Health and Mortality Variations across the Urban-Rural Continuum: Context, Composition or Migration

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by:

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Chapter 1

1 Introduction

Researchers and academics alike have long been interested in geographic inequalities in health within industrialised countries. Whilst many have attempted to investigate urban-rural variations, an important dimension of residential context, results have proved inconclusive with numerous theories emerging as a result (Teckle et al 2012). One theory to materialise is that of the positive urban-rural health gradient, with poor health tending to increase parallel to increasing levels of urbanisation (DEFRA, 2016, Chilvers, 1978). Others have offered the theory of a U-shaped health continuum, with major cities and remote rural contexts experiencing poorer health in comparison to their semi-urban and semi-rural counterparts (Barnett et al, 2001; Levin, 2003). Finally, some have contested the notion of a rural advantage altogether, proposing a negative urban-rural health gradient (e.g. Lankila et al, 2012).

These urban-rural health variations are immersed in contentious debate regarding the causes of such disparities, whether they be contextual (the residential environment), compositional (the socio-demographic characteristics of the population at each location) or migratory (Macintyre et al 1993, Senior et al 2000, Bowler et al 2010, Coutts et al 2013, Higgins et al 2010, Lorenc et al 2012, Ruckerl et al 2011, Alirol 2011, Wallace and Kulu, 2014 Riva *et al,* 2009). Further, it is unclear if the rural-urban gradient exists/ operates in the same way for all disease types or, indeed, in the same way for mortality and morbidity more generally. Nor is it clear at which spatial scale the urban-rural gradient is best studied.

Consequently, while urban-rural health and mortality variations have been investigated within industrialised contexts, the rural advantage remains contested, and the reasons for such variations poorly understood.

A further aspect of health variations across the continuum requiring attention is gender. Existing studies have for the most part ignored the influence of sex, have been labelled as gender blind, for the majority of studies fail to consider the ways in which health, composition and context interact with gender.

Finally and most importantly, there is no universal definition of what constitutes rural or urban. Thus, academics are currently forced to take a pragmatic approach, and utilise a definition which best suits their research needs. Consequently, investigation have been criticised, suggesting that results are simply a 'data artefact', a consequence of the definition used. It is important for the influence of varying definitions upon results to be tested, in order to clarify if urban-rural health differences exist, or are simply a result of the classification utilised.

Thus the main aims of this thesis are:

1 To explore health and mortality variations across the Urban-Rural continuum within England and Wales for males and females.

2 To study the sensitivity of results to differing rural-urban definitions and spatial scales utilised.

3 To investigate the underlying causes of health and mortality variations, namely to what extent such disparities are attributable to contextual (the environment) compositional (specifically socio-economic status, education, marital status and ethnicity) or migratory causes, and how these differ across the sexes.

Why is this study needed?

Geographical inequalities in health within Britain are some of the largest in Europe. Even more disturbingly, in recent years such inequalities have grown (DEFRA, 2016). The World Health Organisation in 2008 claimed that social injustice was killing on a grand scale, with a toxic combination of *'poor social policies and programs, unfair economic arrangements, and bad politics'* being responsible for producing and reinforcing health inequalities (Marmot and Bell, 2012). In order to resolve spatial health inequalities across England and Wales, specific polices are required. The current lack of understanding and agreement amongst academics, with regards to the spatial health variations and the reasons for these disparities, seriously challenges the governments ability to create and impose policies to address such inequalities.

How will this thesis improve our understanding?

As mentioned earlier, due to a lack of a single accepted rural-urban definition, previous investigation results can be viewed as data artefacts of the definition adopted. Unlike any investigation in existence, this study will analyse the sensitivity of results to differing urban-rural classifications, thus answering critics and demonstrating the robustness of this investigation in ways far beyond any before it. Further, unlike the majority of existing studies, this investigation surpasses the simple rural-urban dichotomy, implementing a fine-grained approach classifying areas within the rural-urban continuum. This is necessary, as it is vital to understand the mortality and morbidity inequalities faced by residents living in nether urban nor rural environments. This investigation further extends our understanding in terms of gender, and the ways in which contextual and compositional factors influences the sexes. Studies before this have assumed that males and females are influenced in identical ways. Thus, they have either ignored sex all together or controlled gender as a linear additive effect. Consequently, the ways in which gender interacts with such factors is not fully understood. Finally, this investigation examines mortality by an individual's residential context and socioeconomic/ demographic characteristics. Exiting studies of England and Wales have utilised crude methods to estimate morbidity/mortality and area level deprivation indices to study urban-rural variations, both accused of being too highly aggregated to present accurate results.

Existing studies of urban-rural health differentials have focused on ecological analysis based on area level aggregates. This raises the issue of results being subject to the ecological fallacy. In this thesis, therefore, attention is fixed firmly upon the investigation if individual level data to help decompose compositional effects on local levels of morbidity and mortality.

1.1 Theoretical Framework:

1.1.2 Urban-Rural Health Gradient

Positive Urban-Rural Health gradient

This concept is related the urban health penalty, the notion that urban areas are characterised by poor health and rural by superior health (Riva et al, 2011). Chilvers in 1978 proposed the theory of a health gradient, suggesting that poor health trends tend to increase parallel to increasing levels of urbanisity. Such a theory is still prominent today, as in 2016 within England, males and females on average were discovered to live two and one and a half year's longer in rural compared to urban locations (DEFRA, 2016).

U-Shaped Health Gradient

Rather than simply accepting the idea of a rural advantage, many have argued that the so called 'rural idyll' is increasingly being recognised as a myth (Kyte & Wells, 2010; Watkins & Jacoby, 2007). Levin in 2003, reported that remote rural areas have a tendency to display poorer health outcomes compared to those boarding main towns. In light of this, Barnett et al (2001) proposed the theory of a U-Shaped association, as remote rural locations along with large cities experience poorer health outcomes, compared to sub-urban and semi-rural locations which fall between.

London: The Capital City Effect

If a positive urban-rural or U-shaped health gradient exists, then the highest levels of mortality and morbidity should be located within the capital city. According to Riva et al 2009 however, this is not the case. Residents of London were found to be less likely to report their health status as fair or poor in comparison to other cities. Further, Norman *et al* (2011) noted that London residents are healthier than would be anticipated given their deprivation levels. This is characterised as the 'London Effect' (Whynes 2009). The healthy migrant effect has been suggested as an explanation for this anomaly, concentrating healthier individuals (migrants) within the capital (Boyle and Norman, 2010).

Negative Urban-Rural Health Gradient

Rather than a positive urban-rural gradient, many studies have suggested a negative association between health and rurality. Lankila et al (2012) postulate that rather than increasing, health expectations in reality reduce with decreasing population densities. Within northern Finland, poor self-rated health, LLTI's and age adjusted mortality rates were found to be much higher in rural context compared to the urban, persisting once socio-demographic factors have been controlled.

1.1.3 Contextual Influence

Academics such as Ecob and Jones (1998) assert that urban-rural health disparities are a consequence of the inherent variations within a person's residential setting. That is, characteristics of the rural and urban environment have a direct impact upon an individual's health.

So what then are the environmental influences? Here are three examples

Green space – There is an abundance of evidence which suggests that natural environments are not only a healthier environment to live in, but also promote improved health related behaviour (Coutts et al, 2013; Bowler et al 2010). Green space is said to increase physical activity, and that activity in such a setting possesses greater physiological benefits (Pretty et al 2005). Moreover, the natural environment is believed to hold inherent curative characteristics, providing protection from the biological effects of stress (Mitchell & Popham, 2008).

Pollution- A range of adverse health consequences have been recognised related to pollution exposure, with those situated closer to the source fairing worse (Ruckerl et al., 2011). Cardio vascular and Cardio pulmonary mortality have been found to increase with increasing pollutant particulates, along with other circulatory diseases such as stroke, coronary heart disease and myocardial infractions (Jenke et al 2009). A clear adversarial connection has also been discovered between pollution, lung functioning and diseases of the respiratory system (Pope & Dockery, 2006).

Crime- The final contextual factor is related to the uneven distribution of crime. Within urban locations the risk of becoming a victim is much greater than within rural. Both crime and the fear of it is said to be associated with a range of negative health consequences and health related behaviours (Higgins et al 2010. Lorenc et al., 2012). Crime is believed to act as a barrier to physical activity, leading to individuals placing restrictions on outdoor activities, resulting in elevated risks of cardiovascular disease and poorer physical functioning (Stafford et al., 2005).

1.1.4 Compositional Influence

The compositional theory suggests that rural-urban health variations can be explained in terms of the socio-demographic characteristics of the population at each location. Senior et al (2000) suggests that the foremost factor resulting in the rural health advantage, is that individuals residing within urban locations tend to be much more deprived. The inverse relationship between social class and health is well established, and within the UK the majority of measures employed to measure deprivation conclude that urban areas are commonly more deprived (Davey Smith, et al 2001). Consequently, academics suggest that once class has been controlled, the tendency towards better rural health disappears. Similar arguments have been proposed in terms of demographic factors such as marriage. Rural individuals are more likely to be married and less likely to be divorced or widowed, the latter associated with excess mortality (Liu, 2009, Sbarra et al 2011, Gautier et al 2009). Finally, ethnic minority concentration within built up areas have also been suggested (Parliamentary Office of Science and Technology, 2007). Having said this, research suggests that migrants tend to have better health than natives (Wallace and Kulu 2014). To conclude, such academics believe that health disparities over geographic areas are simply a reflection of compositional, rather than contextual, bearings.

1.1.5 Migratory Influence

The final explanation is related to internal migration. Migration and health in isolation have received substantial levels of attention. However, it is only recently that the link between the two has been investigated (Lu, 2008). Limiting health explanations to contextual or compositional influence on the current population assumes that populations are stagnant, when in fact they are incredibly dynamic. Migration introduces noise into the analysis thus, it is possible that spatial patterns of health are to an extent a reflection of movement (Geronimus *et al,* 2014).

Pre-migration

Health selective migration

Migration is far from random, as the tendency to relocate varies according to numerous factors, most significantly for this study, health (Kennedy et al 2015). The theory advocates that certain types of moves are facilitated by superior health, and others necessitated by poor health. Consequently, the health of movers and non-movers within the UK will differ substantially (Brimblecombe *et al*, 2000, Norman *et al* 2005).

Healthy Migrant Hypothesis

The healthy migrant hypothesis advocates that migrants are a selectively healthy group, un-representative of the population as a whole (Lu and Qin, 2014, Wallace and Kulu, 2014). Migration leads to considerable disturbance upon an individual's life, and adaption to a new environment is necessary. Thus, good health is vital. Further, individuals holding higher education along with social-economic standing are more inclined to relocate, both of which effect morbidity rates (Lu and Qin, 2014, Kennedy et al, 2015, Kibele *et al,* 2008).

Whilst the theory has been principally focused within the realm of international movement, as of late studies have begun to tackle its existence within the context of internal migration. However, evidence is limited (Tunstall *et al,* 2014). It has been suggested that the intensity of positive health selection may vary in importance, as selection may be more extreme for international movement though this has yet to be fully investigated. (Tong and Piotrowski, 2012).

This health-selective movement of individuals will potentially substantially alter the spatial distribution of health inequalities. Areas of negative health in receipt of healthy migrants will display lower levels of mortality and morbidity, whilst areas of superior health will face a depletion of its healthiest individuals, displaying higher morbidity and mortality levels (Larson et al, 2004).

Salmon Bias

A competing explanation is Salmon Bias theory. This theory suggests that due to an inability to attain high productivity within the labour market, as most movements are in search of better economic returns, unhealthy migrants have a greater tendency to return home (Turra and Ela, 2008 Lu and Quin, 2014). This results in an issue of data artefact, as the morbidity/mortality of those returning home are not captured. Thus, migrant individuals become statistically immortal. Again investigations related to Salmon Bias are rare, and the majority that exist tend to focus upon international migration.

Negative Health Selection

Whilst the concept of the healthy migrant hypothesis is largely accepted, investigations into developed nations have indicated that rather than superior health, a number of movements are in fact associated with failing health (Tunstall et al, 2014). Bentham (1988) postulates two types of movement, the first being assistance migration, which is the movement of ill individuals to be better placed in terms of medical care. The second relates to the movement of those suffering illness, away from the areas presumed to be hazardous to health. Theoretically this will offset spatial health inequalities, as mortality and morbidity will be elevated in areas within care facilities and healthy surroundings, whilst origin areas will exhibit more favourable health outcomes (Norman *et al,* 2005).

Post-Migration

Many postulate that health selective migration will have minimal impact upon spatial health inequalities, as soon after arrival the surrounding environment and the process of acculturation will lead to an alteration in a migrant's health status.

Acculturation

During the process of acculturation a migrant will alter their behaviour, following the cultural and social expectations of the society in which they now live (Urquia and Gagnan, 2011). The effects of acculturation are complex, associated with both positive and negative health outcomes (Wallace and Hill, 2014). Although the vast majority of research is based upon international migration, there is no reason to believe that such mechanisms are not apparent in the context of internal migration. However, this is yet to be fully investigated.

Physical Environment

Along with changes to an individual's behaviour, upon relocation living conditions and the surrounding environment will significantly alter, resulting in health adjustments (Lassetter and Callister, 2009). This change in the environment is so often overlooked within existing literature and requires attention (Delavari, 2015).

1.1.6 Gender

In terms of existing investigations as a whole, the gender dimension tends to be for the most part ignored, as it is assumed that men and women are influenced by their environmental context in identical ways. Thus sex is either ignored, males and females pooled together, or gender is controlled within analyses as a linear additive effect. However, a theory has emerged of late highlighting how males and females are influenced by their residential environment and socio-economic class in significantly different ways (Stafford et al, 2005).

It has been suggested that within the UK, differences in the physical surrounding environment affect female's self-reported health in ways far beyond males (Stafford et al 2005). Kavanagh et al (2006) postulates that men and women interact with their residential environment in considerably different ways, altering the levels of exposure to their surroundings. As females tend to be the primary care givers they spend increase time in the local area, generally being employed in part-time positions, undertaking a higher proportion of the domestic chores such as local food shopping. Further, along with different interactions, it is also contended that females are more vulnerable to the health effects of their residential surroundings.

