Gendered Mortality Differentials over the Rural-Urban Continuum:

The Analysis of Census Linked Longitudinal Data from England and Wales

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Abstract

Background. Previous research shows that mortality varies significantly by residential context; however, the nature of this variation is unclear. Some studies report higher mortality levels in urban compared to rural areas, whereas others suggest elevated mortality in rural areas or a complex U-shaped relationship. Further, it also remains unclear the extent to which compositional factors explain urban-rural mortality variation, the extent to which contextual factors play a role and whether and how the patterns vary by gender. This study investigates urban-rural mortality variation in England and Wales and the causes of this variation.

Method. The study applies survival analysis to the Office for National Statistics Longitudinal Study. Population aged 20 and older in 2001 are followed 10 years.

Results and Conclusions. The analysis shows a clear urban-rural mortality gradient, with the risk of dying increasing with each level of urbanisation. The exceptions are those living in areas adjacent to London who consistently exhibit lower mortality than anticipated. Once the models are adjusted to individuals' socio-economic characteristics, the variation across the urban-rural continuum reduces substantially, yet the gradient persists suggesting contextual effects. Females are found to be influenced more by their surrounding environment and males by their socio-economic position, although both experience lower mortality in rural compared to urban areas.

Keywords: Mortality, health, rural, urban, survival analysis, gender, England and Wales.

Introduction

A growing body of literature has investigated geographical inequalities in health and mortality in industrialised countries (O'Reilly et al., 2007; Bambra et al., 2014). The evidence provided by research on urban-rural health variation, an important dimension of geographical heath inequalities, has been inconclusive (Teckle et al., 2012). Numerous studies report a positive urban-rural health gradient, with health tending to deteriorate with increasing levels of urbanisation (DEFRA, 2014, Chilvers, 1978, Allan et al., 2017; Gebregziabher et al., 2018). Others propose the theory of a U-shaped health continuum, with large cities and remote rural locations experiencing poor health outcomes compared to suburban and semi-rural locations (Barnett et al., 2001; Levin, 2003). Finally, some studies refute the concept of a healthy rural population altogether, suggesting a negative urban-rural health gradient (e.g., Lankila et al., 2012).

Although most previous studies report significant urban-rural health variation, a number of issues remain unclear. First, the extent to which these urban-rural health differences are attributable to compositional or contextual factors (Senior et al., 2000; Ecob and Jones 1998). Second, whether and how these differences, and their causes, vary between men and women (Kavanagh *et al.,* 2006). This study investigates mortality variation over the rural-urban continuum in England and Wales, and the extent to which observed variation is attributable to compositional and contextual influences. Further, we examine the ways environmental, socio-economic and demographic factors influence male and female mortality. The study applies survival analysis to the Office for National Statistics Longitudinal Study (ONS LS), using relative mortality risks to examine urban-rural mortality variation between 2001 and 2011.

The study extends previous research in the following ways. First, it applies survival analysis to examine mortality by individuals' residential context, controlling for their socio-economic characteristics (e.g., education level and SES). Previous studies have either used relatively crude methods to estimate individuals' mortality (e.g., mortality over a 5 or even 15 year period rather than monthly or yearly estimates) or used area-level deprivation indices to study urban-rural mortality variation. Second, the study moves beyond the urban-rural dichotomy to recognise a rural-urban continuum. Third, instead of medium-sized geographical entities (e.g., counties, local authority districts) which may contain urban or rural pockets, this study utilises the smallest possible spatial units (census output areas) to classify areas as urban or rural. Finally, the study analyses urban-rural mortality variation by sex to determine whether place effects are different for males and females.

Literature Review

Urban-Rural Health Gradient

Researchers have long been fascinated by cities and their influence upon public health (Galea and Vlahov 2005). Many studies in industrialised countries demonstrate that more favourable health outcomes are discovered in rural areas (Riva et al., 2011). For example, rural males and females in England are expected to live 2 and 1.5 years longer than their counterparts in major urban areas (DEFRA 2014). Similar results have also been reported for other countries such as Germany, Netherland and Ireland (O'Reilly et al., 2007; Eurofound, 2014). Several decades ago, Chilvers (1978) proposed the theory of a health gradient, where mortality rates increase consistently with degree of urbanisation. Recently, Allan et al. (2017) provided supporting evidence, discovering that limiting long term *illness* increases with the level of urbanisation in England and Wales.

The rural health advantage is immersed in a contentious debate regarding whether disparities are attributable to contextual or compositional factors (Macintyre et al., 1993; Norman, 2016). The Compositional Theory suggests that variations can be explained with regards to the socio-demographic characteristics of the population at each location. Senior et al. (2000) proposes that the foremost factor resulting in the health gradient is that individuals residing within urban areas tend to be much more deprived. The role of rural-urban variations in marriage rates has also been discussed, as married individuals experience lower mortality (Gautier et al., 2009). The reason for this marriage health gap is twofold. Firstly, marriage selection, in which healthy non-married individuals seek healthy partners in the marriage market. Such individuals are also much less likely to divorce. Secondly marriage protection, with married individuals being more likely to participate in preventative medical care then their single counterparts (Guner et al., 2018). Married individuals are also said to be invested in each others health, thus monitor one another's health behaviours, encouraging healthy habits over unhealthy ones (Tumin, 2017). For example, in a study by Guner et al. (2018), a married individual was found to be 23 percentage points more likely to give up smoking if they get married, compared to staying single. By contrast, the Contextual Theory advocates that disparities are, for the most part, a consequence of the inherent variations within a person's residential environment (Ecob and Jones 1998). Allan et al. (2017) discovered that a rural-urban health gradient in illness persisted, although at a reduced level, once compositional factors were accounted for. Research suggests that living within urban areas exposes individuals to unhealthy environments, with reduced green space, increased levels of crime and pollution and close proximity living, resulting in excess mortality by various mechanisms (Bowler et al., 2010; Coutts et al., 2013; Higgins et al., 2010; Lorenc et al., 2012; Ruckerl et al., 2011; Alirol 2011).

