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The equalisation hypothesis and changes in geographical inequalities of age based mortality in England, 2002-2004 to 2008-2010

Abstract

The equalisation hypothesis argues that during adolescence and early adulthood, inequality in mortality declines and begins to even out. However the evidence for this phenomenon is contested and mainly based on old data. This study proposes to examine how age-specific inequalities in mortality rates have changed over the past decade, during a time of widening health inequalities. To test this, mortality rates were calculated for deprivation quintiles in England, split by individual ages and sex for three time periods (2002-2004, 2005-2007 and 2008-2010). The results showed evidence for equalisation, with a clear decline in the ratio of mortality rates during late adolescence. However this decline was not accounted for by traditional explanations of the hypothesis. Overall, geographical inequalities were shown to be widening for the majority of ages, although there was some narrowing of patterns observed.

Keywords: Age; Mortality; England; Inequality; Deprivation.

Introduction

The processes which create and maintain inequalities in mortality vary across a wide plateau of social, individual and geographical factors. How these factors interact can be observed through measuring inequalities by age. It is frequently assumed that social gradients are consistent throughout the life course; however this is simply not true. Levels of inequality vary in strength by age and do not always follow traditional social gradients. An often ignored concept in the inequality literature regards the equalisation hypothesis. At any one time during adolescence and early adulthood, the level of inequality in health outcomes appears to attenuate between social groups and areas. This results in an apparent evening out of geographical inequalities in health at those ages.

Evidence for this concept in England and the UK has so far been varied, with full (Dibben and Popham, 2013; Macintyre & West, 1991; West, 1988; 1997), partial (Spencer, 2006; West and Sweeting, 2004) and little support (Emerson et al., 2006) for such processes found. An explanation is that support for the hypothesis tended to be stronger when mortality measures were used, as opposed to morbidity or self-rated measures (although see West, 1997). This would suggest that using measures of mortality to research the hypothesis would be better to assess its existence. Nevertheless evidence for the hypothesis outside of England and the UK remains less supportive (c.f. Engström et al., 2003; Starfield et al., 2002; Torsheim et al., 2004).

The phenomenon of apparent equalisation of mortality rates during these ages is not necessarily due to greater improvements in health amongst the poor. Rather, those from the less deprived areas have, in some cases, experienced increases in relative mortality risks, bringing their rates more in line with the rates for disadvantaged areas. With adolescence being a time of increased health-adverse risk taking, it is possible that lifestyle changes cut

across social differences, flattening inequalities (Chen et al., 2006; West, 1997; West and Sweeting, 2004). This has been mostly explained by reference to a few external causes of mortality, especially road traffic accidents, as the more affluent are more likely to afford a car when young (Dibben and Popham, 2013; Laflamme et al., 2004; West and Sweeting, 2004). It helps explain why the equalisation hypothesis is more strongly associated with mortality than compared to morbidity (although see Williams et al., 1997). However, this possible increased risk taking is not apparent for other external risks such as drug-related deaths or intentional self-harm, despite both causes of mortality being high among younger age groups (Dibben and Popham, 2013).

Evidence surrounding the hypothesis and other information regarding varying levels of inequality by age has been constrained by data limitations, resulting in out-dated studies. The most recent study which found evidence of equalisation focused on the period of 1997 to 1999 (Dibben and Popham, 2013). However the England that existed over a decade ago is in some key ways different to the society that currently exists. The release of the 'Marmot Review' (Department of Health, 2010) once again highlighted the vast social gradients that have become entrenched in the UK, to the extent that whilst life expectancy has continued to rise throughout the 2000s, health based inequality has also continued to widen. As such, those in the poorest areas will die on average seven years before those in the most affluent areas, as well as experiencing greater levels of disability (ibid). These trends have been replicated in mortality studies. Although mortality rates by area were widening during the 1990s (when most of this research was conducted) and have continued to widen since (Langford and Johnson, 2010; Thomas et al., 2010), we still have to carefully check each subsequent year's data for any signs of a change in the trends. This combined with rising levels of income inequality since the 1980s (OECD, 2011) and an economic recession with an uneven distribution of its damaging effects (Dorling & Thomas, 2011), would suggest that

the effect of mortality equalisation during adolescence might be diminishing. This is especially the case since societal changes are more likely to be felt amongst the youth. However to date there has been no attempt in the literature to examine the direction of these trends and hence it is unknown whether this widening of geographical inequalities has occurred for all ages. Based on this framework, the following hypotheses are proposed:

1. There is a decline in the level of inequality of mortality rates during late adolescence.
2. There are higher rates of mortality for land transport accidents in the least deprived areas during late adolescence, unlike for the other main external causes of mortality.
3. Inequality in mortality rates has increased over time for all ages.

