance for average life satisfaction of the bottom 40%, but retained significance for standard deviation of life satisfaction.

In terms of the broken down IMD components, mean income deprivation and mean living environment score became significant for standard deviation of life satisfaction. Mean living environment score retained significance for both measures.

Use of outdoor space for exercise/health reasons lost significance for standard deviation of life satisfaction.

Female life expectancy, RSA/HLF index of heritage activities and IMD score retained significance on both measures.

Table 8: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities across Great Britain between 2011-2015 (not controlling for mean life satisfaction): Results of multi-level models*

	Standard deviation of life satisfaction		**Average life satisfaction of the bottom 40%**	
Variables *Included in a single model*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Year-dummy 2012	-0.019	0.457	-0.006	0.897
Year-dummy 2013	-0.038	0.153	0.081	0.084
Year-dummy 2014	**-0.060**	**0.040**	**0.177**	**<0.001**
Median income (between areas)	**-0.000**	**<0.001**	**0.000**	**<0.001**
Median income (over time)	0.000	0.942	-0.000	0.737
Income inequality (80:20 ratio)	-0.027	0.110	0.054	0.064
% population Asian	-0.001	0.147	0.000	0.866
% population Black	0.002	0.359	**-0.006**	**0.044**
Log population	-0.014	0.153	**0.049**	**0.006**
Life expectancy (male)	-0.006	0.499	0.025	0.120
Life expectancy (female)	**-0.028**	**0.011**	**0.049**	**0.010**
Pollution (PM 2.5 non-anthropogenic)	0.063	0.182	-0.146	0.074
Pollution (PM 2.5 anthropogenic)	**0.016**	**0.001**	**-0.056**	**<0.001**
Unemployment rate	**0.011**	**<0.001**	**-0.023**	**<0.001**

Table 9: ***Un-standardised coefficients*** *between local variables and wellbeing inequalities in local authorities in England only between 2011-2015 (not controlling for mean life satisfaction): Results of multi-level models*

	Standard deviation of life satisfaction		Average life satisfaction of the bottom 40%	
Models and related variables *New models indicated by a new heading*	**Beta coefficient**	**p-value**	**Beta coefficient**	**p-value**
Base set of control variables:				
Year-dummy 2012	**-0.060**	**<0.001**	**0.100**	**<0.001**
Year-dummy 2013	**-0.081**	**<0.001**	**0.185**	**<0.001**
Year-dummy 2014	**-0.131**	**<0.001**	**0.344**	**<0.001**
Log population	0.004	0.698	0.004	0.826
% population in rural context	-0.000	0.770	**0.002**	**<0.001**
% population Asian	-0.001	0.498	-0.001	0.570
% population Black	**-0.004**	**0.006**	-0.002	0.374
Index of Multiple Deprivation score	**0.012**	**<0.001**	**-0.021**	**<0.001**
Median income split effects:*				
Median income (between areas)	**-0.000**	**0.002**	**0.000**	**0.016**
Median income (over time)	0.000	0.164	**-0.000**	**0.038**
Income inequality:*				
Income inequality (80:20 ratio)	-0.024	0.204	0.060	0.059
Male Life expectancy:*				
Male life expectancy	0.009	0.452	-0.020	0.301
Female life expectancy	**-0.044**	**<0.001**	**0.076**	**<0.001**
Use of outdoor space:*				
Use of outdoor space for exercise/health reasons	-0.001	0.214	-0.000	0.880
RSA/HLF Heritage Index:*				
RSA/HLF Index of Heritage Assets	-0.062	0.360	0.149	0.173
RSA/HLF Index of Heritage Activities	**-0.282**	**<0.001**	**0.462**	**<0.001**
Pollution:*				

Pollution (PM 2.5 non-anthropogenic)	-0.093	0.087	0.163	0.074
Pollution (PM 2.5 anthropogenic)	**-0.013**	**0.022**	0.014	0.140
Unemployment:*				
Unemployment rate	0.005	0.060	**-0.010**	**0.032**
Index of Multiple Deprivation categories:**				
Mean Income deprivation score	**1.243**	**0.002**	**-2.300**	**<0.001**
Mean Education, Skills and Training deprivation score	0.002	0.141	-0.004	0.095
Mean Health Deprivation and Disability score	0.043	0.088	-0.061	0.140
Mean Crime score	0.000	0.990	-0.028	0.606
Mean Barriers to Housing and Services score	**-0.005**	**0.004**	**0.005**	**0.039**
Mean Living Environment score	**-0.002**	**0.044**	**0.003**	**0.047**

**Controlling for all base set control variables*

***Controlling for all base set control variables excluding IMD*

CHANGES TO THE ORIGINAL METHODOLOGY

The following changes were made from the original methodology:

- Year dummies were included as a result of undertaking the robustness check above.
- Initially we had hoped to include local authority expenditure as an independent variable in the model. However, given that both overall local authority expenditure and, within this, different expenditure are likely to be responsive to need, it was later decided that it was too susceptible to reverse causality and this analysis was dropped.

APPENDIX III: ESTIMATING VALUES

LIFE SATISFACTION

Values were estimated for 2011-12 for the metropolitan and London boroughs. All other data was available including values for Metropolitan counties and Inner/Outer London for 2011-12. For ease of writing, we shall use to the term Met County+ to include Inner and Outer London.

To estimate 2011-12 figures for boroughs we calculated did the following:

1. For each borough for each year (2012-13 onwards), we calculated the percentage difference between the score for that borough and the overall score for the Met County+.

$R_{MBi}=(X_{MBi}-X_{MCi})/X_{Mci}$

X_{MB} is the score for the borough, X_{MC} the score for the Met County+. All refer to the ith year.

2. We then used Excel TREND function to estimate the trend for R_i so as to estimate R_i for 2011-12.

3. We then reversed the formula in step 1, to use R_i to estimate X_{MBi} for the borough in 2011-12.

LIFE EXPECTANCY

Life expectancy data was not available at local authority level for 2013-2015. However, values were available at country level. We therefore used a similar method as that described above, calculating how each local authority differed from the overall country figure for each year, took the trend of this deviation, and used this trend to estimate results for 2013-15.

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