Many, however, have warned against the uncritical acceptance of a rural advantage (Watkins and Jacoby 2007; Kyte and Wells, 2010). Levin (2003) reports that remote rural areas display poorer health than those closer to urban locations. As a result of such findings Barnett et al. (2001) suggested the theory of a U shaped association, with large cities and remote rural locations experiencing poorer health outcomes than suburban and semi-rural locations (Verheij et al., 2008). The poorer health outcomes in the most remote rural areas are attributed to a mixture of rural poverty and lack of access to health care services.

If a rural-urban health gradient does exist, then the greatest levels of poor health should be found in the capital cities. However, Riva et al., (2009) found that in the UK London residents were less likely to report their health status as fair or poor than the populations of other UK cities. Further, Norman et al. (2011) noted that London residents are healthier than would be anticipated given their deprivation levels. Whynes (2009) termed this exception the "London effect". One potential explanation is that the healthy migrant selection process exerts a positive influence, concentrating healthier individuals (migrants) within the capital, leading to reduced mortality (Boyle and Norman, 2010).

Some studies disagree with the concept of a rural advantage altogether, suggesting a negative association between health and rurality. Lankila et al. (2012) go as far as to suggest that health decreases inversely to population density. Poor self rated health, LLTI's and age adjusted mortality rates were found to be inflated within the rural context of northern Finland, persisting once socio-demographic factors had been controlled. Further, Hartley (2004) discovered that within the US for 21 out of 23 health indicators (including morbidity and mortality) rural areas ranked poorly. Again, rural poverty and lack of services were the main suggested reasons. Access to health care is increasingly more difficult for those rural dwellers in more geographically extensive countries, as services are widely dispersed at low density, with increased distances and limited transport. Within smaller territories like the UK, the problem is less apparent. Although remote rural areas are more common in some countries (USA and Canada) than in others (e.g., Western Europe), peripheral areas exist in all countries (Smith et al., 2008).

Rural Urban Definition

There is no universally accepted definition of what constitutes rural (Gartner et al., 2011). As a result any observed rural–urban health variations could simply be a consequence of the definitions used (Higgs 1999). Allan et al. (2017) took note of this methodological matter when investigating rates of ill-health across the rural-urban continuum. They tested numerous rural-urban categorisations, and concluded that their results were only slightly influenced by the classification used.

Gender Dimension

While the theory of a gender health gap, with females demonstrating larger life expectancies, was first discovered in developed countries in the 21st century, it has now become a universally accepted phenomenon (Barford et al., 2006). Currently, within the richest nations females are expected to live between 4 to 5 years longer than males (Oksuzyan et al., 2008). Having said this, existing studies suggest that females, at any age appear to be less healthy than males. So why then do females live longer? It is suggested from a behavioural perspective, females are less willing to participate in risk taking health behaviours, such as drugs taking, smoking and excessive drinking. For males, gender theory suggests that masculine ideals are health damaging, through reduced health care seeking actives and higher engagement in risky behaviours. Masculinity dictates that male should be powerful and impervious to health issues, thus males often deny pain, ignore health problems, and fail to seek help (Bates et al., 2009). From a biological perspective, females are seen suffer from nonfatal chronic conditions such as arthritis, whilst males are more likely to suffer from life threatening chronic conditions, such as coronary heart disease (Schünemann et al., 2017).

It is generally assumed that men and women are affected equally by their environmental context. Consequently, sex is either ignored, pooling males and females together, or simply controlled for within the analysis as a linear additive effect. However, Stafford et al. (2005) found that within the UK differences in residential environment, particularly differences in physical environment, affected women's levels of self-reported health far more than men's.

Kavanagh et al. (2006) note that males and females tend to interact with their local environment differently, leading to different exposure risks. Women spend increased time in the local area, as they are most likely to be the primary care giver to their children and so spend increased time at home. Along with increased time occupying the local area, it is argued that women are potentially more vulnerable to the health effects of their surrounding environment. For example, Kavanagh et al. (2006) found that fear of attack led women to engage less with their local environment for leisure and physical activities, both of which are associated with improved mental and physical health. In contrast, neighborhood safety was found to be completely unrelated to male health.

The criticism of 'gender blindness' can also be applied to analyses of the influence of socio-economic circumstances upon health. For example, the vast majority of studies examine socioeconomic heath gradients for males only, assuming that their findings are generalizable to females. Other investigations control for sex, but assume that the affect is additive (Macintyre, 2001); or fail to control for gender at all. In contrast, those few investigations which have studied interactions with gender suggest that social inequalities in health tend to be much steeper for men than for women. In England, Raleigh and Kiri (1997) found a difference of 4 years in life expectancy between men in the top and bottom deprivation categories, compared to only 2.4 years for women.

Gendered differences in health gradient could reflect the inherent difficulty of assessing female social status (Langford and Johnson, 2009). Females tend to possess weaker attachments to the labour market; and receive less pay than male counterparts employed in identical occupations due to a mixture of 'Sticky Floor' and 'Glass Ceiling' effects (Booth et al., 2003; Arulampalam et al., 2007; Geiler and Rennebong, 2015). Women are also more likely to be working in part-time employment unreflective their skills and qualifications, due to traditional gender roles that disproportionately burden women with family caring commitments undertaking a higher share of the domestic chores, including grocery shopping in the local area. This also includes career breaks for childbirth and child-rearing (Macran et al., 1994; Leaker 2008). For these reasons, Johnson (2011) argues that educational attainment may provide a more sensitive measure of socio-economic status for women. Qualifications are both universally applicable and stable over the life course, thus providing a better measure of labour market potential. In this context it is interesting to note that, amongst working age adults in the US, the difference in age-adjusted mortality rates between the top and bottom of the socioeconomic scales, whether measured using income or education, was still found to be greater for males than for females (Papas *et al* 1993).