Along with gender blindness connected

to the physical environment, it can also be found with regards to the analysis of the influence of socio-economic circumstances upon an individual's health. The vast majority of existing studies either fail to account for sex, control for gender as an additive effect or simply examine male socio-economic health gradients, assuming that results are identical for females (Macintyre, 2001). Of the few that have studied gender interactions, it has been discovered that social inequalities in health tend to be much steeper for men as opposed to women. However, it is possible that differences in the health gradient could reflect the difficulties in assessing female social status by occupation, as females tend to possess weaker attachments to the labor market (Langford and Johnson, 2009)

1.1.7 Urban-Rural Definition

Finally, upon investigating Urban-Rural health variations we are faced with a fundamental methodological issue, that there is no universally accepted definition of what constitutes rural (Gartner et al., 2011). Within the literature of rural studies, the difficulty in defining rurality has received a great deal of consideration. However, according to Higgs (1999) in spite of this there is little chance of reaching a definition by which most agree. Due to this uncertainty, the majority of academics resort to taking a pragmatic approach, that is they utilise rurality measures best suited to their own research (Martin et al., 2000). Consequently, by 2007 it was estimated that over 30 different definitions of rurality were being implemented across the UK (Pateman, 2011). Due to this issue, it has been speculated that any urban-rural health differences observed could simply be a data artefact; a result of the method used to define rurality (Higgs, 1999)

1.2 Data

1.2.1 The Census 2001: Small Area Microdata (sample of anonymised records)

Chapter two uses the 2001 UK Census small area microdata. First established in 1801, the census is the most comprehensive source of information within the UK, as it is the only survey which delivers a detailed picture of the entire population. The survey is unique in its ability to span the whole population at the same time, asking identical core questions, enabling the comparison of different groups of individuals.

Every 10 years a survey is sent to each household, containing questions regarding each individual and the household in general. The census contains information upon a variety of topics including demographic and economic factors.

This investigation utilises an adapted version of the 2001 Census, 'The Census 2001: Small Area Microdata' (SAM), created by the Office for National Statistics with input from the census microdata unit. This dataset is a 5% sample of all individuals for all countries within the UK, consisting of 2.96 million cases. The smallest geographic level utilised is the Local Authority district for England and Wales, Parliamentary Constituencies for Northern Ireland and finally Council Areas for Scotland. The dataset consists of information upon a range of topics including age, sex, health, employment, education, social class, and population demographics.

1.2.2 Office for National Statistics Longitudinal Study

Chapter 3 and 4 uses the Office for National Statistics Longitudinal Study (LS). The LS is a study consisting of Linked census and vital events data on a 1% sample of the population of England and Wales. First established in 1974, with a sample enumerated from the 1971 census, selection into the study was based upon dates of birth, using four equidistant dates of the year, generating a sample which could be followed. The study is designed as a multi-cohort continuous study, with members information updated and additional samples subsequently drawn at each following census, using the same selection criteria (1971, 1981, 1991, 2001 and 2011) (Hattersley and Creeser, 1995). The total number of LS members enumerated at each census is approximately 500,000. At present the study contains information regarding over 1 million individuals

Information from the census are linked with data upon vital events, such as entry events (births and immigration), exit events (deaths and emigration) and finally cancer registration. The data is sourced from the National Health Service central register, which is regularly updated with migration, birth and death information.

New members can be added to the LS through one of three pathways, completion of the census, birth registration or registration with the NHS. New members may enter the LS by virtue of birth, if born on one of the LS anonymous birth dates (The recording of births within England and wales are very reliable, as registration is required by law) (Hattersley and Creeser 1995). With regards to immigration, entry is recorded when a patient first registers with a doctor, joining the NHS, or on completion of a census form (Hattersley, 1999). In terms of exiting, this may transpire through death or emigration. By law within England and Wales deaths must be registered, thus they are unlikely to be overlooked. In terms of emigration, an exit will only be noted if the NHSCR is contacted by the Department for social security, indicating that an individual is departing the country for period of 3 or more months, combined with a deregistration from the NHS (however this is not compulsory).

1.2.3 The British Household Panel Survey (BHPS)

Chapter 5 utilises the BHPS, a nationally representative study first established in 1991, unique in its ability to follow the same representative sample of persons (the panel) over a period of years (waves 1991-2009).

The original sample was first selected utilising a stratified clustered design, sourced from the Postcode Address File (8167 issued addresses). Every individual residing at this address during the first wave of the survey were selected as part of the panel, known as original sample members (OSM). The original sample consisted of 5,500 households, roughly 10,000 individuals aged 16+. By 2009 a total of 18 waves had been collected, making the BHPS one of the longest running panel surveys in the world.

Individuals enter the survey through two different pathways. Firstly, babies born to original sample members automatically become original members, and will be interviewed and followed once they turn 16. Individuals can also be included if they reside with an original sample member, and are over the age of 16. These persons are classed at temporary sample members (TSM), as they will cease to be interviewed if the residential situation changes (no longer reside with OSM). A TSM will only become an OSM if they have a child with an original sample member (Tylor et al, 2010)

Every member of the survey is interviewed at each consecutive year. Where individuals are not located at the expected address, they are attempted to be traced using a variety of methods.

In terms of the longitudinal aspect, the survey is made up of core components (questions asked every year), rotating core components (asked every 2 – 3 years) and variable components (one offs). Themes included in the core section comprise of demographic issues such as marital status and ethnicity, socio-economic issues such as employment and education and health and migration issues (Taylor et al, 2010)

1.2.4 Data Summary

The 2001 SAM Census contains variables representing district, limiting long term illness, education, occupation, marital status and ethnicity. Consequently, it enables the investigation of individual health across different residential categories, whilst controlling for socio-economic and demographic influences. Unfortunately, the dataset is cross-sectional thus cannot study change over time, nor does it contain information regarding mortality, a further aspect of this investigation. Unlike the census the LS is longitudinal, containing socio-demographic and economic data along with cause specific mortality. Consequently, it enables the investigation of mortality across different residential categories over a 10-year period. A further advantage of the LS is the geographic scale, rather than district level, the dataset contains a much finer scale of Output Areas. Unlike the LS the BHPS does not contain information reading mortality or cause of death, further the geographic scale is at the higher level of LSOA. The dataset does however hold information regarding individual migration, health and socioeconomic and demographic factors. As a result we are able to investigate health across different residential categories, and the impact of migration whilst controlling for other influences.

1.3 Methods

Throughout this investigation three different methods are utilised, logistic regression, survival analysis and multi-level modelling.

Within chapter 2 the associational method of multivariate binary logistic regression is implemented. This particular technique assess the impact of multiple predictor variables (independent) upon a dichotomous dependant variable (Leech *et al*, 2005). Essentially, it produces a prediction model, generating odds ratios against a reference category that a particular outcome will occur (Verma, 2009). In this instance the method estimates the likelihood of an individual reporting a limiting long-term illness according to their residential location along with other explanatory variables (socio-economic and demographic).

The model is formalised as follows:

$$\ln \frac{p(Y_i = 1)}{1 - p(Y_i = 1)} = \alpha + \sum_k \beta_k x_{ik} , \qquad (1)$$

Where $p(Y_i=1)$ is the probability of suffering from a limiting long-term illness for individual i, α is a constant, x_{ik} is the value of variable k for individual i, with k variables.

Chapter 3 and 4 utilise survival analysis, a set of statistical procedures in which the outcome is time until the occurrence of a certain event (survival time), which within this investigation is death (Kleinbaum and Klein 2012). This method studies the hazard rate h(t), which is the conditional probability that an event (death) occurs at a particular time interval (t). Put simply, it studies the length of time it takes until the event occurs (Mills, 2011). The objective is not to simply study the time until an event, but to investigate the relationship between survival time and explanatory variables (residential location and socio-economic and demographic characteristics)

Individuals are at risk upon entry into the analysis, and are then followed (risk period) until either the occurrence of the event, termed failure, or they become right censored. An individual is classified as right censored if they reach the pre-specified ending time and the event has not occurred. In this case they have survived the whole observation period (Moore, 2016). An individual can also become right censored if they leave the study during the observation time for a number of reasons such as migration or lost to follow up (Mills, 2011).

Chapter 3 utilises parametric survival analysis, as opposed to non-parametric methods, to investigate all-cause mortality of adults across the varying residential contexts. With the latter there is no underlying assumption regarding the hazard function shape. Whilst non-parametric methods are ideal for preliminary analysis, we are confident that the hazard function within this investigation follows a specific pattern, that of the Gompertz distribution, suggesting an exponential increase in mortality with age. The Gompertz distribution is thought to offer a close fit to western adult mortality, and provides more precise estimates (Mills, 2011).

In order to investigate cause-specific mortality, chapter 4 again implements parametric survival analysis. However, this time a Cox propositional hazard model is utilised. As we are not confident in the pattern of the hazard function (of each individual cause of death), Cox analysis is appropriate as it does not require knowledge of the underlying hazard distribution. The hazard function of varying individuals are presumed to be proportional and independent of time. That is the ratio of risk of death is the same for two individuals regardless of how long they survive (Lee and Wang, 2013). Unlike the Gompertz, the method makes fewer assumptions, postulating that covariates influence the likelihood of an event. However, no specific underlying probability is suggested.

$$\mu_i(t) = \mu_0(t) \times \exp\left\{\sum_j \beta_j x_{ij}(t)\right\} \qquad (2),$$

where $\mu_i(t)$ signifies the hazard of mortality for individual i at age t and $\mu_0(t)$ represents the baseline hazard (Gompertz/ Cox). $x_{ij}(t)$ characterises the values of variables measuring an individual's socio-demographic background with j variables; β_j is the parameter estimate for the variable.

Chapter 5

The final chapter uses multilevel modelling (mixed effects logistic regression). This model is similar to the logistic regression methods utilised in chapter 1, in that it will generate prediction models, producing odds ratios against a reference category that a particular outcome will occur. In this instance the model will predict the likelihood an individual reporting their health as fair or poor. Unlike simple logistic regression, multilevel modelling allows for both fixed and random effects.

The data utilised is from the BHPS, which is multilevel in its nature, as it is longitudinal and has a clustered structure, with numerous lower level observations (repeated series of observations) nested within a high-level individual subjects (Wang et al 2011). Simple logistic regression is no longer appropriate as it treats all units of analysis as independent observations. Within the BHPS this is not the case, as within subject observations are dependent, as repeated measures over time are nested within an individual. Such Ignorance of the clustered structure leads to an underestimation of standard errors of regression coefficients, resulting in an overestimated statistical significance.

It is possible that lower level outcomes may be due in part to differences amongst the higher-level groups. Put simply differences in individual's health outcomes may be in part due to the differences between individuals. Multilevel modelling controls for individual and any higher level effects as does standard regression. However, it also calculates confidence intervals and P-values that are correct for the lack of independence between observations due to clustering. Further, the model apportions the variability in outcomes between individuals across the levels in the model.

1.3.1 Covariates

All chapters within this investigation control for the rudimentary demographic factors of age and sex. Table1 displays the additional covariates controlled for (demographic and socio-economic) along with the outcome variable.

Table1 Chapter Covariates

Chapter	**1**	**2**	**3**	**4**
Outcome Variable (Dependant Variable)	Limiting Long -Term Illness	All-Cause Mortality	Cause Specific Mortality	Self-Reported Health
Independent Variable	Age Sex NSSEC Education Marital Status Ethnicity	Age Sex NSSEC Education Marital Status Ethnicity	Age Sex NSSEC Education Marital Status Ethnicity	Age Sex NSSEC Education Marital Status Ethnicity Migrant Status Direction of Movement

Age is consistently controlled for as it the single most important influence upon an individual's mobility and mortality. It is well established that mortality levels increase, and health deteriorates as individuals age. Sex is incorporated as females live longer than males (ONS, 2016). Further, male and female health is postulated to be affected by the environment (contextual) and socio-economic and demographic factors (compositional) differently (Kavanagh et al 2006 and Raleigh and Kiri 1997). Class and Education are controlled for as compositional influences, as those in lower social classes with fewer qualifications are expected to be in poorer health and possess higher mortality levels (Davey Smith et al, 2001 and Batty et al, 2010). Marital status and ethnicity are also compositional influences.

Marital status is incorporated as marriage is believed to have a protective effect when it comes to morbidity and mortality (Gautier *et al* 2009). Ethnicity is adjusted for as it is accepted that those from different ethnic backgrounds will experience different mortality levels (Scott and Timaeus, 2013). Finally, Migrant status and direction of movement are controlled for as migratory influences within this study as both are expected to exert an influence upon morbidity (Lu, 2008, Turra and Ela, 2008, Tunstall *et al,* 2014)

1.4 Chapter Summaries

1.4.1 Chapter 2

Chapter 2 investigates Limiting Long-term illness across the urban-rural continuum within England and Wales, utilising the 2001 Census (Small Area Microdata). Previous investigations have suggested that health substantially differs according to residential location within the Urban-Rural continuum however, results have proven inconclusive. Further, a contentious debate of the causes of such variations exist, whether they be due to compositional or contextual influences. Along with these debates there is a fundamental methodological issue attached to the study of residential locations, that there is no universally accepted definition of what constitutes rural or urban. Thus, it has been suggested that any health variation observed could simply be a data artefact. The aim of this chapter is to clarify just how health varies within England and Wales across the Urban-Rural continuum, and the causes of these differences in terms of compositional or contextual influences. To tackle the methodological issue, a multivariate logistic regression sensitivity analysis is performed. Various rural-urban classifications/ definitions are utilised at the Local Authority level, to investigate the influence that the classification used has on the health variations discovered across the rural-urban continuum. Utilising the 'best fit' classification, further logistic regression is performed incorporating compositional and contextual influences to determine if health variations across the continuum persist once they are controlled.

This chapter is based upon Allan,R. Williamson,P. Kulu,H. (2017) Unravelling Urban-Rural Health Disparities in England. Journal of Population Space and Place 23 (8).

The writing and analysis were undertaken by Allan; advice guidance and editorial support provided by Williamson and Kulu.