Methods

A similar framework to Dibben and Popham's (2013) recent study was employed for this analysis. To capture deprivation, the latest Indices of Deprivation (2010) measure for England was used. Only the 'income' domain was used to differentiate between areas, to avoid circularity issues as the overall index contains information on health and mortality, as well as it being identified as the most important part of the measure (Department for Communities and Local Government, 2011). The index is created for the Lower Super Output Area (LSOA) level, a geographical scale which splits England into 32,482 evenly sized areas with an average population size of 1500. This allows a detailed analysis through capturing intricate differences in deprivation. Using the rankings provided, areas were split into quintiles to differentiate between the types of areas. These areas were kept constant over each time period, to allow comparable analyses.

The mortality data used were gathered from the mortality statistics collected by the Office for National Statistics (ONS). The database compiles information on each individual death in England through civil registration records (Griffiths et al., 2005; Rooney and Smith, 2000). This comprehensive data source contains information on year of death, age, sex, cause of death and geographical location (postcode). Accessibility to the data set was approved by the 'ONS Microdata Release Panel' and 'Approved Researcher Status' was also granted, allowing use of the data for research purposes. The quintiles of deprivation were joined to the database and each quintile was aggregated, split by age and sex, to gain the total number of deaths.

To further investigate the overall mortality rates by age and changes in them, data on various external causes shown to be important in past analyses (Dibben and Popham, 2013; Laflamme et al., 2004; West, 1997; West and Sweeting, 2004) were extracted from the database. The relevant ICD-10 (International Classification of Diseases-10) codes to measure external causes (Northern Ireland Statistics and Research Agency, 2010) were: land transport deaths (V01-99), drug-related deaths (F11-16, 18, 19, X40-44, X85, Y10-14) and intentional self-harm (X60-X84). Other causes were examined to explore new avenues for explanation.

Individual aged population data for LSOAs were compiled from mid-year estimates requested from the ONS (0 to 85 and over). Using this data, totals were aggregated for each age (split by sex) by each quintile. Data was split into three time periods, each containing data for three individual years (2002-2004, 2005-2007 and 2008-2010). Rates (per 100,000) were then compiled for each individual year of age, split by sex and area deprivation quintile. To measure the level of inequality at each age, the Relative Index of Inequality (RII) was calculated. This was chosen as it is a robust measure that accounts for the differences in population sizes (Mackenbach and Kunst, 1997), given the variation of age groups between area types. It was also useful in Engström et al.'s (2003) investigation of the equalisation

hypothesis. The measure can be interpreted as the difference in the relative risk of mortality between the most and least deprived areas. Additionally, the change in the RII between periods was calculated and also plotted to display the temporal pattern.

Smoothing of the data was employed to reduce the impact of spurious and extreme data points, to better visualise the general trend. With small quantities of data during younger ages, the trend line was greatly affected by noise prior to smoothing. It also simplified the data, moving towards a 'slow change' in trends (Hastie et al., 2009). This is more akin to the hypothesis, which theoretically is less about sharp changes. As such, the results provide greater focus with regards to this. Smoothing of these results was achieved through using kernel-weighted local polynomial regression (Fan et al., 1995). It was chosen as the data approaches the polynomial distribution. A Gaussian kernel, with first degree polynomial was selected, with bandwidth kept minimal to improve the quality of the results (Hastie et al., 2009).

Results

Figure 1 shows the smoothed RII for mortality rates by sex. For both sexes, there is a distinct decline in inequality beginning in late adolescence, before flattening out and later rising again in the mid-20s. This contrasts with the wide geographical inequalities observed earlier in the life course. Although this pattern is similar to the equalisation hypothesis, the scale shows whilst inequalities begin to narrow after age 15, the trend line does not reach true equalisation (i.e. a value of zero). Despite evidence of equalisation, a social gradient remains during this period. Overall, the first hypothesis can be accepted.