Research Hypotheses

Given the findings of previous research, we expect first to discover substantial variations in mortality between residential contexts. What is unclear is whether we will uncover increasing or decreasing mortality across the rural-urban continuum. Second, we anticipate that mortality variations will decline once additional compositional characteristics are incorporated into analysis, especially individuals' education and socio-economic status.

However, we are unsure to what degree mortality variations will reduce, and to what extent differences can be attributed to contextual or compositional influences. Finally, we foresee that males and females will display slightly differing mortality patterns across the rural-urban continuum. We anticipate that females will be more sensitive to their residential environment (context) and males more sensitive to their socio-economic status (composition) (Stafford et al., 2005, Kavanagh et al., 2006 and Raleigh and Kiri, 1997). How sensitive is an interesting question that needs an answer.

Method

The ONS Longitudinal Study

The dataset utilised within this investigation is the Office for National Statistics Longitudinal Study (ONS LS). The LS is a record linkage study that links Census and vital event data (births, deaths, immigration) for a 1% sample of England and Wales. The ONS LS sample was originally drawn from the 1971 Census, taking all individuals born on one of four equidistant birth-dates. The same dates were then used to supplement the sample in 1981, 1991 and 2001. The use of the LS for this present study is appealing due to the robust sample size, the high rates of response and retention, and the range and stability of the information available over time (Goldring and Newman 2010; Wallace and Kulu 2014; Franke and Kulu 2017). Utilising individual level data also allows us to avoid making inferences about individuals based upon area-level averages (the ecological fallacy).

Sample Size

This paper utilises the two most recent linked LS samples to analyse patterns of mortality over the period 2001-2011. Although mortality is investigated across the period, it is the attributes/influences from 2001 which are utilised. Our original 2001 ONS LS sample contained 629,871 persons. Of these, 2,425 'untraced' individuals were removed, since they lacked a link to the NHS Central Register which records inter-censal events such as death (reliably) and emigration (unreliably). All individuals who fell outside of the sample age group (younger than 20 years at the time of the 2001 Census) were also removed (119,350). A further 42,450 members were removed as they were not present in the 2011 Census, but had not been recorded as dying or emigrating in the intervening years. The assumption is that they have completed an unreported emigration or were missed by the 2011 Census (lost to follow up). Previous research shows that unrecorded emigration or lost to follow up has little (if any) effect on mortality estimates (Franke and Kulu 2017). This left a final sample of 465,646, spanning 3.6 million person years during which there were 58,842 observed deaths (Table 1).

2011 ONS Rural Urban Classification (RUC)

This study uses a modified version of the ONS 2011 Rural Urban Classification (RUC) of Census Output Areas (OAs), applied to the place of residence of each LS sample member at the start of the observation period (2001). Within this classification, any settlement with over 10,000 individuals is considered urban, with all others classified as rural. Rural and urban OAs are then further classified into 'Urban Major', 'Urban Minor' 'City and Town', ' Rural Town and Fringe', 'Rural Village' and 'Hamlet and Isolated dwellings' using OA density profiles (Bibbly and Brindley, 2013). Allan et al. (2017) found that separating out the Capital City from the other 'Urban Major' areas better reflected the observed district-level rural-urban gradient in self-reported illness. They also found an inner/outer London effect. Therefore, for this study of mortality, OAs lying within the capital were similarly reclassified from 'Urban Major' to 'Inner' and 'Outer' London. In contrast to Allan et al. (2017), the classification is of OAs rather than districts (average population: between 40-100 residents), on the grounds that districts may contain within them smaller zones with rural traits. To our knowledge, this study is the first to use such a fine-grained classification in the study of urban-rural mortality differences (Figure 1).

TABLE 1 ABOUT HERE

FIGURE 1 ABOUT HERE

Statistical Methods

Basic Approach

Survival analysis has been utilised to investigate and compare mortality rates of individuals residing in various residential contexts across the rural urban continuum. The basic model is:

$$\mu_i(t) = \mu_0(t) \times \exp\left\{\sum_j \beta_j x_{ij}(t)\right\} \qquad (1),$$

where $\mu_i(t)$ denotes the hazard (or the 'force') of mortality for individual *i* at age *t* and $\mu_0(t)$ denotes the baseline hazard, that is, the mortality risk by age, which we assume to follow a Gompertz distribution (Pletcher, 1999). A Gompertz model is utilised as human mortality rates increase exponentially with age, reflecting the Gompertz distribution. As a sensitivity (and preliminary) analysis, survival analysis utilising the Cox model was also performed (with no distributional assumptions) with identical results uncovered. Individuals are under the risk at entry (age 20 and over in 2001) and are followed until the event of death, or right censoring at April 2011 (the date of the 2011 census), whichever comes first. $x_{ij}(t)$ represents the values of variables measuring an individual's socio-demographic background with *j* variables; β_j is the parameter estimate for the variable. This modelling approach has been used to first explore rural-urban variations in mortality; and then to analyse potentially gendered differences in how the socio-demographic factors operate.

Rural Urban Variations

A series of five basic models have been fitted. Model 1 studies mortality variations over the rural-urban continuum, controlling for sex and age. Model 2 further divides the sample into two groups: working age (20-64) and post working age (65+), again controlling for sex and age. Model 3 additionally controls for occupational status, to determine whether health variations decline once we control for social class. As occupational status is recorded reliably only for persons aged 20-64, those aged 65+ are not included within this and the subsequent two models. Model 4 additionally controls for level of qualification. Finally, Model 5 controls also for ethnicity and marital status.