1.4.2 Chapter 3

Chapter 3 investigates urban-rural mortality variations in England and Wales between 2001-2011, utilising the ONS Longitudinal study (LS). Existing studies have been accused of gender blindness, as males and females within investigations are either pooled together, assuming that they are affected equally by their environmental and socio-economic/demographic factors, or gender is simply controlled for as a linear additive effect. The aim of this chapter is to assess whether the urban-rural health differences discovered in chapter 2 still exist when studying mortality and when utilising smaller spatial units, in this case Output Areas. Further, the chapter aims to discover if and how mortality differs by gender across the urban-rural continuum, and whether males and females are effected by contextual and compositional factors differently. Survival analysis is utilised, again incorporating compositional factors to conclude if mortality disparities persevere once they are controlled. To tackle the issue of gender blindness, males and females are studied both jointly and separately.

This chapter is based upon Allan, R. Williamson,P. Kulu,H. (2018) Gendered Mortality Differentials over the Rural-Urban Continuum: The Analysis of Census Linked Longitudinal Data from England and Wales. Social Science and Medicine 221 pp:68-78.

The writing and analysis were undertaken by Allan; advice, guidance and editorial support provided by Williamson and Kulu.

1.4.3 Chapter 4

Chapter 4 studies cause specific mortality across the urban-rural continuum in England and Wales, over the period of 2001-2011 using the ONS LS. Although investigating all-cause mortality demonstrates how death varies across the continuum, it is possible that we may miss significant geographic trends in health by specific causes. Of the scant studies which exist regarding specific causes, collective evidence is mixed. Numerous assumptions are drawn in terms of how mortality for specific causes varies over rural-urban areas, along with the causes of such differences whether they by contextual or compositional. Further, the bulk of these investigations have overlooked gender, in spite of substantial evidence that the effect of a person's socio-demographic/economic attributes and residential context may vary considerably by sex. The aim of this chapter is to discover if and how cause-specific mortality varies across the urban-rural continuum, to investigate the drivers of high all-cause mortality in specific areas, and to discover if high all-cause mortality can co-exist with low cause-specific mortality. The chapter also attempts to investigate the reasons for such mortality variations, whether they be contextual or compositional. Finally, the chapter studies cause specific mortality and its interactions with gender. Survival analysis is performed on each specific cause in isolation, controlling for compositional influences, to discover if disparities persist once they are controlled. Further, survival models are run for males and females separately, to investigate the ways in which gender interacts with cause-specific mortality.

1.4.4 Chapter 5

Chapter 5 investigates self-rated health across the urban-rural continuum in England and Wales, over the period of 1991-2009 utilising the British Household Panel Survey. Academics have attempted to explain such urban-rural mortality and morbidity differences in terms of compositional and contextual influences. However, one potential explanatory factor which has been for the most part been ignored is that of migration, and in particular, internal migration. Migration and health are complexly intertwined, and it is possible for internal migration to have a significant impact upon spatial health inequalities. This chapter aims to study the influence of internal migration, distance of relocation and the direction of movement upon urban-rural self-rated health. Multi-level modelling is utilised to study how the health of migrants and non-migrants differs, and how the direction of movement influences an individual's health. Further, migrant status and direction of movement will be controlled for along with other compositional influences, to determine to what extent migration influences existing health variations across the continuum.

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Chapter 2

Unravelling urban–rural health disparities in England

Previous research shows significant health and mortality variations by residential context. Numerous studies report better health and lower mortality among rural populations in comparison to urban residents, whereas other research shows the opposite, with poor health and high mortality in rural areas. This study investigates health variations in England by residential contexts and the causes of such differences. Further, it examines the sensitivity of results to different rural–urban classifications. Applying logistic regression models to individual-level data from the 2001 UK census, significant health variation by residential context are demonstrated. A clear urban–rural positive health gradient is apparent, with levels of ill health increasing parallel to levels of urbanisation. Briefly, people living in rural areas have better health than those living in cities and other urban contexts. However, the capital city (London) provides an exception to the gradient, with its inhabitants having better health than anticipated. Once individual sociodemographic characteristics are controlled, including occupational status and educational level, the urban–rural health variations are reduced, but significant differences still persist. Most notably, Outer London residents have health outcomes similar to those residing in the most rural locations. Clearly, results support the existence of a positive urban–rural health gradient, with the exception of a protective "capital city" effect. These findings persist regardless of the precise urban–rural classification used. Finally, having accounted for composition and the rural–urban context, there still remains a North–South divide in health outcomes[1]

[1] Chapter 2 is based upon the research paper of the same name published in *The Journal of Population Space and Place* 23 (8) (2017)

2. 1 Introduction

Research shows that health and mortality vary considerably by residential context. Previous studies in the UK demonstrate poorer health and higher mortality in the North and West, compared to the South and East (Hacking, Muller, & Buchan, 2011). The results regarding urban–rural variation, a further dimension of residential context, are less conclusive. Historical studies of England support the notion of the urban penalty; in the late 19th century, mortality levels were significantly higher in urban compared to rural settlements (Wood, 2004). Numerous empirical studies indicate the continuation of such a trend, with illness and mortality levels steadily increasing with levels of urbanisation (Chilvers, 1978; DEFRA, 2016; Kyte & Wells, 2010). In contrast, an alternative stream of research has argued that the rural idyll is progressively becoming a myth, as rural communities come to face issues impinging upon their health (Lankila et al., 2012). The hypothesis of a U-shaped health continuum has also been proposed, with rural areas and large cities experiencing relatively poor health outcomes, compared to suburban and semirural areas, which lie in the middle (Barnett, Roderick, Martin, & Diamond, 2001).

The reasons for health and mortality variation across the rural–urban continuum are unclear. Some researchers attribute spatial variation to contextual factors, emphasising the significance of an individual's immediate living environment (Maas et al., 2009; Mungall, 2005; Ruckerl, Schneider, & Breitner, 2011; Stafford, Chandolam, & Marmot, 2007; Wrigley, 2002). Other researchers emphasise the critical role of compositional factors, proposing that health and mortality vary between locations, as different people inhabit different residential contexts (Sloggett & Joshi, 1994). This paper investigates health variations in England by residential context, with a focus upon urban–rural health differences. The objectives are to determine the relationship between an individual's health and residential context, and to investigate the sociodemographic and economic relationships with urban–rural health variations. Logistic regression models are applied to individual-level data from the 2001 UK census to determine the level of urban–rural health variation, with and without adjusting for individual demographic and socioeconomic characteristics. This study extends previous research in the following ways. First, we use large scale individual-level data, allowing for the precise measurement of the relationship between an individual's health and place of residence. Second, we apply multivariate analysis to determine the extent to which individual socioeconomic characteristics explain urban–rural health variation and the extent to which other potential contextual factors play a role. Third, our analysis moves beyond the simple urban–rural dichotomy still dominant in the literature, and distinguishes between multiple residential contexts along the rural–urban continuum. Fourth, given that there is no universally accepted definition of urban and rural, we test the robustness of our findings to different urban–rural classifications.

2.2 Previous research on urban–rural health variation

2.2.1 Urban–rural positive heath gradient

Historical studies of England support the notion of an urban penalty, with urban areas characterised by poor health in comparison to rural areas. Numerous empirical studies indicate the continuation of urban–rural differences (DEFRA, 2016; Riva, Curtis, & Norman, 2011; Wood, 2004). Chilvers (1978) suggested that mortality steadily increases with levels of urbanisation, creating a positive urban–rural health gradient. Charlton (1996) found that for all age groups, people living in rural local authority districts enjoyed the lowest rates of all-cause mortality. Kyte and Wells (2010) demonstrated that overall life expectancy was consistently higher in rural compared to urban locations. Further, DEFRA (2016) found that males and females in rural England on average lived, respectively, two and one-and-a-half years longer than those in urban areas. However, this rural advantage is postulated to vary between population subgroups. O'Rilley et al. (2007), for example, observed that the protective effect of rurality fails to extend into older ages, adding that mortality tends to converge at older age groups. Further, gender is also perceived to have a mediating effect upon the health advantage. Previous studies have argued that residential contexts are highly associated with female health, whilst males tend to be influenced by socioeconomic factors to a much greater extent (Kavanagh, Bentley, Turrell, Broom, & Subramanian, 2006; Stafford, Cummins, Macintyre, Ellaway, & Marmot, 2005).

Many studies assume that the rural health advantage is a consequence of contextual differences (Ecob & Jones, 1998), postulating that the advantage is upheld once socioeconomic and demographic factors have been considered. For instance, Riva, Curtis, Gauvin, and Fogg (2009) using a UK national sample found that one-fifth of rural residents reported poor health, whereas the figure was one-fourth in urban areas, independent of socioeconomic characteristic. Senior, Williams, and Higgs (2000) suggested that one of the foremost factors resulting in mortality and health differentials between rural and urban locations is that individuals residing within the latter tend to be much more deprived. It is well established that deprivation has a strong detrimental relationship with health. Furthermore, within the UK the vast majority of measures utilised to consider disadvantage demonstrate that urban areas are commonly more deprived (Davey Smith, Whitley, Dorling, & Gunnell, 2001).

Consequently, research suggests that once social class is controlled for, the tendency towards better rural health may disappear. For example, Gartner, Farewell, Roach, and Dunston (2011) showed that after controlling for area deprivation utilising the Index of Multiple Deprivation, rural–urban mortality differences reduced substantially.

Similar arguments have been advanced relating to the compositional role of demographic factors. For example, rural residents are more likely to be married, and less likely to be divorced or widowed (Gautier, Svarer, & Teulings, 2009), the latter being associated with excess mortality (Liu, 2009; Sbarra, Law, & Portley, 2011; Waite, 1995). Excess mortality may also be associated with urban concentration of particular ethnic groups, although research shows that immigrants have better health and lower mortality than natives (Wallace & Kulu, 2014).

If rural populations have better health and lower mortality once demographic and socioeconomic characteristics have been controlled for, what then are the contextual factors that account for urban–rural health differences? Maas, Verheij, Groenewegen, de Vries, and Spreeuwenberg (2006) argue that the availability of green space is an important factor in explaining the rural–urban health variations. There is growing evidence that natural environments have independent salutogenic effects, as they are both healthier environments to live in and promote improved health-related behaviour (Coutts, Chapin, Horner, & Taylor, 2013; Maas et al., 2009; Bowler, Buyung-Ali, Knight, & Pullin, 2010). Research suggests that exposure to green space enhances physical activity, and that activity in such settings has superior physiological benefits (Pretty, Peacock, Sellens, & Griffin, 2005). Furthermore, according to restoration theory the natural environment is said to possess inherent curative qualities, encouraging restoration from attention fatigue (Bowler et al., 2010). Contact with green space also provides protection from the biological effects of stress, reducing diseases of the circulatory system (Mitchell & Popham, 2008).

Another contextual factor is the uneven distribution of crime. The risk of becoming a victim of any household crime is higher in urban compared to rural areas (Higgins, Robb, & Britton, 2010). Higher levels of neighborhood crime have been associated with a range of negative health consequences, including all-cause mortality as well as health-related behaviours (Lorenc et al., 2012). Research suggests that crime acts as a barrier to health-promoting physical activities. It leads to avoidance behaviours, as urban individuals place restrictions on outdoor activities, with elevated risks of cardiovascular disease and poorer physical functioning (Stafford et al., 2007).

Pollution may also play a role. Epidemiological studies have identified a spectrum of adverse health consequences due to exposure, with those located closer to the source, such as urban traffic pollution, faring worst (Ruckerl et al., 2011). Studies have revealed that there is a clear increase in cardiovascular and cardiopulmonary mortality associated with pollutant particulates (Laden, Schwartz, Speizer, &

Dockery, 2006). Jenke, Propper, and Henderson (2009) also observed positive associations with circulatory diseases such as acute myocardial infractions, stroke, and coronary heart disease. This complements other research suggesting a clear adversarial association between pollution, lung functioning, and respiratory system diseases (Pope & Dockery, 2006).

2.2.2 U-shaped health continuum

Many researchers have warned against the uncritical acceptance of the positive urban–rural health gradient, as the "rural idyll" is increasingly being recognised as a myth (Kyte & Wells, 2010; Watkins & Jacoby, 2007). Bentham (1984) found a tendency for more remote rural areas to experience higher than expected mortality rates, whilst rural areas bordering main towns had lower than anticipated mortality. In light of such findings, Barnett et al. (2001) proposed the theory of a U-shaped association between mortality and population density. The most densely populated locations and the most sparsely populated experience relatively poor health outcomes compared to their counterparts, which fall within suburban and semirural areas (Verheij, Maas, & Groenewegen, 2008). Jordan, Roderick, Martin, and Barnett (2004b) study of South West England provides supporting evidence, concluding that levels of limiting long-term illness (LLTI) display upward trends in more remote areas, particularly for the working-age population.

2.2.3 The capital city of London—an exception?

London can also be used to question the validity of the urban–rural positive health gradient and the notion of a U-shaped association. London is the most populated urban zone within the UK, thus it would be expected to experience the poorest health and the highest mortality levels. According to Riva et al. (2009) this is not the case, with residents of London being less likely to report their health status as fair or poor, in comparison to residents of other cities. Moreover, Norman, Boyle, Exeter, Feng, and Popham (2011) suggested that people within London are healthier than would be anticipated given their deprivation levels: an outcome Whynes (2009) characterised as the "London effect". The precise reasons for this are unclear. It is believed that London benefits from being situated within the southeast, the wealthiest and healthiest region within the UK. Further, the health selection processes are thought to exert a positive influence. London experiences the highest levels of population growth through internal and international migration. Thus, the low mortality experience is thought to be a consequence of the healthy migrant effect, concentrating healthier individuals within the capital (Boyle & Norman, 2010). On the other hand, Martin, Brigham, Roderick, Barnett, and Diamond (2000) note the pro-urban bias of most area-based deprivation indicators, emphasising the need to revisit this question using individual-level data.

2.2.4 Urban–rural negative health gradient

Studies on health in London and sparsely populated areas have led some researchers to conclude that the relationship between health and level of urbanisation is positive rather than negative. Lankila et al. (2012) suggested that the share of individuals with poor health tends to increase with decreasing population densities. They observed that mortality rates and poor self-reported health tended to be elevated within the rural context, persisting once sociodemographic factors have been controlled. Smith, Humphreys, and Wilson (2008) suggested that rural disadvantage will aggravate the effects of socioeconomic disadvantage, leading to poorer health outcomes than would be expected from deprivation levels. Numerous reasons have been proposed to explain poor health in rural areas.