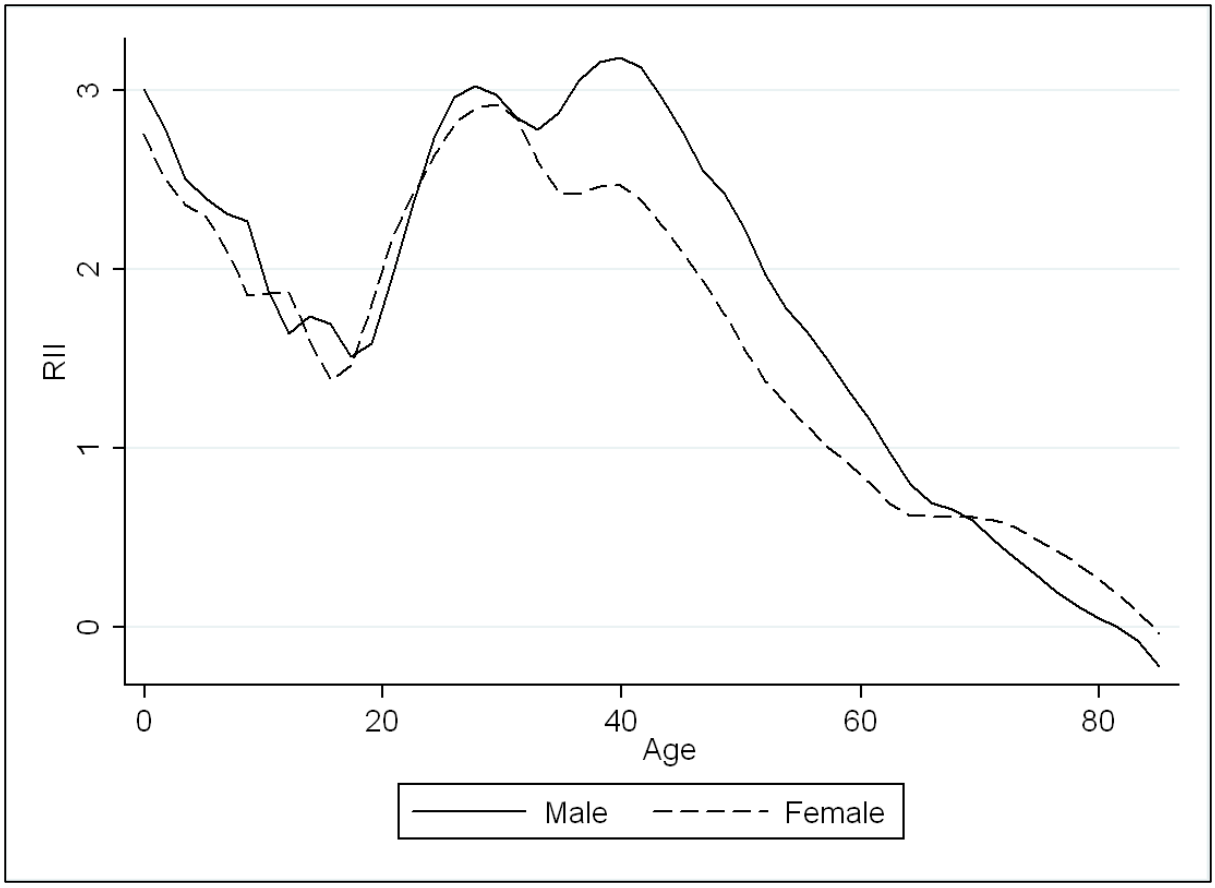
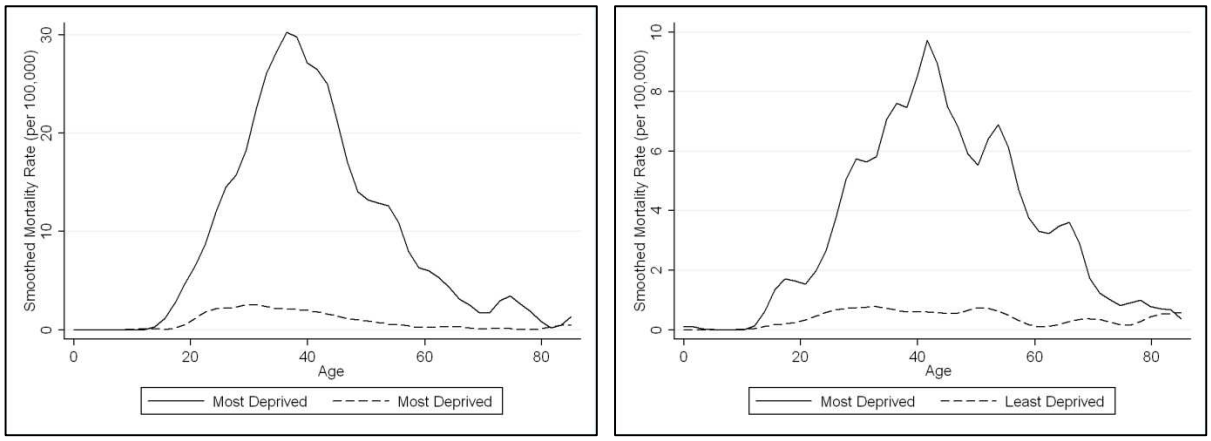