Social class, along with highest qualification, represent socio-economic characteristics. Highest level of qualification is categorised as: Level 4+ degree and above, Level 3, Level 2, Level 1, Other, and No qualification. Social class is defined as: Higher managerial and professional; Intermediate occupations; Routine and manual occupations; Never worked/long term unemployed; and Student. Ethnicity and marital status signify socio-demographic characteristics. Ethnicity is categorised as: White, Black, Mixed, South Asian, Other Asian, and Other. Marital status is defined as Single, Married, Separated, Divorced and Widowed.

Gender Difference

Models 1-5 treat sex as a simple linear additive term (main effect). This 'gender blind' approach implicitly assumes that males and females are influenced by their surrounding environment and their socio-economic and demographic attributes in identical ways.

Therefore in the second phase of our analysis we repeat models 1-5, but fitting them separately for males and females, thereby allowing for the possibility that the other terms in the models vary by sex.

Results

Rural-Urban Mortality Variations

Table 2 confirms the existence of an improving health picture from urban to rural locations, which persists regardless of the age group under observation (Models 1, 2a and 2b). For example, when studying those of working age, individuals residing in major urban areas are 54% more likely to die than those in the most rural locations. The risk of dying is reduced parallel to decreasing levels of urbanisation, to its lowest level for those residing in the most rural locations. One anomaly to this improving health along the urban-rural gradient exists, regardless of the age group under investigation. Outer London consistently retains lower mortality than would be anticipated given its degree of urbanisation, with the likelihood of mortality sitting between City and Towns and Rural Town and Fringe locations. For Inner London, levels of mortality are a few percentage points lower than that of experienced in Urban Major areas, for the all age and retirement age populations (Models 1 and 2b). In contrast, for those of working-age (20-64), the largest relative mortality is experienced by those residing within Inner London.

TABLE 2 ABOUT HERE

Model 3 additionally controls for social class, Model 4 for qualification levels and Model 5 for marital status and ethnicity. Once additional covariates are included, particularly social class, differences across the rural-urban continuum substantially reduce across all rural-urban categories. For instance, after controlling for social class the relative morality rates for those in Urban Major areas fall by one-third, from 54% higher than those living in the most rural areas (Model 2a) to 35% higher (Model 3). Crucially, although differences are reduced considerably, the improving health story along the urban rural gradient persists. Having controlled for social class, Inner London, Urban Major areas, Urban Minor areas and City and Town locations remain 41%, 35%, 30% and 31% more likely to die. Again, Outer London remains an anomaly to the gradient.

Variations reduce further once qualifications are included, but only slightly (Model 4). Once ethnicity and marital status are incorporated (Model 5) for Rural Villages, Rural Town and Fringe and Urban Major locations no changes are experienced. For City and Towns, Urban Minor and Inner London, relative mortality is slight reduced. Unexpectedly, for outer London relative mortality increases by 6 percentage points.

The impact of covariates resembles expectations with the exception of ethnicity. The female outlook is consistently better than males, and increased mortality is experienced by those with lower social class and educational levels. Furthermore, as expected, married individuals have much better prospects than those who are single separated, divorced or widowed. Unexpectedly, all ethnic categories have lower mortality than white individuals, which may be related to low mortality among immigrants (Wallace and Kulu 2014).

Gender Differences

The analysis above assumes that there is no interaction between gender and the other covariates in the model, including residential location. Fitting models for males and females separately allows the identification of any potential interaction effects, whether contextual (urban-rural location) or compositional (NSSEC, qualifications, marital status, ethnicity). The results are shown in Table 3. As for Table 2, regardless of the age group under study an improving health pictures exists across the urban rural gradient for both sexes, with the exception of the Capital City (particularly Outer London) and, for working-age adults, either the Urban Major or Urban Minor areas (Table 3 Models 1, 2a and 2b).

TABLE 3 ABOUT HERE

For 'all ages' mortality (Table 3 Model 1), the relative risk of dying is higher for men than for women in every single rural-urban category. For males, the relative likelihood of dying spans from 5% higher for those living in Rural Villages to 39% higher for those living within Inner London. This range is much larger than that experienced by females, for whom the highest relative mortality of 25% is found amongst those living in Urban Major areas. Both males and females experience improving health across the rural-urban gradient, with mortality increasing with level of urbanisation. The exceptions are Inner London (females only) and Outer London (males and females), where lower than anticipated levels of mortality are found.

When studying those of retirement age, the range in health variation across the continuum is once more larger for males than females. Once again males consistently possess higher levels of relative mortality; and once again an improving health picture across the urban-rural gradient is visible for both sexes, with the omission of Outer London for males, and both Inner and Outer London for females.

A change is observed when switching focus to working-age adults (Table 3 Model 2a). For this group males and females share a similar range of relative mortality risks across the different residential categories. For example, working-age males and females residing in Urban Major locations are 52% and 57% more likely to die than those in the most rural locations, a difference of just 5 percentage points between the sexes. In addition, women, rather than men, now experience the highest relative mortality, for all residential categories except Urban Minor. For males, decreasing mortality across the urban-rural continuum remains, with the exception of Outer London. For females, the gradient also persists, but it is not as clear cut as that observed for all ages or those aged 65+. Outer London again possesses lower than expected mortality levels, whilst City and Town areas display higher than expected mortality.

As before, once we control for socioeconomic status (Table 3, Model 3) the improving health picture across the urban-rural gradient remains intact (less clearly so for females), but is reduced in size. This observed reduction in gradient is considerably greater for males than for females. For example, controlling for social class reduces the relative mortality risk for males living in Major Urban areas by 22 percentage points, from 52% to 30%, a 45% reduction. For women the comparable figures are a 14-percentage point (27%) reduction in relative mortality risk from 57% to 43%. The same can be said for all other categories with the exception of Inner London, where the relative risk of mortality, having controlled for social class, reduces equally for males and females in both absolute and relative terms.