In the UK, health service centralisation has occurred at an increasing pace (Mungall, 2005; Powell, 1995), leading to the demise of rural health services. Studies have demonstrated that the utilisation of services is inversely related to the distance a patient lives from facilities (Gulliford & Morgan, 2013). As a result, residents will take up services less frequently, leading to adverse health outcomes (Farmer et al., 2006). Haynes and Bentham (1982) showed that consultation rates were substantially higher in urban areas than rural locations for those with an LLTI. The lowest consultation rates were observed in those distant rural areas without health facilities. Although in later work Haynes suggested this issue is not as great as first thought. Such a disadvantage is not felt uniformly, as private transport within rural areas varies, with the elderly and lower classes less likely to possess a car (Jordan, Roderick, & Martin, 2004a).

There is consistent evidence that geographical variations in mortality and morbidity mirror variations in food consumption patterns, reflecting local accessibility of healthy foods (Wrigley, 2002). Research shows that the majority have a good knowledge of what constitutes a healthy diet, but that for rural dwellers location conspires against its implementation (Liese, Weis, Pluto, Smith, & Lawson, 2007). As the power of the multiple has grown, so the market has become made up of fewer and larger urban based retailers (Furey, 2001), leading to inequitable shopping provision. Rural residents, unable to access large multiples, are forced to shop in small independent stores instead (Dawson et al., 2008). A study conducted by Liese et al., (2007) discovered that the availability of healthy food was substantially higher in supermarkets in comparison to independent stores. Hence, Wang et al. (2010) found that healthy food was more readily available in urban than in rural environments (Wang et al., 2010). There is also a price penalty with healthy produce costing approximately one-third more in rural environments (Shaw, 2014). This situation is exacerbated for those living in remote locations, as due to store monopoly retailers are able to charge extortionate prices (Bell, Mora, Hagan, Rubin, & Karpyn, 2013). Consequently, it is argued that healthy food options are no longer affordable to isolated rural residents (Lee et al., 2007).

2.2.5 Methodological issues of previous research

The vast majority of studies investigating rural–urban health variations and the influence of contextual and compositional factors use ecological data and area-based deprivation or socioeconomic measures (such as that of the Townsend Index). Numerous studies investigating measurements of rural deprivation have questioned the validity of the frequently used area-based indices. Such traditional measures are thought to be biased towards the urban community (Levin & Leyland, 2006), leading many researchers to conclude that the use of such indices will lead to severe misrepresentation of deprivation within rural areas (Kyte & Wells, 2010).

Further, the analysis of relationships between variables using ecological data may over or underestimate the strength of the relationships between various individual characteristics, or even show relationships that do not exist if individual-level data were analysed. This is because, for example, health status is directly affected by personal employment status; and only very indirectly, if at all, by the employment status of others. In contrast, the health benefits of a rural environment will accrue to all living within it.

A second challenge is that there is no universally accepted definition of what constitutes rural (Gartner et al., 2011). Over the past two decades the problem of defining rurality has received a great deal of attention within the rural studies literature. In spite of this, according to Higgs (1999) there is little chance of reaching a consensus definition. As a consequence, most academics take a pragmatic approach, utilising measures best suited to their own research needs (Martin et al., 2000), ranging from an emphasis on population density through functional labour market areas to the nature of local service provision, land use, and built form. By 2007, it was estimated that approximately 30 different definitions were in use across the UK (Pateman, 2011; Scott, Gilbert, & Gelan, 2007). Because of these methodological issues and constraints over the exact definition of "rural," any observed rural–urban health variations could simply be a data artefact—a consequence of the methods used to define rural areas (Higgs, 1999).

2.3 Research questions

Based on previous research, we expect to find significant health differences by residential context. We also expect health variation by residential context to decline once we control for individual characteristics. What remains unclear is, first, whether we will observe a positive or negative urban–rural health gradient; and second, to what extent residential variations in health are explained by compositional factors. We also expect results to be sensitive to the area classification utilised. What is uncertain is how and to what extent the urban–rural health gradient will alter. Finally, we expect much of the spatial variability in health outcomes to be accounted for by urban–rural area type and local population composition. Having done so, what remains unclear is the extent to which any wider regional health effects will still persist.

2.4 Data and methods

2.4.1 Data

The study uses a sample of anonymised records of the 2001 UK census; this is a 5% sample of census microdata, with a total of 2.96 million individual records. The study population is restricted to the 1.79 million individuals aged 20 and older. The data allows the cross-classification of individuals by 10-year age groups, place of residence, occupational status, and limiting long-term illness, enabling the examination of the relationship between health, social class, and rural–urban residence at the individual level.

We use limiting long-term illness as a proxy for individual health status; information which comes from the 2001 census question, “Do you have any long term illness, health problem or disability which limits your daily activities or the work that you can do?” This dichotomous variable relies upon self-assessment, thus it does not reflect any direct medical diagnosis, challenging its objectiveness (Bentham, Eimermann, Haynes, Lovett, & Brainard, 1995). Having said this, previous research provides support for this approach, reinforcing the validity of utilising self-assessed measures of health (Rees, Wohland, & Norman, 2009). For example, studies have discovered that results of LLTI correlate well with data regarding General Practitioner (GP) consultations, along with outpatient hospital visits (Boyle, Norman, & Rees, 2002). Moreover, self-rated health has been revealed to be a powerful predictor of subsequent mortality, suggesting that individuals are good judges of their own health (Drever, Doran, & Whitehead, 2004).

Control variables used in this study are “Age,” “Sex,” “Occupational status,” “Highest level of Qualification,” “Ethnicity,” and “Marital status.” “Ethnicity” was recoded into six categories consisting of: White (White British, White Irish, White Other), Black (African and Caribbean), South Asian (Indian, Bangladeshi, and Pakistani), Other Asian (Chinese and Other Asian), and Mixed and Other. “Highest level of Qualification” also comprises six categories: “Level 4/5” (First degree, Higher degree), “Level 3” (A levels) “Level 2” (5+ General Certificate of Secondary Education (GCSEs)), “Level 1” (1–4 GCSEs), “No Qualification” and “Other Qualification/Level Unknown.” “Occupational status” was recoded according to NSSEC- National Statistics Socio-Economic classification, into five categories: Upper class (managerial and professional occupations); Middle class (intermediate occupations); Lower class (routine and manual occupations); Never worked/Long term unemployed; and Not applicable. Those individuals aged 20 to 64 lacking a recorded occupational status were distributed evenly across age groups for both males and females. The same cannot be said for individuals aged less than 20 or over 64. Thus this variable is representative of the working age sample, but not of the “non-working age” (<20; 65+) sample. Retired individuals are substantially different to those NA’s of a working age. This is taken account of in the analyses that follow, with socio-economic influence controlled for only when investigating the working age population (Table 1).

Table 2.1 Census Descriptive statistics of the sample

	Overall		LLTI	
Variable	**Count**	**Percentage**	**Count**	**Percentage**
Age				
20–24	114527	6.4	7535	6.6
25–29	156264	8.7	10975	7.0
30–39	376327	21.0	34908	9.3
40–49	325300	18.2	46143	14.2
50–59	307807	17.2	70776	23.0
60–64	119013	6.7	40443	34.0
65–74	204573	11.4	84063	41.1
75–84	137360	7.7	78920	57.5
85+	47538	2.7	36186	76.1
Sex				
Male	855942	47.9	185570	21.7
Female	932767	52.1	224379	24.1
Marital status				
Single	431164	24.1	64033	14.9
Married	989200	55.3	20475	20.7
Separated	368345	20.6	141165	38.3
Ethnicity				
White	1662477	92.9	386104	23.2
Black	32211	1.8	6084	18.9
Mixed	14394	0.8	2490	17.3

South Asian	59063	3.3	12264	20.8
Other Asian	13788	0.8	2177	15.8
Other	6776	0.4	830	12.2
Residence ONS RUC London adjustments				
Inner London	90633	5.1	17935	19.8
Outer London	166363	9.3	32998	19.8
Major urban	357674	20.0	92482	25.9
Large urban	261935	14.6	64085	24.5
Other urban	242581	13.6	55741	23.0
Significant rural	237491	13.3	51333	21.6
Rural 50	216007	12.1	48472	22.4
Rural 80	216025	12.1	46903	21.7
NS-Sec				
Managerial and professional	479802	26.8	36337	7.6
Intermediate	284500	15.9	30043	10.6
Routine and manual	465390	26.0	61695	13.3
Never worked/long term unemployed	60739	3.4	22112	36.4
N/A and not defined	498278	27.9	259762	52.1
Education				
Level 4/5	337521	18.9	34584	10.2
Level 3	108159	6.0	10992	10.2
Level 2	284370	15.9	33536	11.8
Level 1	270869	15.1	32855	12.1
Other qualification/ level unknown	120408	6.7	27121	22.5
No qualification	482484	27.0	155755	32.3
N/A	184898	10.3	115106	62.3
Total	**1788709**	**100.0**	**409949**	**22.9**

Abbreviations: LLTI = limiting long-term illness; ONS = Office for National Statistics; RUC = rural–urban classification

To explore the impact of rural–urban classification upon the observed rural–urban health gradient, this paper compares six alternative classifications of the Local Authority Districts (LADs) within which individuals reside. LADs are administrative spatial units with populations in the range of 2,153 (Isles of Scilly) to 977,087 (Birmingham) with a median of 112,797 individuals.

The first rural–urban classification (RUC) considered is the Office for National Statistics (ONS) 2001 RUC, consisting of a six-fold core grouping made up of: Major Urban, Large Urban, Other Urban, Significant Rural, Rural 50, and finally, Rural 80. This classification categorizes LAD according to settlement size and built form, with the main emphasis upon identifying the type of settlement along with the wider geographical context in which such settlements are placed (Kyte & Wells, 2010).

Whynes (2009) and Norman et al. (2011) both suggest that the capital city might provide a protective health effect. For this reason our second classification again utilises the ONS RUC, but separates out London from the other "Major Urban" locations; whilst the third classification further subdivides London into Inner and Outer London. In both cases London LADs are categorized using the ONS London Borough classification.

The fourth classification relies upon the idea of "functional regions" (cf. Halas, Klapka, Tonev, & Bednar, 2015), utilising LADs population size, density, and commuting flows. Functional regions were created by merging LADs linked by commuting flows of at least 15% of the employed population in the origin LAD in 2001, provided the destination LAD had a population of at least 200,000. The resulting functional regions were then classified according to their population density (residents per km^2) as follows: London, Cities 3,000+, Cities 2,000+, Counties 1,000+, Counties 500+, Counties 250+, Counties 100+, and finally, Counties <100 residents per km^2. A similar classification, combining settlement hierarchy (based on LAD population size and density) with functional regions has previously been used in the study of urban–rural fertility variation to control for the effect of selective residential moves (Kulu & Washbrook, 2014).

The final two classifications considered only population density, using alternative sixfold classifications (equal intervals and sextiles), as there is no logical breakpoint for any measure of population density, meaning that any categorisation is necessarily artificial (Higgs, 1999). A six-fold categorisation was used to match the six categories in the original ONS 2001 RUC.

2.4.2 Methods

We use a logistic regression model to study health by residential context. The model is formalised as follows:

$$(1)\ In\ \frac{p(Yi=1)}{1-p(yi=1)} = a + \sum_k \beta_k x_{ik1}$$

where $p(Y_i = 1)$ is the probability of suffering from a limiting long-term illness for individual i, α is a constant, x_{ik} is the value of variable k for individual i, with k variables. The results are presented in the form of odds ratios, that is, odds of having an LLTI for a particular group relative to the reference group. The reference categories for each variable are as follows: age (youngest), ethnicity (White), sex (male), marital status (single), occupational status (managerial and professional occupations), highest level of qualification (Level 4/5), and residence (rural 80). In our model, urban–rural residence is treated as a fixed effect which fully captures the clustering of individuals within urban–rural classes.

Model 1 controls for age and sex (all ages). Model 2 divides the age range into two smaller groups, 20 to 64 ("working age") and 65+ ("post working age"). Occupational status is recorded reliably only for persons aged 20 to 64. For the working-age population only, Model 3 controls for occupational status to determine if health variations decline once we control for social class. Model 4 additionally controls for level of qualification. Finally, model 5 further controls for ethnicity and marital status.

As previously mentioned there is no universally accepted definition of what constitutes rural, thus researchers have suggested that any observed health variation would potentially be a reflection of the classification used. In an attempt to select the best classification possible and to test the robustness of results, each of the five logistic regression models outlined above were fitted utilising the six alternative RUCs under consideration.

One stream of research has shown that residential environment has a stronger association with self-reported health among women (Kavanagh et al., 2006; Stafford et al., 2005). Alternatively, apparent gender differences may largely be due to the inability of occupational status to capture the effect of socioeconomic status on mortality among women. To explore the interaction of sex with these factors, we initially conducted our modelling process separately for males and females. However, the results that emerged were broadly similar, with a comparable rural–urban health pattern identified for each sex. The only noteworthy exception was for

Model 3, which found that male health was influenced by social class to a much greater extent than female health. For simplicity's sake, therefore, this paper presents results from models in which sex is included only as a main effect.

2.5 Analysis

2.5.1 Model fits

For each rural–urban classification, Table 2.2displays the fit of Model 1, and the improvement over successive models as additional covariates are added. The results for Model 2 show that the best performing RUC is an extended ONS RUC, which distinguishes Inner and Outer London. Notably, separating the capital into Inner and Outer London improves the model fit considerably compared to the original ONS RUC.

Table 2.2 Model fit and improvement

Model	Rural–urban classification					
	ONS RUC	**ONS RUC L Sep**	**ONS RUC L inner outer**	**Density sextiles**	**Density equal intervals**	**Functiona l regions**
Model Fit (−2 Log Likelihood)						
1. Age and sex	1117625.4 2	1117625.4 2	1117625.4 2	1117625.4 2	1117625.4 2	1117625.4 2
Improvement compared to previous model (Reduction in − 2 Log Likelihood)						
2. Age, sex and classification	2887.665	3665.012	3932.059	3474.484	1344.827	3386.001
3. Age, sex, classification and NSSEC	108737.82 4	108403.30 6	108247.18 7	108409.52 3	109542.95 7	108833.10 8
4. Age, sex, classification , NSSEC and education.	6529.257	6352.835	6368.499	6483.413	6710.492	6344.28

5. Age, sex, classification, NSSEC, education, marital status and ethnicity	7657.309	7771.094	7691.692	7648.457	7739.186	8018.594
7.Age, sex, classification, NSSEC, education, marital status, ethnicity and north south	1464.831	1082.661	1082.382	N/A	N/A	N/A

Abbreviations: NSSEC = National Statistics Socio-economic Classification; ONS = Office for National Statistics; RUC = rural–urban classification

As might be expected, model fit improves for all classifications as additional covariates are added. However, the largest improvement is observed when National Statistics Socio-economic Classification is controlled for. Having taking account of RUC and the compositional variables in the model, controlling for regional location (North–South) still leads to model improvement.