Figure 1: The smoothed relative index of inequality of mortality rates for deprivation quintiles in England, 2008 to 2010.

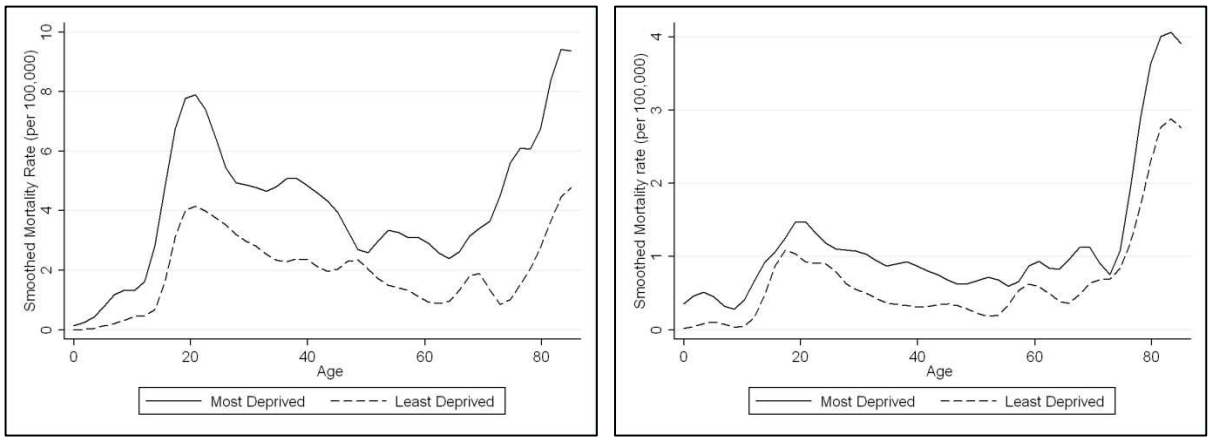
After the age period of youth, inequalities begin to rise consistently for both sexes. As the trend lines reach the age of 30, the gradient begins to differentiate itself between the sexes slightly. For males the gradient continues at a high rate, whereas for females it begins decline. Both trends peak at around a relative risk of mortality of three times higher in the most deprived quintile than compared to the least, with this level of inequality being slightly higher for males. For males, the trend falls at a greater rate than for females (later in the life course), eventually converging around the 70s where it is consistently lower than for females. As the trend lines approach the later stages of life, inequality finally begins to equalise absolutely.