Taking account of compositional variations in education further reduces relative mortality risks (Table 3 Model 4), with the exception of Inner London and Rural Villages for males. The level of reduction is significantly smaller than that induced by controlling for social class. However, whereas relative mortality risks reduced most for males when controlling for social class, females are the ones to benefit most from the inclusion of education as an additional covariate. After further controlling for ethnicity and marital status (Table 3 Model 5), variations across the rural-urban continuum remain relatively stable for males, with the exception of areas classified as Outer London, Urban Major or City and Towns, where relative mortality slightly increases. Conversely, for females relative mortality risks see a slight further reduction, except in Inner London, where relative mortality is marginally increased.

Discussion

This study investigated mortality of the 465,646 members of the ONS Longitudinal Study between 2001 and 2011 by residential context, using a set of survival models that in all cases controlled for the effect of age. An improving health picture across the urban-rural continuum was uncovered, with the relative probability of dying found to increase with each successive level of urbanisation, with those in the most urban locations possessing the lowest life expectancy levels, and those in the most rural the best. However, an anomaly to the gradient was Outer London. Rather than experiencing relatively high mortality, as anticipated, Outer London residents actually exhibited comparatively low mortality levels. The observed urban-rural mortality gradient reduced substantially once socioeconomic background and, to a lesser extent, education were controlled statistically. In contrast, ethnic and marital composition explained little of the observed variations. This suggests that the socioeconomic composition of an area is a key driver of relative mortality risks (i.e., part of the urban-rural variation is explained by the fact that there are more individuals with low SES in cities compared to rural areas and small towns). Crucially however, the improving health picture along the urban-rural gradient remained intact once these compositional factors had been accounted for in models. Thus, it appears that residential context also plays a part. These findings, for OA-level mortality outcomes, closely mirror those of Allan et al. (2017) in a study of limiting long-term illness (LLTI) at district level in England and Wales. Levels of LLTI were found to grow with increasing levels of urbanisation, with the exception of London. The capital city was again found to possess better than anticipated health expectations, even more so than in this study, with those located in Outer London possessing health expectations similar to those in the most rural locations. Similarly, this study explicitly demonstrates that there is a significant urban-rural mortality variation, which persists after adjusting for compositional factors.

There are a number of reasons why rural-urban environment might influence mortality risk. These include pollution, crime, levels of green space, proximity to others and the quality/accessibility of local health and other services (Bowler et al., 2010; Coutts et al., 2013; Higgins et al., 2010; Lorenc et al., 2012; Ruckerl et al., 2011; Alirol 2011). Left unexplained is the Outer London Anomaly. Based upon contextual theories, it would be expected that individuals residing within the capital would experience poor health, possibly the worst in England. Yet, at least for Outer London, this expectation was not confirmed. The capital city anomaly is consistent with the results from Allan et al. (2017), suggesting that a more thorough investigation into the capital city itself is warranted.

A second key focus of our study has been an exploration of the urban-rural differentials in the mortality experience of men and women. Studies prior to this investigation have been criticised for a certain amount of gender blindness (Stafford et al., 2005), presuming that rural-urban environments affect males and females the same. We have found this not to be the case, as although mortality reduced across the urban-rural continuum for both sexes, the gradient was steeper for working-age women. At the same time, socioeconomic composition accounted for a greater portion of the male mortality urban-rural difference. These results support the theory that female mortality is more sensitive to residential environment, and male mortality to socio-economic status (Macintyre 2001; Kavanagh et al., 2006). A caveat to these findings is that they may arise from the inherent difficulty in analysing female health using socio-economic classifications based upon occupation. There are conceptual difficulties, as women tend to possess weaker attachments to the labour market, reducing the effectiveness of basing class upon employment (Langford and Johnson, 2009). The gender pay gap further complicates matters, along with female family commitments leading to occupational downgrading (Geiler and Rennebong 2015; Macran et al., 1994). Johnson (2011) states that it is essential for investigations to continue based upon other means of classification, which evaluate the role of social-capital and non-occupational based factors. He suggests that classifications based upon educational attainment may be a more sensitive measure for females. We found that, once qualification level is incorporated, urban-rural mortality differences reduced more for females than males. However, the reduction was marginal, suggesting that either education is a poor proxy for female socio-economic status; or that our findings remain robust in the face of this criticism.

This investigation has contributed to the study of geographic variations in mortality in a number of ways. First, this study applied survival analysis to individual-level longitudinal data, to properly model and adjust mortality estimates to individuals' (rather than area-level) socioeconomic characteristics. Second, the study utilised the spatially fine-grained geography of Output Areas in the analysis of urban-rural mortality. This contrasts with a recent study by Allan et al. (2017), which used Local Authority Districts to investigate self-reported health. Districts have been criticised for being too spatially coarse to capture *local* environmental contexts; and self-reported health as being too vague a measure of health. Third, rather than using a simplistic binary rural-urban dichotomy, a more nuanced eightfold classification based on the ONS RUC was employed, allowing the identification of 'capital city' and 'Outer London' effects. Fourth, this study fitted models separately for males and females, in order to explore the different ways in which the environment and personal socio-demographic factors influence male and female health.

Limitations

Although a strength of this study lies in its ability to provide further insight into rural-urban health inequalities, it is not without its limitations. This study specifically focused upon England and Wales. Consequently, it is vital to contemplate whether the results observed here can be generalised to other countries. In many (continental) European countries we would expect to uncover comparable results, linked to the similarities in features of the rural and urban environments. For some other industrialised countries, however, such as Australia, Canada, and the US, the variations in health over the continuum may be different, due to the extreme remoteness of some rural areas (Lagacé et al., 2007). Research from the US shows that in the early 1990s mortality levels were the lowest in suburbs of metropolitan areas, and they were the highest in central cities; non-metropolitan areas held an intermediate position. However, since the mid-1990s mortality levels have declined faster in metropolitan areas compared to non-metropolitan regions, and since the early 2000s the life expectancy has been higher in cities than rural areas (Cosby et al., 2008; Cossmann et al., 2010; Elo et al., 2018). These findings suggests that the results may vary between countries. It would be interesting to determine what have been the trends in the UK and elsewhere in Europe, that is, whether mortality levels have declined at a similar rate across residential contexts or not?