Given these results, the remainder of this paper focuses on models utilising the extended ONS RUC, justified both by the observed superiority of model fit, and by theoretical considerations. The ONS RUC was devised to reflect critiques of existing classifications and is recommended by DEFRA (2005) as the "de facto" standard for the analysis of rural–urban differences; whilst others have also noted the possible existence of a "capital city effect" (Norman et al., 2011; Whynes, 2009).

2.5.2 Results: Rural–urban health differentials

Figure 2.1 demonstrates that levels of limiting long-term illness vary by both age and place of residence. As anticipated the proportion of individuals possessing an LLTI increases with age (Marshall & Norman, 2013). For younger age groups (20–39), levels of illness by residential location appear to be largely similar (within a 3% range), chiefly explained by small absolute differences between the residential groups and reduced levels of LLTI in younger cohorts. From age 40 onwards a rural–urban health gradient is more clearly detectable. Individuals residing within major urban areas consistently possess the highest levels of LLTI, whilst the lowest levels are experienced by those living in the most rural locations. Levels of ill health increase with levels of urbanisation, with the exception of London, which experiences reduced levels of LLTI, most notably in Outer London where levels of LLTI are similar to those in "significant rural" locations.

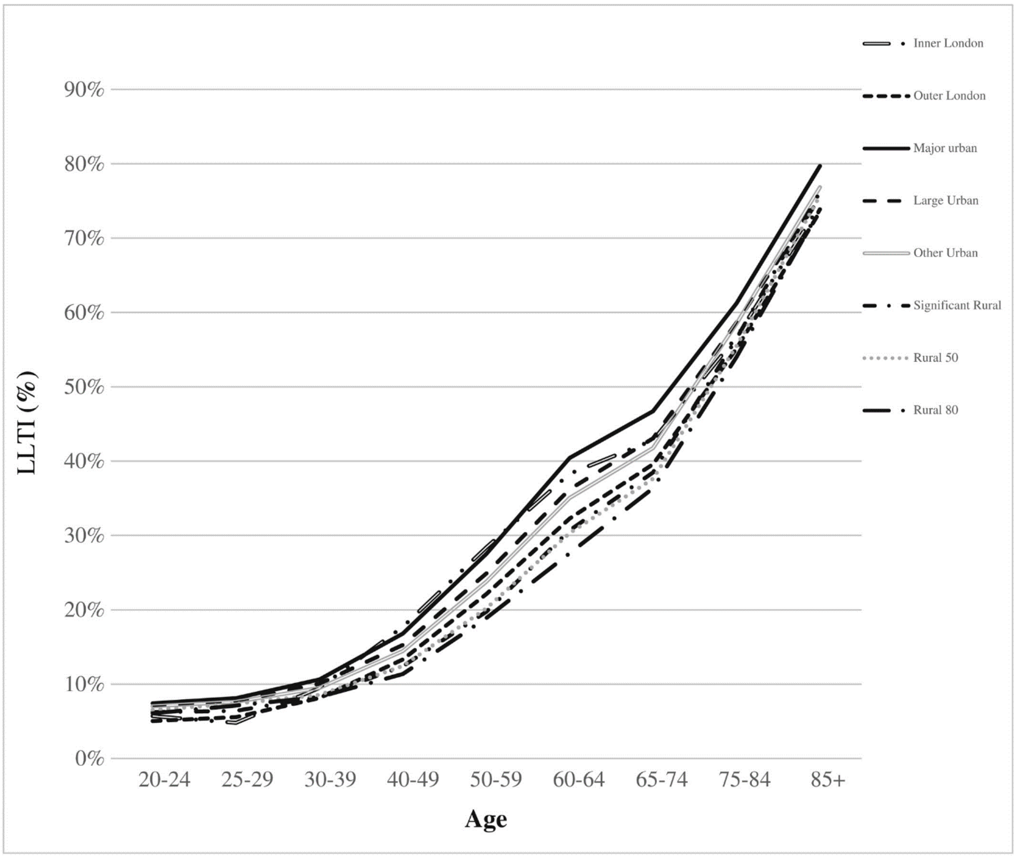


Figure2.1 Share of individuals with limiting long-term illness (LLTI)

As Table 2.3 shows, the observed rural–urban health gradient persists regardless of whether we study all adults (Model 1); working age adults (Model 2a); or pensionable age adults (Model 2b). For example, those individuals aged 20 to 64 residing in Major Urban areas are 54% more likely to develop an LLTI in comparison to those residing in the most rural locations. Furthermore, the odds are also relatively high for those residing in Large Urban areas (37%) and Other Urban areas (30%; Table 32.4, Model 2a). One main exception to the gradient exists: London. Rather than displaying the highest relative levels of LLTI, levels in the capital are actually lower than expected. Whilst working-age adults in Inner London are still 41% more likely to develop an LLTI than those residing in rural locations, they are 13 percentage points less likely than those residing in major urban locations. Outer London residents fare even better, with observed health risks almost as low as for those in rural locations. Overall we conclude that the urban–rural health gradient is more or less constant with age within the working age population (20–64), whilst that the gradient reduces, but persists, into old age. Norman and Boyle (2014) report similar evidence of convergence in the ill health experience at older ages when examining health differences between areas with differing levels of deprivation.

Table 2.3. Logistic regression results (an extended ONS rural-urban classification, which distinguishes Inner and Outer London)

	Model 1 20–85+	**Model 2 a 20–64**	**Model 2 b 65–85+**	**Model 3 20–64**	**Model 4 20–64**	**Model 5 20–64**
Rural 80						
Rural 50	1.08***	1.09***	1.06***	1.08***	1.07***	1.07***
Significant rural	1.08***	1.07***	1.10***	1.06***	1.05***	1.04***
Other urban	1.27***	1.30***	1.23***	1.23***	1.20***	1.17***
Large urban	1.33***	1.37***	1.25***	1.27***	1.23***	1.20***
Major urban	1.51***	1.54***	1.45***	1.34***	1.28***	1.25***
Outer London	1.11***	1.13***	1.09***	1.05***	1.05***	1.01
Inner London	1.35***	1.41***	1.21***	1.22***	1.23***	1.12***
Male						
Female	.99**	.97***	1.02**	.72***	.73***	.74***

Professional/ higher managerial					
Intermediate occupations			1.41***	1.23***	1.22***
Routine and manual occupations			1.84***	1.45***	1.43***
Never worked and long-term unemployed			8.32***	6.05***	5.55***
Not applicable/not defined			10.17***	8.15***	7.95***
Level 4/5					
Level				1.11***	1.11***
Level 2				1.17***	1.18***
Level 1				1.20***	1.21***
Other qualification/level unknown				1.47***	1.50***
No qualification				1.83***	1.83***
White					
Black					1.00
Mixed					1.17***
Indian					1.12***
Asian					.89***
Other					.70***
Single					
Married					.59***
Separated					.93***

- *** $p < 0.01$
- ** $p < 0.05$
- * $p < 0.10$

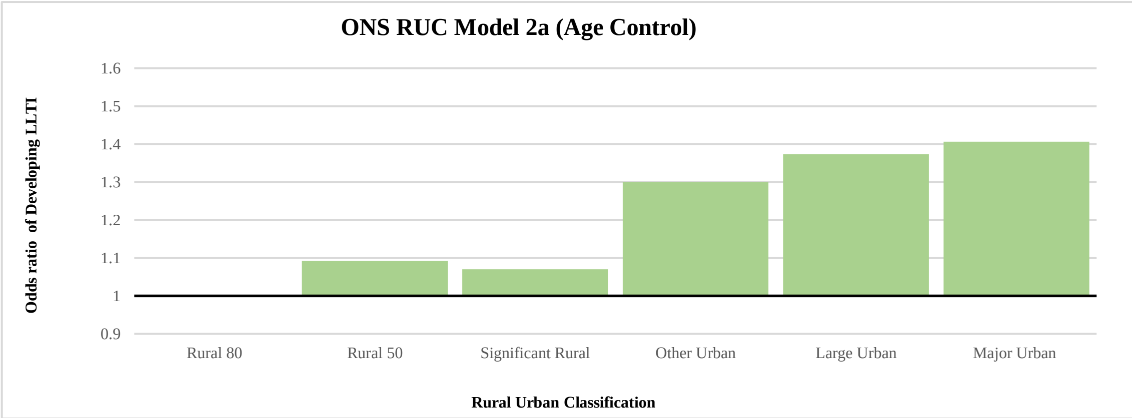
Note: All models are controlled for age; age groups used in the analysis are defined in Table 1.

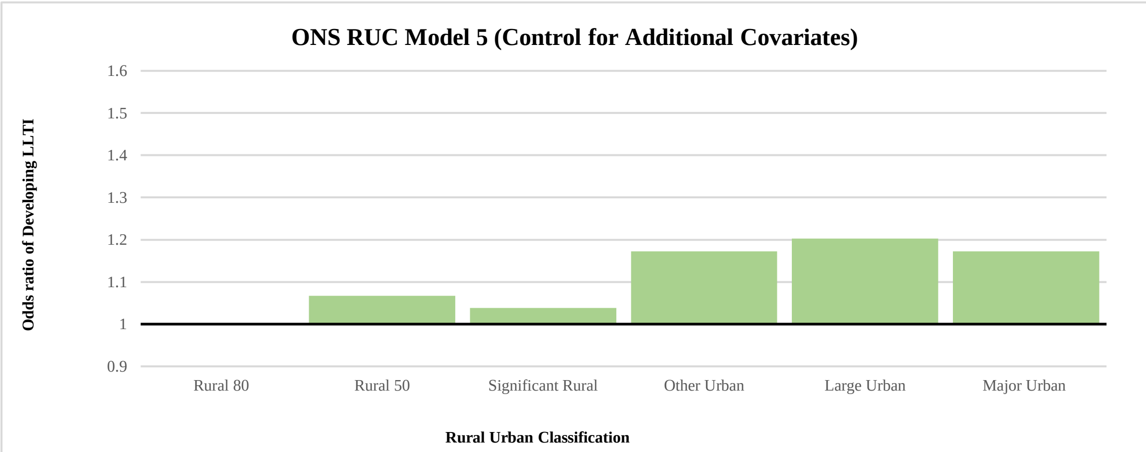
Model 3 controls for National Statistics Socio-economic Classification, whilst Model 4 further controls for education, and Model 5 for ethnicity along with marital status. Once these additional covariates are incorporated, health variations across the rural–urban continuum reduce substantially, most notably once social class is accounted for. Nonetheless, noteworthy differences persist. Those residing in urban locations remain significantly more likely to develop an LLTI than those living in the most rural locations, with Major, Large, and Other urban residents 25%, 20%, and 17%, respectively, more likely to develop an LLTI (Table 2.3, Model 5). The already observed London exception also remains. After controlling for the additional covariates, residents in Outer London are as likely to have an LLTI as those in the most rural areas (Rural 80) and notably healthier than residents in all other parts of the rural–urban continuum, whilst Inner London residents are healthier than all non-London urbanites.

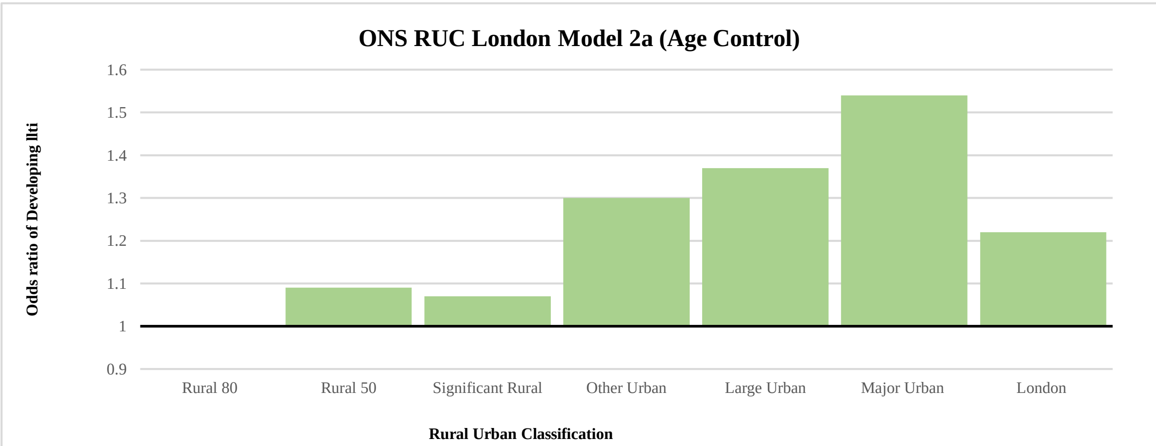
The influence of covariates corresponds to expectations. Health is worst among men, unemployed and never-worked individuals, those from lower occupational statuses, and those with low educational qualifications (Table 2.3, Model 5). The idea that males experience poorer health in comparison to females is far from new; higher male mortality rates have been explained by a variety of possible biological and behavioural causes (Kalben, 2000; Kruger, 2004). Asians and other ethnic groups have better health than White British, whereas Indian, Black, and those with mixed ethnicity seem to have poorer health. Previous research has demonstrated low mortality for all immigrant groups (Wallace & Kulu, 2014). Whether observed differences are due to poor health among the descendants of immigrants or because of a weaker association between health and mortality among immigrants and ethnic minorities is a topic for future research. Finally, married individuals have better health than single and separated, which is also expected (Table 2.3, Models 5).