Males **Females**

(a) **Drug Misuse** **(b)**



(c) **Land Transport** **(d)**



(e) **Intentional Self-Harm** **(f)**

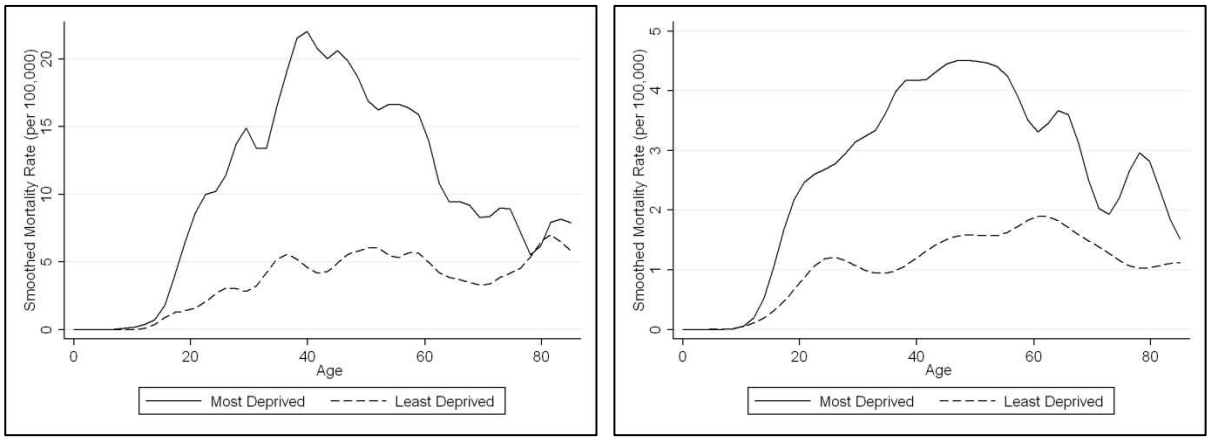


Figure 2: Variations in smoothed rates (per 100,000) of external causes of mortality by sex in England, 2008-2010. (a) Male drug-related mortality rates; (b) Female drug-related mortality rates; (c) Male land transport related mortality rates; (d) Female land transport

related mortality rates; (e) Male intentional self-harm mortality rates; (f) Female intentional self-harm mortality rates.

Figure 2 shows the smoothed mortality rates in the most and least deprived quintiles for the main causes of death for young people; land transport accidents, drug-related deaths and intentional self-harm. The patterns follow similar paths for both genders and although mortality rates are higher for males, the relative differences between quintiles are fairly analogous. Mortality rates for the three causes are consistently higher across the life-course within the most deprived quintile. During adolescence, there is no evidence for any of the causes that this pattern reverses. Indeed for both intentional self-harm and drug-related deaths, it is during adolescence that the trend lines begin to separate. For land transport accidents, the relative difference is less in this period. The second hypothesis should therefore be rejected.

However for each subgroup, the total mortality attributable to external causes of death never exceeds 50 per cent of all deaths between the ages 16 and 21 (chosen to both incorporate the period of risky behaviour, as well as where the equalisation period exists in Figure 1), for the period 2008-2010. Examining the other causes which account for this will also help aid our understanding of this period of declining inequalities. Many of these other causes, even once aggregated into larger groups, did not contain useful numbers of deaths to make meaningful comparisons. Comparing the ratio between the most and least deprived quintiles consistently gave either an even value or was slightly higher in the most deprived areas. Only for 'Hodgkin Lymphoma' (C81) in males did the gradient reverse, but the numbers of deaths involved were too small to be useful. Furthermore this did not hold for 'Haematological Cancers' (C81-96) as a whole (where the rate for males in the most deprived areas (1.46 per 100,000) was higher than in the least (1.28 per 100,000)).