Further, in terms of methods, it is possible that a spatial scale intermediate between district and OA level is required to best capture the health impacts of local residential context. That said, the consistency of findings at district and OA level are reassuring, suggesting that in future studies of health and residential context it may be possible to use the coarser district-level geographic resolution without substantially jeopardising results. Finally, an issue we must be aware of when considering the results of this study, is that information regarding an individual's place of residence is taken from just one time point (2001). As we are investigating subsequent mortality, we must consider that two influences are at play. Firstly, over the 10-year period a residential environment can alter, and classifications assigned to such an area may become outdated. Secondly, people can change their residential location. With this study utilising such a fine-grained approach to residential classification, it is more likely that people have moved across boundaries. Previous studies have highlighted the substantial impact of such migration upon residential health variations. In fact, Riva et al. (2011) suggested that between 1981-2001 residential mobility account for approximately 30% of urban-rural inequalities over this period. This investigation fails to incorporate such an influence and should look to do so in the future. However, since migration selects individuals based upon certain demographic and socioeconomic characteristics of the kind incorporated into this study, the effects of migration may already have been at least partially accounted for. In addition, as already noted, the results from this paper are consistent with those of the district-level analysis of Allan et al. (2017). Since moves between districts and changes in the rural urban classification are even less common for districts than for the smaller spatial units used in this present paper, this is suggestive that changes in residence or area classification are sufficiently few to have only a limited influence on the results in this paper.

Conclusion

Existing research has demonstrated that mortality varies substantially over differing residential contexts; however, conclusions regarding the nature of these variations are mixed. Further, the causes of such differences remain unclear, in terms of the extent to which compositional factors influence rural-urban mortality, and the extent to which contextual factors play a role, and how such patterns vary by gender. Using survival analysis upon the ONS LS Data, this study demonstrates a clear urban-rural mortality gradient, with the risk of dying increasing with each level of urbanisation, except for those who reside in areas adjacent to London, who consistently possess lower than anticipated mortality. After controlling for individual socio-economic status, variations across the rural-urban continuum reduce substantially however, the gradient persists suggesting the importance of contextual effects. With regards to gender, this study concludes that females tend to be influenced more by their surrounding environment and males by their socio-economic position. Having said this, both males and females experience lower mortality in rural locations as opposed to urban.

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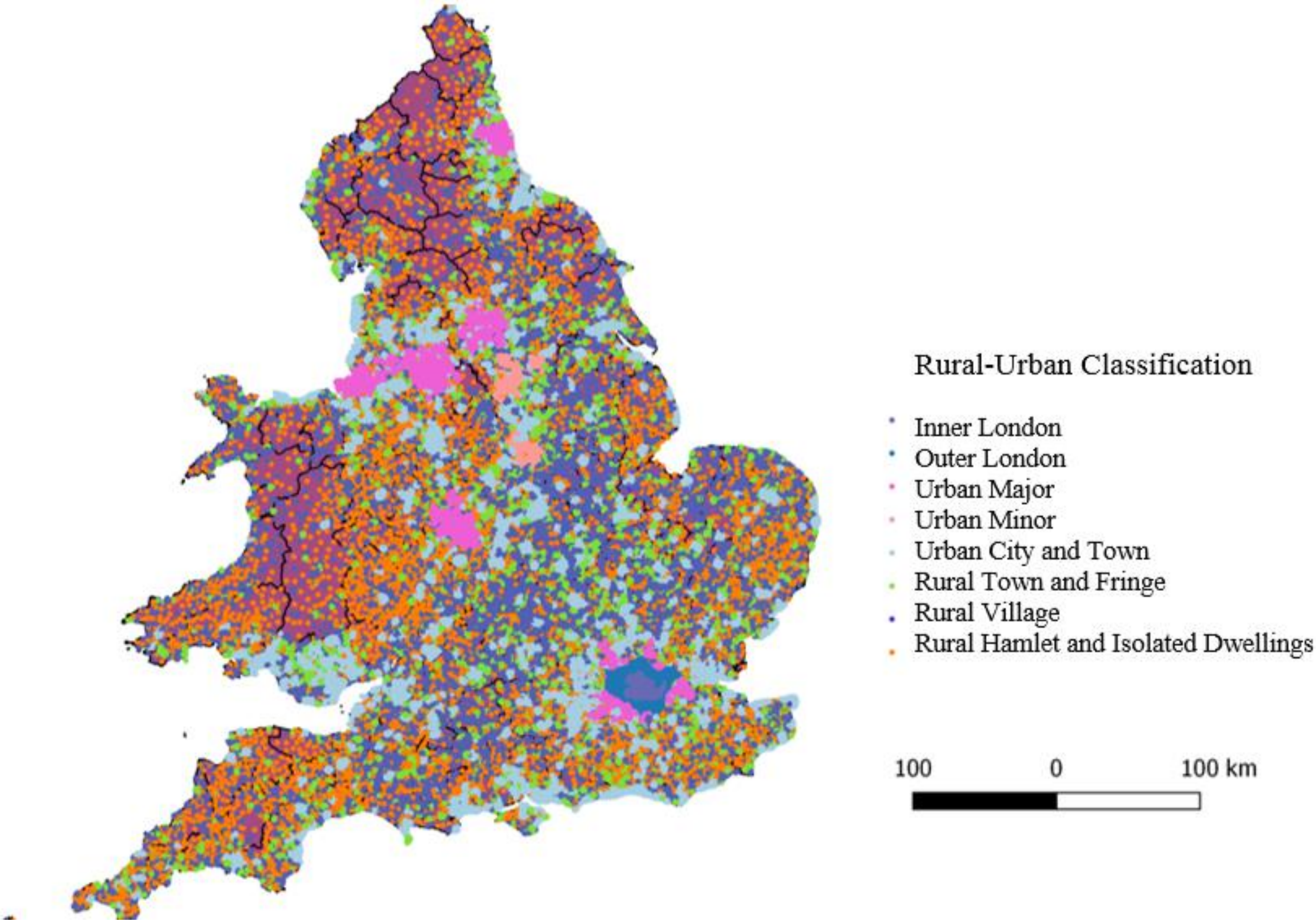