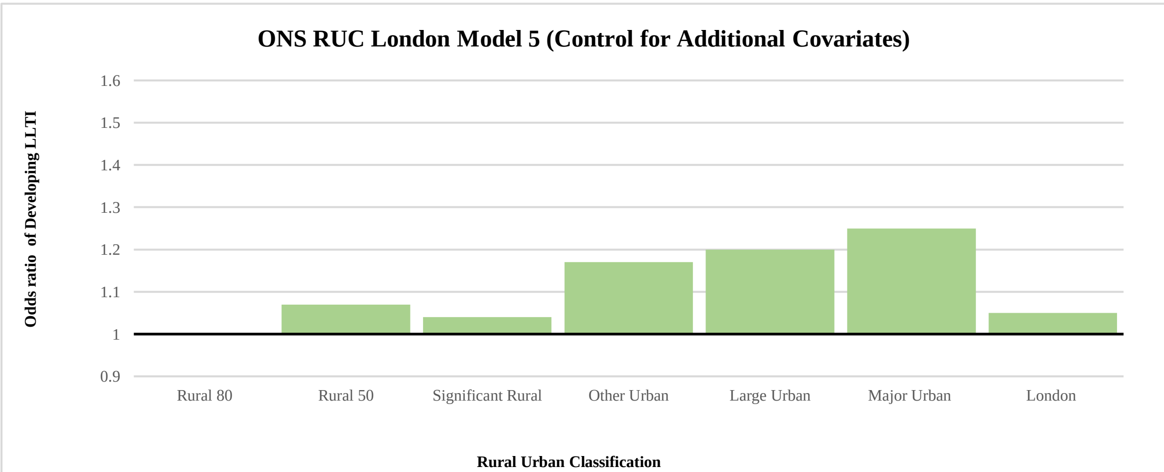
2.5.3 Gradient sensitivity—test for robustness

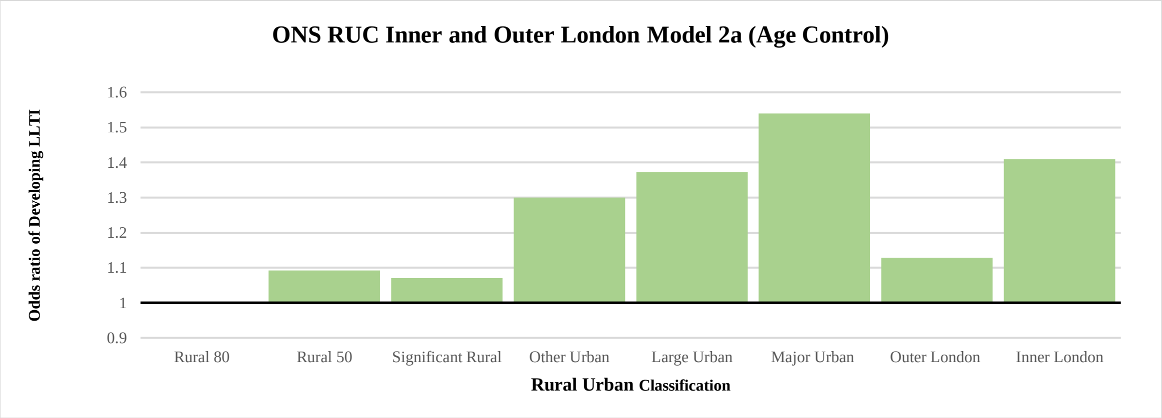
To test the robustness of the results presented above, logistic regression was performed utilising alternative rural–urban classifications. Figure 2.2 demonstrates the sensitivity of results based upon the classification implemented. The overall finding is that for all classifications a rural–urban health gradient may be observed and that these effects persist, in attenuated form, once all individual-level covariates have been included in the model. Clearly, levels of ill health increase parallel to increasing urbanisation. For those classifications separating out London, a “capital city effect” may be observed. As the rural urban health gradient is observed for all classifications, this sensitivity analysis shows that our findings are robust and not simply a consequence of the method used to define rural areas.

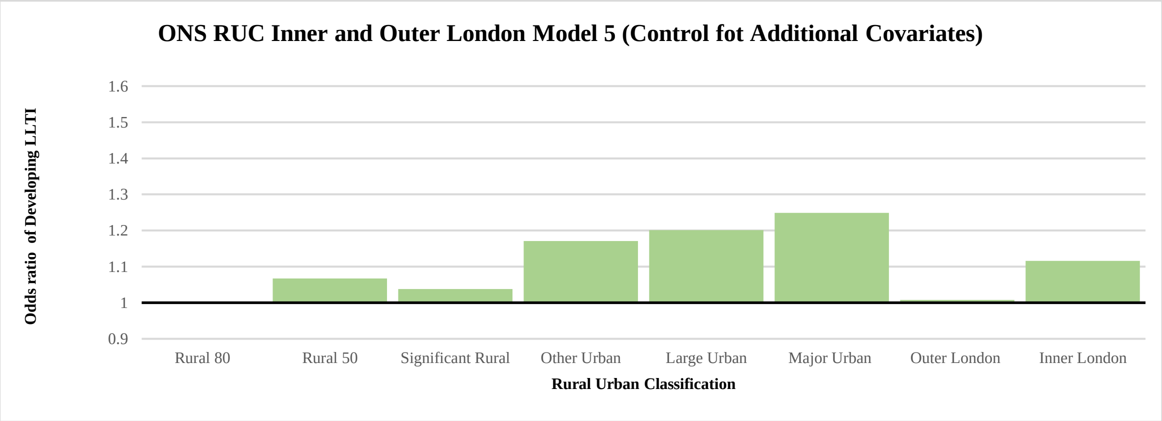

ONS RUC Model 2a (Age Control)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
Rural Urban Classification

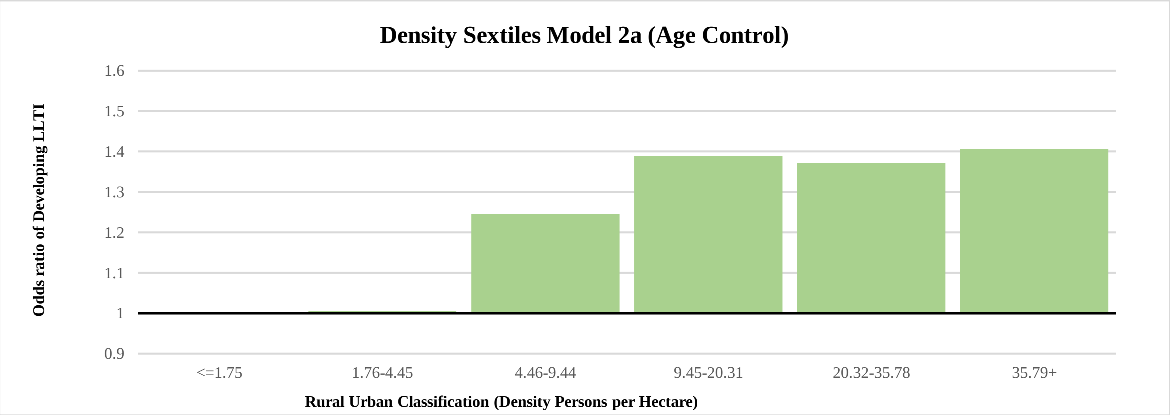

ONS RUC Model 5 (Control for Additional Covariates)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
Rural Urban Classification


ONS RUC London Model 2a (Age Control)
Odds ratio of Developing llti
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
London
Rural Urban Classification


ONS RUC London Model 5 (Control for Additional Covariates)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
London
Rural Urban Classification


ONS RUC Inner and Outer London Model 2a (Age Control)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
Outer London
Inner London
Rural Urban Classification


ONS RUC Inner and Outer London Model 5 (Control fot Additional Covariates)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
Rural 80
Rural 50
Significant Rural
Other Urban
Large Urban
Major Urban
Outer London
Inner London
Rural Urban Classification


Density Sextiles Model 2a (Age Control)
Odds ratio of Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
<=1.75
1.76-4.45
4.46-9.44
9.45-20.31
20.32-35.78
35.79+
Rural Urban Classification (Density Persons per Hectare)

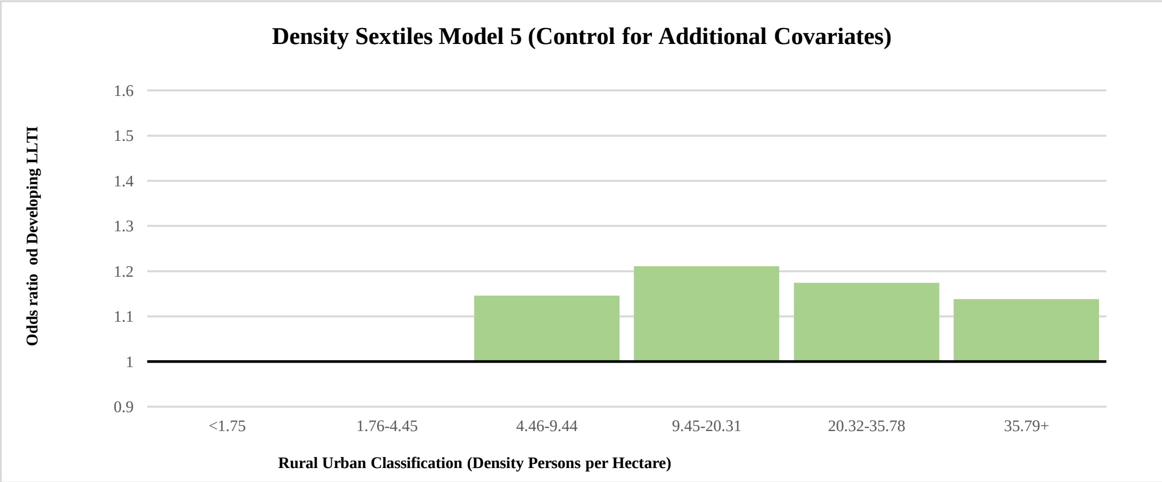
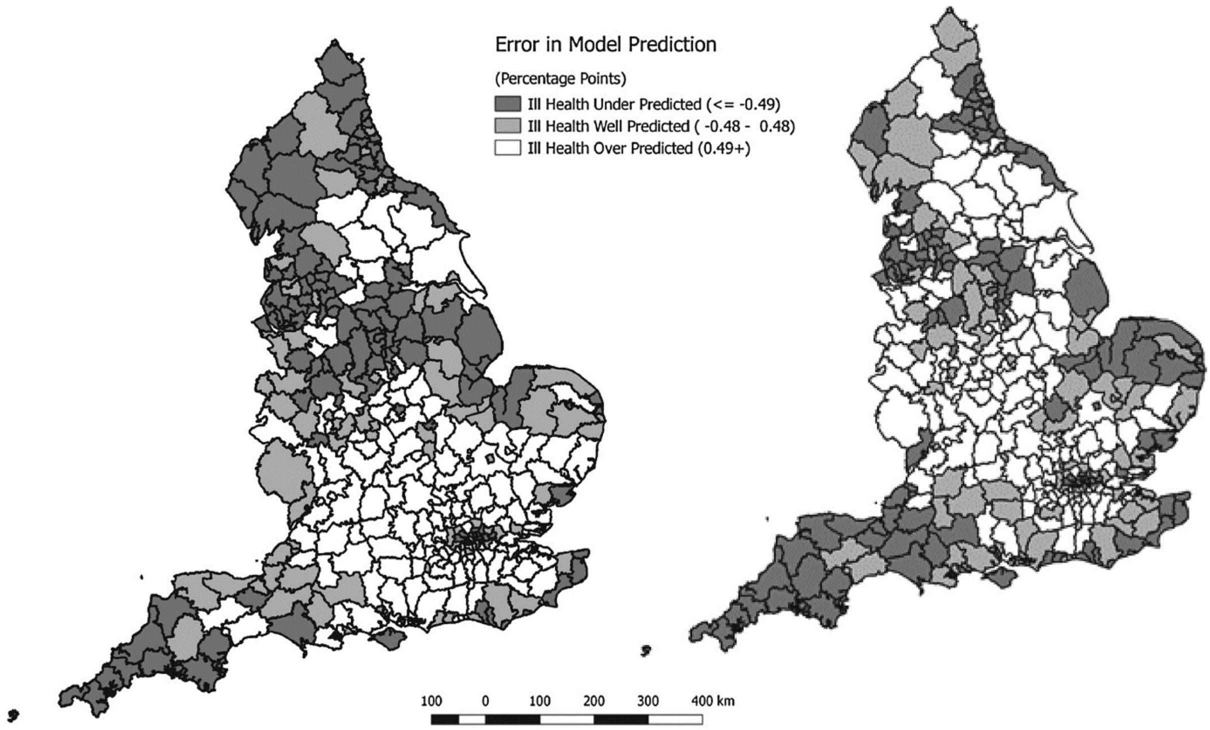

Density Sextiles Model 5 (Control for Additional Covariates)
Odds ratio od Developing LLTI
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
<1.75
1.76-4.45
4.46-9.44
9.45-20.31
20.32-35.78
35.79+
Rural Urban Classification (Density Persons per Hectare)

Figure 2.2 Sensitivity Analysis to Rural-Urban Classification.

2.5.4 Spatial pattern of model residuals

Figure 2.3 displays the spatial distribution of residuals from Model 5 using the ONS RUC Inner and Outer London adjustment, highlighting the locations in which ill health is either over or under predicted by the model. The RUC is utilised to understand if the predictive power of the model is improved once regional influences are controlled (the North–South divide). It is clear that the majority of locations within the South of England, with the exception of the far South West and Central London, are either adequately or over predicted, that is, health is better than the model forecasts. In contrast, districts in the North (particularly the most Northern) are under predicted, along with those districts in the tip of the South West, with individuals experiencing health worse than predicted. This finding persists regardless of the actual rural–urban classification used.



(a)Residuals from Model 5

(b)Residuals from Model 5 plus control for North-South divide

Figure 2.3 Spatial Patterns of Model Residuals

Model predictions of % persons in ill health, controlling for Office for National Statistics rural–urban classification and Inner and Outer London effects. (a) residuals from Model 5; (b) residuals from Model 5 plus control for North–South divide

Given that a clear spatial patterning is observable (spatial pattern of either over or under prediction of LLTI) in the model residuals, an attempt has been made to account for these using a simple North–South dichotomy. The division was set by aggregating the nine government office regions of England into the five northernmost and four southernmost locations. The dividing line was set between the Wash and the Severn Estuary, a line commonly adopted within existing literature. For example, it is said to represent the division in life expectancy amongst the southern and northern regions (Hacking, Muller, & Buchan, 2011). Other regional classifications were also tested including the South–East versus the rest of England and even region of residence. These were found at best to only marginally improve model fit. Interaction effects between RUC and the North–South divide were also investigated. No interactions of substantive interest were found.