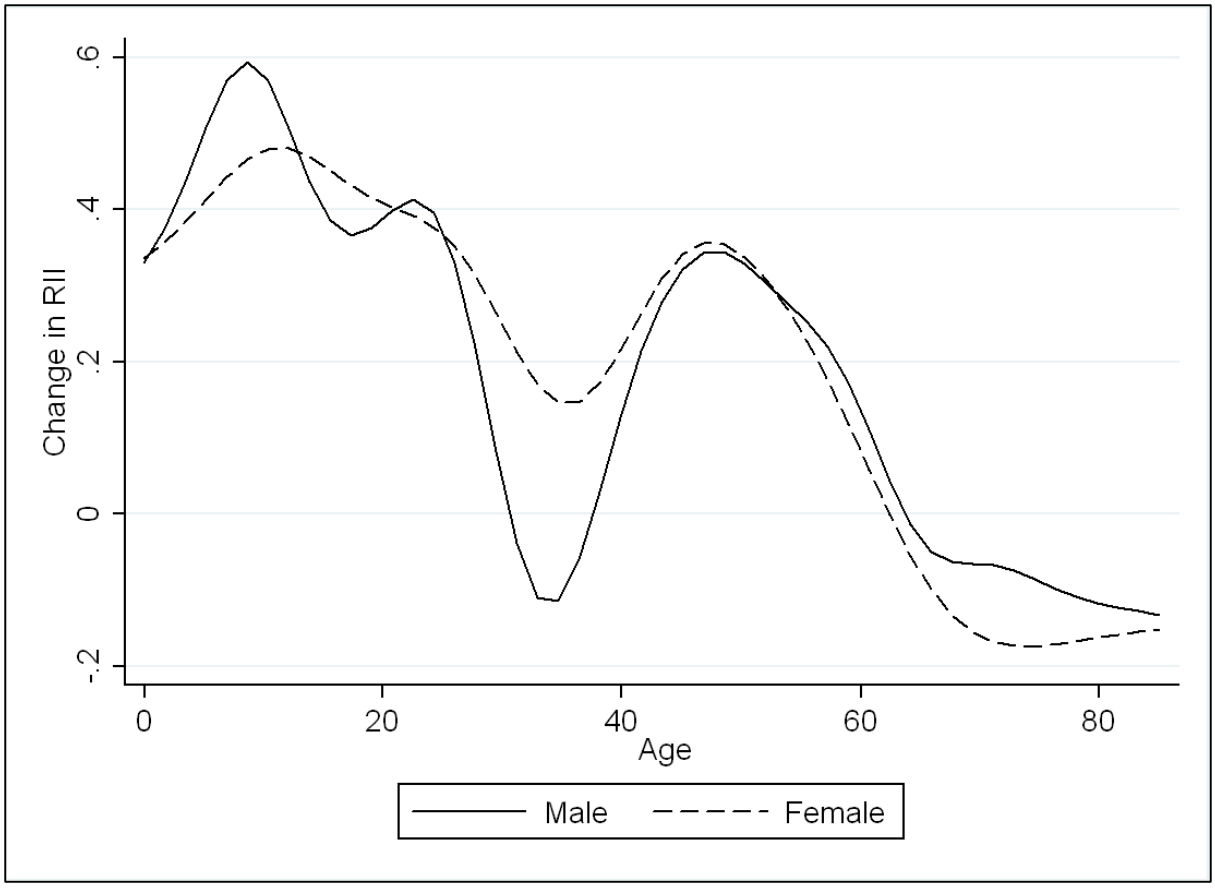


Figure 3: The smoothed change in the relative index of inequality of mortality rates for England attributed to all causes between 2002-2004 and 2008-2010 (RII for 2008-2010 minus the RII for 2002-2004).

Calculating the same statistics in exactly the same way for the period 2002 to 2004 allowed the examination of the changing trend in inequalities (Figure 3). What is found is that the direction for the trend of inequality varies by age, with the majority of ages reporting widening trends. The increase has been greatest during youth, which would indicate that the process of equalisation is being eroded. There is a small decline for the ages between 30 and 40, where inequality was also shown to be widest, although this was only observed for males (although the pattern for females does mirror this trend). Yet this decline in inequality is only small and soon reverses. There is a more consistent narrowing of inequality late in the life course, for both genders. This general pattern held when comparing the period 2005-07 and

2008-10 (albeit with smaller changes) and when the 2004 Index of Multiple Deprivation for grouping areas was used instead (results not shown).

The analyses were also performed using the full version of the Indices of Deprivation 2010 and also a different inequality measure (the ratio of mortality rates between the most and least deprived quintiles). This was to check that the patterns remained stable and were not sensitive to methodological differences. Overall, patterns remained the mostly the same, with evidence found for the equalisation hypothesis and widening inequality over time (results not shown). However one difference was that with using the full index, during adolescence the mortality rate for land transport accidents (as a result of car-related deaths) was slightly higher in the least deprived areas for both genders than compared to the most deprived areas. Therefore it may be important, although given the circularity issues involved with the measure (as it includes a measure of premature mortality rates), this finding should not be taken.