Figure 1: England and Wales Map of Rural-Urban Classification

Table 1: Distribution of risk time and deaths

Covariate	Years at Risk N	Years at Risk %	Deaths	Covariate	Years at Risk N	Years at Risk %	Deaths
Sex				**NSSEC**			
Male	1717185	47	27590	Higher Managerial and Professional	1089579	30	6513
Female	1922842	53	31252	Intermediate Occupation	701826	19	5062
				Routine and Manual Occupation	1279440	35	12991
Age				Never Worked and Long-term Unemployed	135788	4	1688
20-64	2742830	75	8557	Student	119722	3	114
65+	897196	25	50285	Missing / NA	313670	9	32474
Residence				**Marital Status**			
Inner London	145377	4	1899	Single	949625	26	5647
Outer London	312222	9	4371	Married	2044645	56	28105
Urban Major	694106	19	11557	Separated	87731	2	727
Urban Minor	126086	3	2097	Divorced	306036	8	4075
City and Town	1651566	45	27447	Widowed	251989	7	20288
Rural Town and Fringe	348157	10	5982				
Rural Village	225545	6	3526	**Ethnicity**			
Rural Hamlet and Isolated Dwelling	136968	4	1963	White	3337140	92	56999
				Black	73116	2	458
Education				Mixed	25811	1	163
Level 4+ (Degree or above)	672325	18	3177	South Asian	158700	4	1001
Level 3 A Level/Equivalent)	273382	8	933	Other Asian	31454	1	172
Level 2 (GCSE Grades A*-C/ Equivalent)	627763	17	2660	Other	13805	0	49
Level 1 (GCSE Grades D-E/Equivalent)	574728	16	2177				
Other	245179	7	2786	**Total**	3640026	100	58842
No Qualification	982734	27	17320				
Missing/NA	263915	7	29789				

Source: Authors' calculations based on the ONS LS

Table 2 Mortality variations across the Urban-Rural continuum (Hazard Ratios).

	Model 1		Model 2a		Model 2b		Model 3		Model 4		Model 5	
	Age Group											
	20-85		20-64		65+		20-64		20-64		20-64	
	Hazard Ratio	p-value	Hazard Ratio	p-value.	Hazard Ratio	p-value	Hazard Ratio	P-value.	Hazard Ratio	p-value.	Hazard Ratio	p-value.
Residence												
Rural Hamlet and Isolated	1		1		1		1		1		1	
Rural Village	**1.04**	0.22	**1.06**	0.440	**1.03**	0.39	**1.05**	0.55	**1.05**	0.55	**1.05**	0.53
Rural town and fringe	**1.12**	p<.001***	**1.17**	0.03*	**1.11**	p<.001***	**1.10**	0.16	**1.09**	0.21	**1.09**	0.24
City and Town	**1.19**	p<.001***	**1.43**	p<.001***	**1.15**	p<.001***	**1.31**	p<.001***	**1.29**	p<.001***	**1.28**	p<.001***
Urban Minor	**1.27**	p<.001***	**1.49**	p<.001***	**1.23**	p<.001***	**1.30**	0.001 ***	**1.26**	0.01 **	**1.24**	0.01**
Urban Major	**1.30**	p<.001***	**1.54**	p<.001***	**1.25**	p<.001***	**1.35**	p<.001***	**1.31**	p<.001 ***	**1.31**	p<.001***
Outer London	**1.14**	p<.001***	**1.24**	0.003 **	**1.11**	p<.001***	**1.14**	0.07	**1.13**	0.08	**1.19**	0.02*
Inner London	**1.27**	p<.001***	**1.61**	p<.001***	**1.20**	p<.001***	**1.41**	p<.001***	**1.40**	p<.001***	**1.36**	p<.001***
Sex												
Male	**1**		**1**		**1**		**1**		**1**		**1**	
Female	**0.72**	p<.001***	**0.69**	p<.001***	**0.71**	p<.001***	**0.65**	p<.001***	**0.65**	p<.001***	**0.67**	p<.001***
Class												
Managerial							1		**1**		**1**	
Intermediate							**1.21**	p<.001***	**1.08**	0.02*	**1.01**	0.03*
Routine and manual							**1.65**	p<.001***	**1.37**	p<.001***	**1.33**	p<.001***
Never worked/ long-term unemployed							**3.37**	p<.001***	**2.68**	p<.001***	**2.44**	p<.001***
Student							**1.32**	0.03 **	**1.23**	0.10	**1.08**	0.54
Missing							**3.37**	p<.001***	**3.14**	p<.001***	**2.66**	p<.001***
Education												
Level 4									1		1	
Level3									**1.13**	0.034*	**1.11**	0.09
Level2									**1.15**	0.001***	**1.14**	0.002*
Level1									**1.24**	p<.001***	**1.24**	p<.001***
Other									**1.21**	p<.001***	**1.23**	p<.001***
No qualification									**1.57**	p<.001***	**1.56**	p<.001***
Missing									**0.97**	0.92	**1.16**	0.59
Marital status												
Single											**1**	
Married											**0.50**	p<.001***
Separated											**0.80**	p<.001***
Divorced											**0.84**	p<.001***
Widowed											**0.73**	p<.001***
Ethnicity												
White											**1**	
Black											**0.75**	0.003**
Mixed											**0.78**	0.11
South Asian											**0.73**	p<.001***
Other Asian											**0.51**	p<.001***
Other											**0.43**	0.002**

Source: Authors' calculations based on the ONS LS

*** p≤ 0.001 ** p≤0.01 * p≤0.05

Table 3: Gender and the Rural-Urban mortality gradient (Hazard Ratios).