As Figure 2.3 shows, once the North–South divide is taken into account, the spatial pattern of model residuals alters. Model overprediction in the South becomes restricted to a narrower ring around London, whilst model underprediction spreads out across the most rural locations (the South West and northern East Anglia). In the North, model underprediction shrinks to pockets focussed mainly on the major urban conurbations, such as Merseyside and Tyneside.

Controlling for the North–South divide marginally improves the predictive power of the model, but some spatial patterning of the model residuals remains. Evidently, spatial health variations are not simply a matter of rural–urban and compositional differences, but of broader regional differences too, particularly between the South and the North.

2.6 Conclusion and Discussion

This study has examined health variation by residential context in England. Our analysis found a positive urban–rural health gradient, with individuals residing in urban locations consistently possessing the worst self-reported health, and those in rural areas the best. However, once London was separated out from other urban areas, residents of the capital were found to possess better than anticipated health. This was particularly the case for those residing in Outer London, who were found to have health similar to those in the most rural locations. The observed urban–rural health gradient was substantially reduced, but persisted once we controlled for individual characteristics, particularly, occupational status and education. Thus, our results lend partial support to those who argue for a positive urban–rural health gradient, with the exception of a protective “capital city” effect.

A significant portion of the initial urban–rural health gradient was explained by the different socioeconomic composition of residential contexts; the share of unemployed and never-worked individuals was the largest in large cities and the smallest in rural contexts. Interestingly, potential differences in marital status, for example, higher divorce rates in urban areas combined with higher marriage rates in rural areas, and the presence of increased ethnic minorities within the urban context, explained very little health variation by residential setting, suggesting that the results are robust to various individual characteristics. What, then, are the factors that account for better health in rural areas and deteriorating health with increasing urbanicity? We suggest a number of possible influences related to the living environment such as levels of exposure to green space, pollution, crime, and proximity of living.

This leaves unexplained the health advantage of London—the “capital city effect.” Our analysis demonstrated that self-rated health amongst residents of the capital was better than expected, once we adjusted our models to control for individual socioeconomic characteristics. Based on our discussion of contextual influence, it would be expected that the individuals living in London would possess the worst health amongst all areas in England, which, as the study showed, was not the case.

We suggest that this anomaly may possibly be a consequence of selective migration (cf. Andersson & Drefahl, 2016). First, the healthiest individuals move to London to study and work. Second, those with poorer health may migrate from London to other residential contexts, potentially to other urban areas. Such a double selection would leave London with a (internal) migrant population with good health. The role of selective migrations is thus an important topic for further investigation, which this study, based on the cross-sectional census data, was not able to address (Norman et al., 2011). Alternatively, it might be that the compositional factors used in our study fail to adequately capture between-area heterogeneity in wages and living conditions with, for example, professionals in London earning more than their counterparts elsewhere.

Within the capital, we discovered that those residing in inner London possessed substantially poorer relative health in comparison to those living within outer districts of the capital. Possible reasons for the Inner London disadvantage are many. First, according to Haynes (2016) much of the housing within the inner city is in disrepair, with residential, transport, and workplace overcrowding common in comparison to the outer capital, facilitating the transfer of infectious diseases. Further, the inner city population is thought to be more transient, thus immunisation and preventative health programmes are more difficult to implement, and are taken up less frequently (Bardsley & Morgan, 1996). Finally, again migration is thought to play a part, with inner city residents relocating to Outer London following improved employment opportunities, with these individuals tending to be healthier than those left behind (cf. Tunstall, Pearce, Mitchell, & Shortt, 2015).

The validity of previous studies of the urban–rural health gradient has been questioned due to the lack of a universal definition of “urban” and “rural.” Hence, it has been argued that observed rural–urban health variations are a data artefact, reflecting the classification used. Our investigation refutes such critique, as the observed rural–urban health gradient has been found to be impervious to the classification utilised.

Further, this investigation provides an insight into urban–rural effects in the light of the North–South divide, a further dimension of residential context, which has been largely overlooked in existing research. Controlling for this divide, alongside other sociodemographic factors, the spatial pattern of model residuals alters and model fit improves (although the urban–rural gradient persists). Hence, it is evident that health variations are not only an urban–rural issue. All rural (and urban) locations are not equal. Rather, there are regional effects to take into account besides the urban–rural influences investigated here.

The fact that a spatial pattern to the model residuals remains even after controlling for rural–urban classification, socioeconomic, and demographic factors, and position within the North–South divide, suggests that there must be factors that the model has failed to capture. We suggest possible explanations similar to those we have offered for the observed capital city effect: health selective migration and unobserved between-area heterogeneity in wages and living conditions, some of which we suggest will be explained by regional economic structures. Future research should look to investigate such issues.

This study was conducted with data collected from England, so it is important to consider if the observed results can be generalised for different contexts. We would expect to find comparable results in many European countries due to the similarities in characteristics of the rural and urban environments. However, for some other industrialised countries, for example Australia and Canada, the differences across rural populations may be larger than in the UK, as some rural areas are extremely remote. Further, in contrast to Western Europe, rural areas in developing nations will often experience much more poverty in comparison to urban locations (Gartner et al., 2011). It is for these reasons that results would be expected to vary between countries. Along with different locations it is also important to consider different scales, and whether the same results would be produced at different geographical levels. We would expect the positive urban–rural gradient to hold, regardless of the geographical level investigated. However, it is important that future research examines rural–urban health variations at the lower level.

The data utilised within this study were collected in 2001, as it was the latest data available, which encompassed all the required information. A critical reader may question the applicability of the findings 15 years later. Based on our study and previous research, we believe that the basic differences in health across the various locations have persisted. However, future research should investigate whether the variations have grown or reduced over time. Future research should also focus on the role that selective migrations (or long-distance moves) may play in health variation by residential context; on the role of unobserved heterogeneity of income or wealth within occupational and educational qualification groupings; and on possible gender differences. Migration is, however, selective of certain demographic and socioeconomic characteristics, which have been controlled within this study, thus we may have already partially accounted for such migration effects. Moreover, it also remains to be seen whether mortality levels vary by residential context in ways similar to those observed in this paper for morbidity.

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Chapter 3

Chapter 3 builds on chapter 2 by investigating urban-rural mortality differences within England and Wales, and how such differences interact with Gender. Chapter 2, utilising the 2001 UK census, discovered a positive urban-rural health gradient, with levels of ill health increasing with each level of urbanisation. Once individual socio-economic influences were included within the analysis, variations across the continuum reduced substantially however, the positive gradient remained in-tact. Chapter 3 extends this study by investigating if the same urban-rural gradient is identifiable when investigating mortality, utilising the ONS Longitudinal Study. As with chapter 2, individual socio-economic influences are incorporated. If health variations across the continuum remain, it is clear that contextual influences play a significant role when It comes to urban-rural health. This chapter also investigates the interaction between rural-urban rural health variations and gender, in an attempt understand how male and female health varies, and if the impact of compositional and contextual factors is felt equally across the sexes.

Gendered Mortality Differentials over the Rural-Urban Continuum:

The Analysis of Census Linked Longitudinal Data from England and Wales

Abstract

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. Applying survival analysis to the ONS Longitudinal Study, a clear positive urban rural mortality gradient is observed, 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 a positive urban rural mortality gradient [2].

[2] Chapter 3 is based upon the research paper Gendered Mortality Differentials over the Rural-Urban Continuum : The Analysis of Linked Longitudinal Data from England and Wales. Journal of Social Science and Medicine 221 pp:68-78

3.1. 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 Socio-economic status). 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.

3.2Literature Review

3.2.1 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 respectively 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 other's 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).

3.2.2 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.

3.2.3 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 non-fatal 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, this is known as 'gender blindness'. 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. 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 of 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).

3.3 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.

3.4 Data

3.4.1 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, 2001 and 2011. 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). For example, low socio-economic status assigned to all those who live in major urban deprived areas, this may not be the case for certain individuals. Just because a person lives in a deprived area, does not mean they are themselves of low socio-economic status. This would cause issues when trying to control/ account for the effects of compositional influences.

3.4.2 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 3.1).

3.4.3 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. This greater geographic detail leads to a more precise measure of urban-rural. To our knowledge, this study is the first to use such a fine-grained classification in the study of urban-rural mortality differences (Figure 3.1).

Table 3.1: Distribution of risk time and deaths

Covariate	Years at Risk		Deaths	Covariate	Years at Risk		Deaths
	Count	Percent			Count	Percent	
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				

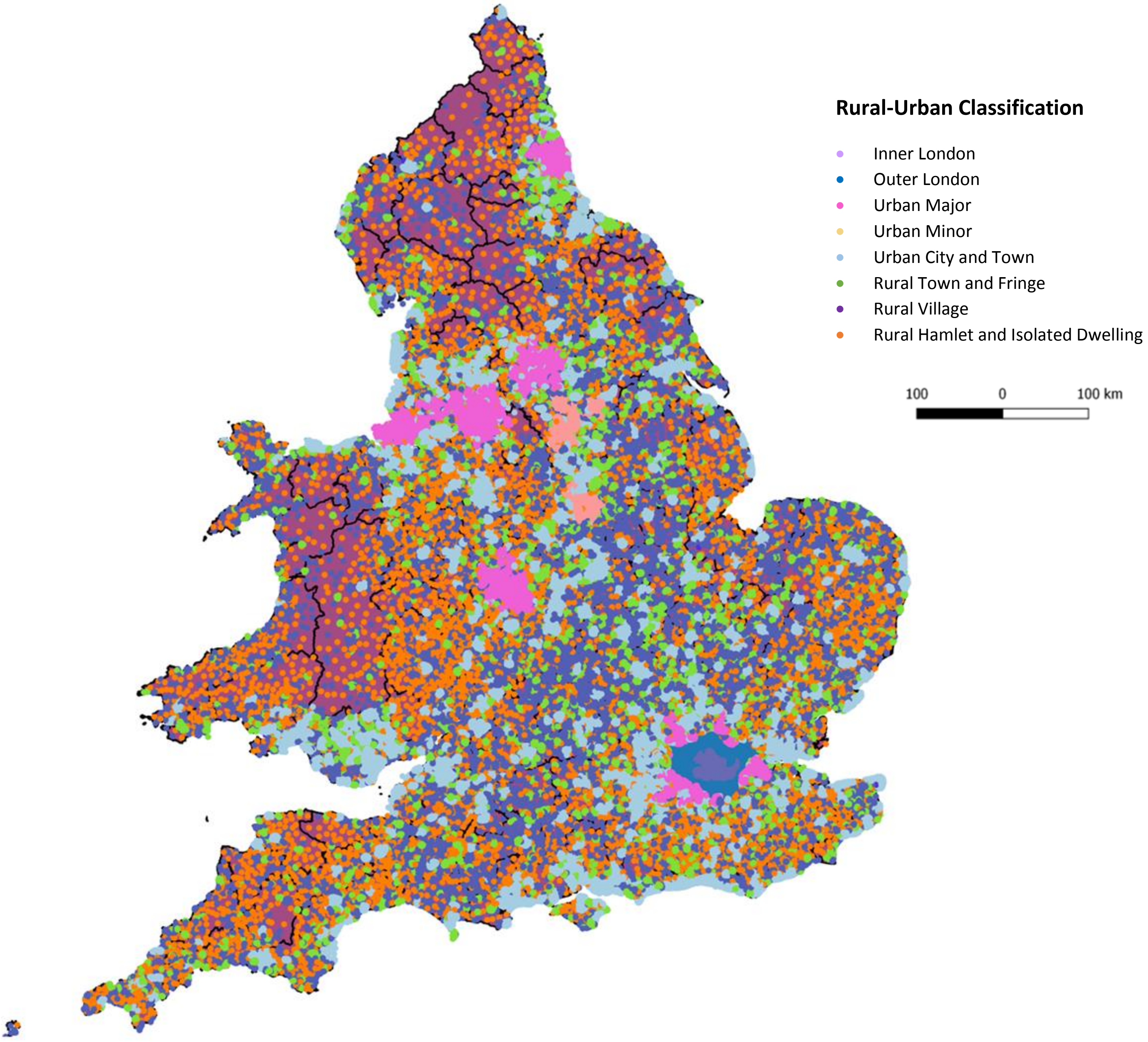

Figure 3.1.: England and Wales Map of Rural-Urban Classification

3.4.4 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:

$$\mu_i(t) = \mu_0(t) \times \exp\left\{\sum_j \beta_j x_{ij}(t)\right\} \qquad (2),$$

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.

3.5 Analysis

Table 3.2 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

3.5.1 Rural-Urban Mortality Variations

Table 3.2 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.

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).

3.5.2 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 3.3. As for Table 3.2, 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 3.3 Models 1, 2a and 2b).

Table 3.3: 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	1		1	
Single	0.482	p<.001***	0.53	p<.001***
Married	0.80	0.01**	0.82	0.04*
Separated	0.88	0.01**	0.81	0.001***
Divorced	0.80	0.04*	0.72	p<.001***
Widowed				
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

For ‘all ages’ mortality (Table 3.3 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 3.3 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 3.3, 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 3.3 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 3.3 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.

3.6 Conclusion and 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, even more so than in this study, with those located in Outer London possessing health 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.

3.7. References

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Unreported Sensitivity Analysis.

-To ensure the appropriateness of the Gompertz distribution, survival analysis was repeated utilising the Cox distribution. Results were unchanged.

-Due to the small numbers residing with 'Rural hamlets and isolated dwellings' (compared to other categories) it was important to investigate the robustness of this grouping as a reference category. To do so, analysis was repeated utilising 'Rural villages' as the new reference category. The results remained practically unchanged, and the reported positive urban -rural morality gradient remained.

-From the results of this chapter it is clear that London is very different from the other urban residential categories. To ensure that the Capital City was not skewing our results, models were repeated with London excluded. Results were unchanged and again the positive urban-rural mortality gradient was maintained.