Discussion

Health inequalities in England have been long reported, including how they vary by age (Department of Health and Social Security, 1980). These findings have provided further support to what is known, showing the wide social inequalities that persist throughout the life course. Health inequalities are not evenly distributed through the life course; rather they vary by age (Dibben and Popham, 2013; Dorling, 2013; Smith et al., 2010). Whilst the analysis finds no evidence that absolute equalisation occurs during mid- to late-adolescence, there is a marked decline in inequality during this period. This shows strong support for the existence of the hypothesis, contrary to the mixed evidence currently found across the literature

(Emerson et al., 2006; Spencer, 2006; West and Sweeting, 2004). It may be though that the hypothesis is only apparent when using mortality data.

Unlike previous studies, external causes of mortality have not been shown to be important for explaining the partial equalisation of mortality rates in early adulthood. Although the evidence surrounding intentional self-harm and drug-related causes has been mixed, support for the existence of an inverse social gradient for land transport has been recently shown (Dibben and Popham, 2013). Rather what is shown here is that land transport currently displays a traditional social gradient during youth, whereby there is an increased mortality risk in the most deprived areas. The mortality rate in the least deprived quintile is, however, higher than for the other external causes, reflecting the increased risky behaviour during this period of the life course in this regard.

Further examination of how these causes have changed over the time period in question aids our understanding of this contrasting finding. Tables 1 and 2 show the mortality rates for the external causes (with car-related accidents (ICD-10 codes V40-49) included separately) for the ages 16 to 21 for 2002-2004 and 2008-2010. Mortality rates were higher in the least deprived areas for car-related deaths in 2002-2004, however this has now reversed. What once partially explained this phenomenon has now changed and this would appear to explain (along with widening inequalities generally) why absolute equalisation no longer exists. For each sub-group, the relative change over time has always been greater in the least deprived quintile. Relative (and sometimes absolute) improvements in mortality have been greatest in those areas of less need, perpetuating inequalities and social injustices. What is particularly worrying is that mortality rates for intentional self-harm have not improved in the most deprived areas, a key policy area that requires tackling.

Cause	2002-04		2008-10	
	Most Deprived	Least Deprived	Most Deprived	Least Deprived
Intentional self-harm	5.99	4.38	5.70	1.44
Drug-related	6.59	1.90	4.10	0.30
Land transport	15.61	14.46	7.83	3.63
Car-related	7.95	9.50	3.80	1.81

Table 1: Mortality rates (per 100,000) for external causes of mortality for males aged 16-21.

Cause	2002-04		2008-10	
	Most Deprived	Least Deprived	Most Deprived	Least Deprived
Intentional self-harm	1.66	1.02	2.15	0.50
Drug-related	3.40	0.56	1.63	0.17
Land transport	2.50	2.96	1.41	1.26
Car-related	2.04	3.98	1.11	0.92

Table 2: Mortality rates (per 100,000) for external causes of mortality for females aged 16-21.

The patterns for both intentional self-harm and drug-related mortality are more important later in the life course. They both contribute to explaining why there is an excess of mortality in the most deprived quintile (as shown in Figure 1), albeit not completely. This contrasts with the pattern for land transport accidents, where the gap between the most and least deprived quintiles remains fairly even across the life course. Whilst patterns are similar for both males and females, the scale of deaths due to external causes is much higher for males. Despite their mortality rates not being as high as for other causes, which are more important during the middle part of the life course, these external causes represent an important and achievable policy option.

Few other specific causes of mortality can help offer an explanation for the narrowing of inequalities as part of the equalisation hypothesis. This is problematic for understanding what is happening, as there are no clear avenues for further investigation. A factor in influencing this involves the small numbers of deaths experienced during these ages.

Adolescence represents one of the safest parts of the life course. Therefore the observed equalisation may instead be a statistical artefact, due to the lack of differences between quintiles. This would fall in line with the lack of evidence for the hypothesis when examining morbidity or self-reported measures during these ages, where a traditional social gradient persists (Emerson et al., 2006; Engström et al., 2003; Starfield et al., 2002).