	Model 1				Model 2a				Model 2b				Model 3				Model 4				Model 5			
	Controlling for…																							
	Age and Sex				Age and Sex				Age and Sex				+ NSSEC				+ Education				+ Marital Status & Ethnicity			
	Age Group																							
	20-85				20-64				65+				20-64				20-64				20-64			
	Male	Sig.	Female	Sig.	Male	Sig.	Female	Sig.	Male	Sig.	Female	Sig.	Male	Sig.	Female	Sig.	Male	Sig.	Female	Sig.	Male	Sig.	Female	Sig.
Residence																								
Rural Hamlet and Isolated	1		1		1		1		1		1		1		1		1		1		1		1	
Rural Village	**1.05**	0.25	**1.02**	0.59	**1.03**	0.79	**1.11**	0.38	**1.05**	0.30	**1.01**	0.856	**1.00**	0.96	**1.11**	0.39	**1.01**	0.94	**1.10**	0.42	**1.01**	0.88	**1.10**	0.42
Rural town and fringe	**1.15**	p<.001***	**1.09**	0.02*	**1.11**	0.26	**1.26**	0.04	**1.15**	p<.001***	**1.06**	0.11	**1.03**	0.77	**1.22**	0.07	**1.02**	0.85	**1.20**	0.10	**1.02**	0.80	**1.18**	0.14
City and Town	**1.23**	p<.001***	**1.15**	p<.001***	**1.35**	p<.001***	**1.54**	p<.001***	**1.19**	p<.001***	**1.10**	0.01**	**1.22**	0.01**	**1.46**	p<.001***	**1.20**	0.02*	**1.42**	p<.001***	**1.21**	0.02*	**1.38**	0.001***
Urban Minor	**1.32**	p<.001***	**1.21**	p<.001***	***1.53***	p<.001***	**1.42**	0.01	**1.27**	p<.001***	**1.18**	p<.001***	**1.29**	0.02*	**1.30**	0.05*	***1.25***	0.03*	**1.24**	0.10	**1.25**	0.04*	**1.22**	0.14
Urban Major	**1.34**	p<.001***	**1.25**	p<.001***	**1.52**	p<.001***	**1.57**	p<.001***	**1.30**	p<.001***	**1.21**	p<.001***	**1.30**	0.002**	**1.43**	p<.001*	**1.26**	0.01**	**1.37**	0.002**	**1.28**	0.003**	**1.35**	0.003**
Outer London	**1.18**	p<.001***	**1.10**	0.01**	**1.18**	0.08	**1.33**	0.01**	**1.17**	p<.001***	**1.07**	0.12	**1.08**	0.38	**1.23**	0.07	**1.08**	0.39	**1.21**	0.09	**1.15**	0.13	**1.25**	0.05*
Inner London	**1.39**	p<.001***	**1.17**	p<.001***	**1.61**	p<.001***	**1.62**	p<.001	**1.32**	p<.001***	**1.11**	0.04*	**1.41**	p<.001***	**1.41**	0.01**	**1.42**	0.001***	**1.40**	0.01**	**1.39**	0.002**	**1.33**	0.03*
Class																								
Managerial													**1**		**1**		**1**		**1**		**1**		**1**	
Intermediate													**1.28**	p<.001***	**1.09**	0.09	**1.12**	0.01**	**1.00**	0.99	**1.10**	0.05*	**1.02**	0.66
Routine and manual													**1.80**	p<.001***	**1.42**	p<.001***	**1.48**	p<.001***	**1.18**	0.001***	**1.40**	p<.001***	**1.20**	p<.001***
Never worked/ long-term unemployed													**3.99**	p<.001***	**2.75**	p<.001***	**3.19**	p<.001***	**2.18**	p<.001***	**2.51**	p<.001***	**2.33**	p<.001***
Student													**1.35**	0.07	**1.24**	0.24	**1.23**	0.21	**1.19**	0.36	**1.08**	0.66	**1.07**	0.70
Missing													**3.93**	p<.001***	**2.69**	p<.001***	**6.83**	p<.001***	**2.15**	p<.001***	**5.31**	p<.001***	**1.98**	0.002**

Education								
Level 4	**1**		**1**		**1**		**1**	
Level3	**1.21**	0.01**	**1.05**	0.57	**1.17**	0.04*	**1.03**	0.72
Level2	**1.26**	p<.001***	**1.04**	0.51	**1.24**	p<.001***	**1.04**	0.57
Level1	**1.25**	p<.001***	**1.24**	0.001***	**1.25**	p<.001***	**1.23**	0.002**
Other	**1.32**	p<.001***	**1.06**	0.49	**1.34**	p<.001***	**1.06**	0.47
No qualification	**1.67**	p<.001***	**1.49**	p<.001***	**1.64**	p<.001***	**1.48**	p<.001***
Missing	**0.46**	0.05*	**1.40**	0.42	**0.59**	0.20	**1.59**	0.27
Marital status								
Single					**1**		**1**	
Married					**0.482**	p<.001***	**0.53**	p<.001***
Separated					**0.80**	0.01**	**0.82**	0.04*
Divorced					**0.88**	0.01**	**0.81**	0.001***
Widowed					**0.80**	0.04*	**0.72**	p<.001***
Ethnicity								
White					**1**		**1**	
Black					**0.74**	0.02*	**0.77**	0.06
Mixed					**0.90**	0.58	**0.62**	0.08
South Asian					**0.78**	0.002**	**0.68**	p<.001***
Other Asian					**0.61**	0.01**	**0.38**	0.001***
Other					**0.21**	0.01**	**0.62**	0.11

Source: Authors' calculations based on the ONS LS; *** p≤ 0.001 ** p≤0.01 * p≤0.05