The incorporation of change over time has added a new dimension to research into the equalisation hypothesis. The widening of inequality in mortality is the dominant trend over time. This supports past research, showing the general widening of inequalities by area in health (Langford and Johnson, 2010; Thomas et al., 2010). It also explains the difference in results from past studies which have shown evidence for the existence of absolute equalisation (Dibben and Popham, 2013; West, 1997), as whilst the pattern remains similar, the scale of inequality shown in Figure 1 has increased. However it is not consistent across the life course, a new and important finding. There has been some improvement in middle-aged males, although the smoothed gains were only slight. With these occurring when inequalities are widest (Figure 1), this represents some useful (albeit small) gain. Rather the decline late in the life course is much more consistent. These are, however, the only times where a narrowing is observed.

Changes in mortality rates help to explain this. Mortality rates have declined consistently for the majority of ages in both the least and most deprived quintiles. However, whilst the decline in absolute terms has been much greater in the most deprived areas, the decrease in the least deprived areas has been large enough (relatively) to result in a widening of the gap. Where mortality rates declined less in the most deprived quintile, than compared to the least deprived area, this was mostly at younger ages. This would explain why the largest temporal change was observed earlier in the life course, as well as important role for policy

improvement. Nevertheless it is also possible that this is a factor of the small numbers involved.

A cohort effect could be a possible explanatory factor in explaining the narrowing of trends. With the morbidity and self-rated health data showing consistent social gradients throughout this period (although see West, 1997), it is plausible that the observed decline between the ages of 30 and 40 is caused by a cohort effect. This is especially the case as there was a widening of the RII either side of these ages and the pattern was only shown for males. This is similar for the pattern for the elderly. The wide geographical inequalities that persist earlier in the life course result in an excess of mortality in the most deprived areas. As such a cohort effect will present itself at later ages, as the damaging effects of social influences decline, bringing rates towards those found in the least deprived areas. With the narrowing being more consistent, this would appear a stronger possible explanatory factor here. It also helps explain the observed decline in Figure 1, not just changes over time.

Limitations to this study mostly pertain to data quality issues. The population data that are used are based upon modelled ONS estimates. Given that our spatial scale of analysis was small (both in terms of single years and geographical scale), the accuracy of these values may have an effect. Mortality data may not also be the best way to research this topic, due to the rarity of the event at younger ages (West, 1997; West and Sweeting, 2004). For example, between the ages of 16 and 21, the mortality rate for males was 27.5 per 100,000 in the least deprived areas, compared to 49 per 100,000 in the most deprived quintile. This was even more problematic when individual years or specific causes were considered, as death counts were often in single figures during adolescence (also see Figure 2). Yearly fluctuations therefore make the results fairly sensitive to change, although smoothing of the data addresses this. However it would appear that the hypothesis is much stronger with this type

of data, when compared to past morbidity studies. With death being the worst possible health outcome, this has a greater policy importance as well.

The analysis is based upon ecological data, which may be poor at conceptualising the concept of deprivation. The individual characteristics of those who died in a deprived area may not relate to the social characteristics of that area (Winkleby et al., 2006). For example the location of retirement or care homes could affect our results through increasing the level of inequality, or masking any decrease at older ages (Lock and Higginson, 2005). The deprivation quintiles were kept constant, which assumed areas remained fixed in terms of whether they are deprived or not. Though theoretically false (as areas can change), this was required to be able to compare different time periods. Otherwise changes over time could be the result of differences in the composition of the measure used, as past iterations of the Index of Deprivation have changed methodologically. However the results for change over time remained consistent when the 2004 Index was also used, showing it to be less of an issue.

In conclusion, this study helps provide further support for the equalisation hypothesis. Social inequality is not consistent across the life course and during adolescence there is a clear decline in the level of inequality. However there still exists some extent of a social gradient in mortality during this period, a result of widening inequality over the past decade which has eroded the effect. The scale of inequalities is evident across the whole life course and equalisation is only truly evident amongst the very elderly population, where social factors begin to possibly have less of an influence, or where only the fittest survive to. These geographical inequalities in mortality have continued to widen for most ages. However there were two periods in the life course where inequalities have narrowed, a result that may have not been expected. Considerable policy attention is required to tackle and reverse this pattern.

Conflict of Interest

None declared.

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