Chapter 4

It is now clear that whether health or mortality is investigated, a positive urban rural gradient is identifiable, with the likelihood of developing an LLTI or dying increasing from urban-rural areas. As the gradient remained intact after controlling for individual socioeconomic factors, it is clear that variations cannot be explained by compositional influences alone. However, It is suggested that by investigating rural-urban variations in general health, or by using overall mortality statistics, as in the previous two chapters, it is possible that significant geographic trends in health by specific causes may be missed This study extends upon chapter 3 by studying geographic variations in mortality by four specific causes, consisting of Respiratory and Circulatory disease, Lung cancer and other cancers. As with the previous chapters, socioeconomic influences are incorporated to understand the extent of the impact of contextual and compositional influences with regards to the specific diseases. If all four causes do not follow the positive rural-urban health gradient, it is possible that such a gradient exists alongside high levels of specific mortality in rural locations and low levels in urban areas.

Urban-Rural Variations in Cause-specific Mortality

Previous research on the UK shows that health and mortality vary considerably by residential context, with urban areas experiencing increased mortality in comparison to rural locations. Much less is known about geographical differences in cause-specific mortality and how the patterns vary by gender. Applying survival analysis to the ONS Longitudinal Study between the years of 2001-2011, using a fine-grained geography (Census Output Areas), a clear positive urban-rural mortality gradient is observed for respiratory disease, lung cancer and circulatory disease, but not for other cancers. Once socioeconomic factors are controlled for variations across the continuum reduce for all diseases; however, the positive urban-rural gradient persists. Within this overall gradient the exception is Outer London, which has lower than expected mortality rates. Males are found be to influenced more by their socioeconomic position, and females more by their surrounding environment.

4.1 Introduction

Previous studies show that health and mortality vary substantially between urban and rural areas in industrialised countries (O'Reilly et al 2007; Bambra et al 2014). However, the nature of this variation remains contested (Teckle *et al* 2012). The majority of researchers advocate a positive urban-rural health gradient, with mortality trends tending to increase parallel to increasing urbanisation (DEFRA 2014; Allan et al 2017a; 2017b; Gebregziabher et al 2018). Others have suggested a U-shaped health continuum, with remote rural along with large city locations experiencing poor health outcomes compared to those suburban and semi-rural areas (Barnett et al, 2001; Levin, 2003). Finally, some researchers have refuted the concept of a healthy rural population altogether (Lankila et al, 2012). Further complicating the matter, a debate concerning the causes of such variations exist, regarding whether they are a result of contextual or compositional influences.

While there is an increasing body of literature investigating geographical inequalities in health and mortality in industrialised countries, only recently has research has examined urban-rural morality variation by cause of death. The cause-specific analysis is critical to improve our understanding of how and why mortality patterns vary across space within countries. This study investigates urban-rural mortality differences by cause of death. Unlike the existing studies, variations in cause-specific mortality will be examined utilising an urban-rural continuum rather than a simple dichotomy. This enables the study of variations in cause-specific mortality over varying residential contexts, whilst controlling for individual level compositional characteristics. The majority of existing studies utilise area-level data, which do not allow for the exact measurement of the relationship between an individual's health and place of residence. Using individual characteristics allows the understanding of the level to which an individual's socioeconomic and demographic characteristics explain cause-specific variations, and to what degree other potential contextual factors may play a role. Finally, this paper also pays close attention to potential male and female differences in mortality across the specific causes of death, as previous investigations have been accused of gender blindness, failing to consider how each gender may be influenced by the environment differently.

4.2 Previous Research

Within the vast majority of existing literature the largest variations over differing residential contexts have been found for four major disease groups; respiratory disease, lung cancer, other cancers and finally circulatory disease. These four causes of mortality are the focus of this paper. They possess the largest mortality rates in the ONS Longitudinal Study between 2001 and 2011, covering 76% of all deaths recorded. It is for these reasons that this study will specifically focus upon deaths as a result of such diseases.

4.2.1 Respiratory Disease

Previous investigations have consistently stated that the greatest rural urban disparities in both incidence and mortality can be found for respiratory disease and lung cancer (O'Reilly *et al* 2007; Gartner *et al* 2011). Within the UK mortality rates of respiratory disease have consistently been large in comparison to other nations, and significant contrasts have been reported in rates between urban and rural locations. Gartner *et al* (2008) revealed that males and females located within rural areas were 23% and 20% less likely to die as a result of respiratory disease, compared to their urban counterparts. Many other studies of specific respiratory diseases have drawn similar conclusions. In 2015 a total of 1,021 registered deaths were attributed to asthma in urban locations, compared to just 277 in rural areas. A similar pattern was observed for Chronic Obstructive Pulmonary Disease (COPD), with 25,197 deaths registered in urban locations, compared to just 5,640 in deaths in rural areas (ONS 2017).

Some researchers believe that these variations are a direct result of compositional factors, largely socioeconomic, including smoking rates (Gartner et al 2008; Lopez et al 2006). Within the UK urban areas tend to contain a much greater proportion of deprived individuals (Senior *et al* 2000). Furthermore, smoking habits have been discovered to vary significantly by class, with the General Lifestyle Survey suggesting that professional groups were much less likely to smoke, compared to unskilled and manual classes (ONS 2013). Consequently, Gartner et al (2008) suggests that any urban excess of chronic bronchitis and emphysema can be largely attributed to variations in smoking (Gartner *et al* 2008). Such explanations have also been associated with variations in COPD (Lopez *et al* 2006). As well as smoking, previous research suggests that socio-economic factors influence the prevalence of COPD independently (Danielsson *et al* 2012). Poor housing conditions such as dampness and overcrowding, poor nutritional status and specific occupations are also said to impact upon the development of the disease (Halvorsen and Martinussen 2014).

Gartner et al (2008) further argue that, although compositional influences are strongly related to the development of respiratory disease, they do not provide a full explanation of geographic disparities. Within their study they discovered that even after controlling for deprivation, utilising the Index of Multiple Deprivation (IMD), rural dwellers continued to be 9% less likely to die from respiratory causes. Unfortunately, Gartner et al (2008) analysed deprivation and mortality at the area rather than individual level. Consequently, the exact relationship between an individual's health, deprivation and place of residence could not be fully established. Even so, a key contextual influence on health variations over the urban-rural continuum appears to be pollution (Sunyer et al 2006). According to Viegi *et al* (2006), evidence suggests that air pollution represents a vital risk factor in the development of COPD and other respiratory diseases. Many studies have provided supporting evidence, for example Ghosh et al (2009) utilising the Canadian National Population Health data, discovered that the prevalence of asthma was higher in urban areas for both smokers and non-smokers.

4.2.2 Lung Cancer

It is widely accepted that a progressive decline in the incidence of lung cancer can be seen from large urban cities and towns through to rural villages (Riaz et al 2011). For instance, NCIN (2011) concluded that within England rural lung cancer incidence rates were approximately 65% of those found in urban locations. As with respiratory disease, many have suggested that these variations can be explained simply in terms of the distribution of socio-economic deprivation. More specifically, many believe that variations in urban-rural lung cancer rates can be accounted for by differences in smoking habits. Riaz *et al* (2011) fully advocate this theory, commenting that although the incidence of lung cancer was in fact higher in urban compared to rural contexts of the UK, once socioeconomic deprivation was accounted for little difference was observed between the two locations. Such findings stress the importance of jointly considering deprivation and location.

Whilst many regard compositional influence as the chief influential factor resulting in geographical differences, others disagree. Gartner *et al* (2008) discovered that after controlling for deprivation, although variations in lung cancer mortality were reduced, substantial difference remained, with mortality rates 10% lower in rural areas. O'Reilly et al (2007) provide further evidence. After controlling for compositional factors including social class, they found that those residing in rural areas of Northern Ireland were 43% less likely to die from lung cancer compared to their urban counterparts. As with respiratory disease, this has led to speculation that such variations may be a result of varying air quality. Levels of pollution within urban areas pose a serious health concern. For example, Pascal *et al* (2013) states that exposure to air pollution is higher than World Health Organisation recommended levels in 25 European cities. A number of studies have investigated the association between air pollution and lung cancer. Having taken into account smoking prevalence, the majority uncovered positive correlations (Cohen, 2003)

4.2.3 Other Cancers

As with lung cancer, rural/urban variations in the incidence and survival of cancer have attracted substantial attention, more so than any other condition. Existing studies have uncovered widespread disparities in the incidence of various types of cancer according to the level of urbanicity (Schouten *et al* 1996). Previous investigations have revealed that in the vast majority of cases incidence rates tend to be much higher within urban locations (WCISU, 2009). For example, DEFRA (2009) utilising standardised mortality rates within England, discovered that males and females residing within rural locations were 12% and 8% less likely to die from cancer. Further, the potential years of lost life was 15 years lower in predominantly rural wards (DEFRA 2014).

As for respiratory disease and lung cancer, researchers have highlighted the need to take into account compositional differences over the urban-rural continuum. In fact, NCIN (2011) goes as far to suggest that the bulk of the urban-rural variation in cancer morbidity and mortality is a result of socio-economic variation. They state that cancers which have strong associations with socio-economic circumstances will demonstrate significant variations across the continuum. For example, the greatest urban excess was discovered for cancers of the lung, mouth, pharynx, oesophagus, larynx and liver, with a moderate excess for colon, rectum, cervix and uteri. The NCIN have concluded that variations are likely a result of personal behaviours such as smoking, alcohol consumption and sexual promiscuity.

4.2.4 Circulatory Disease

The geographic pattern of circulatory disease is slightly more complex than the previously discussed illnesses. Whilst numerous studies have investigated the occurrence of such diseases over the urban-rural continuum, the collective evidence has proved inconclusive. A number of academics have concluded that a clear urban-rural distinction is apparent in terms of incidence rates, with urban areas being visibly disadvantaged. DEFRA (2014) showed that age-standardised coronary heart disease rates for males and females within urban locations were 161 and 75 per 100,000 of the population, whereas village and dispersed areas had a rate of just 137 and 63 respectively. The adverse effect of urbanicity is so severe that the potential years of lost life from coronary heart disease in 2010-2012 was 44 years per 10,000 individuals in urban areas, compared to just 32 years in predominantly rural locations (DEFRA 2014). To a lesser extent a similar pattern has been observed for stroke occurrence, with potential years of lost life being 3.6 years greater in urban locations.

Various contextual explanations have been proposed for the rural advantage, the first being related to air pollution. As previously discussed, concentrations of pollution are higher in urban locations (Hare *et al* 2002). Anderson (2009) notes the strong consensus amongst investigations studying particulate matter and cardiovascular disease, with the vast majority establishing a positive association. Further, positive associations were noted for other circulatory diseases such as stroke, coronary heart disease and myocardial infraction.

A second mechanism is green space. Mitchell and Popham (2008) concluded that an association exists between green space and circulatory disease, independent of deprivation. According to the attention restoration theory, residing within a rural environment enhances health, as the natural environment encourages restoration from attention fatigue (Bowler *et al* 2010). Consequently, green space provides protection from the biological penalties of stress, reducing the occurrence of diseases of the circulatory system (Mitchel and Popham 2008). Moreover, exposure to green space encourages physical activity, as it provides a safe and attractive environment in which to exercise (Pretty *et al* 2005). Enhanced physical activity is linked to an array of health benefits, from reduced obesity (a widely accepted risk factor of circulatory disease), to reductions in cardiovascular diseases and type two diabetes (Coutts *et al* 2013).

Finally, levels of crime are unevenly distributed, with the risk of becoming a victim higher in urban locations (Higgins 2010). Increased levels of neighbourhood crime have been linked to an array of health consequences, most significantly coronary heart disease and reduced physical activity (Lorenc 2012). Fear of crime causes residents to become less active, placing restrictions on outdoor activities in order to reduce their chances of becoming a crime victim, thereby increasing the risk of circulatory diseases (Stafford *et al* 2007).

Notwithstanding the discussion above, Gartner et al (2008) believe that circulatory disease fails to show any specific geographic pattern after controlling for compositional influences. In their study of England it was revealed that males and females where 12% and 5% less likely to die as a result of circulatory disease in rural compared to urban contexts. However, after controlling for compositional influences variations reduced, with rural males being just 1% less likely and females 2% more likely to die.

Not mentioned here as a contextual factor is the spatial variability in health care provision. This reflects the Western European context, where most rural areas have reasonable access to health services (Smith et al 2008). In geographically more extensive developed countries, such as the USA, Australia and Canada, rural access to health services is more limited, having a greater impact on health outcomes. For example, Hartley (2004) reports that rural areas ranked poorly in the US for 21 out of 23 health indicators.

4.2.5 Gender

Most studies of urban-rural differences in cause-specific mortality ignore gender, or assume that males and females follow similar patterns, albeit at different levels. However, Allan et al (2017a), in an investigation of all-cause urban-rural mortality variations, discovered that socio-economic position accounted for a greater proportion of the male mortality gradient. Such results reinforce the theory that female mortality tends to be influenced to a greater extent by the residential environment, and male mortality by socio-economic status (Macintyre 2001). These differences are thought to be a result of the varying ways in which males and females interact with their residential environment. Females are found to spend increased amounts of time in their local area due to domestic and family roles, along with higher rates of part-time employment. Further, it has been suggested that women are more vulnerable to the health effects of the surrounding environment. Kavanagh et al (2006) discovered that females tend to engage less with their local environment for physical and leisure activities, out of fear of being attacked. These activities are associated with improved physical and mental health. In complete contrast, safety was discovered to be unrelated to male health.

Alternatively, it is possible that such gendered differences are a reflection of the inherent difficulty in assessing female social status (Langford and Johnson, 2009). It is largely accepted that females possess weaker attachments to the labour market, receiving less pay due to “Sticky Floors” and the “Glass Ceiling” and are more likely to be in part-time employment unreflective their skills and qualifications, due to traditional gender roles (Booth et al 2003, Arulampalam et al 2007, Geiler and Rennebong 2015; Leaker 2008). For these reasons Johnson (2011) contends that educational qualification may deliver a more sensitive measure of socio-economic status for women. This would explain why Allan et al (2017a) found that once educational attainment was taken into account, the mortality gradient reduced more for females than for males.

4.2.6 Summary

From the review above it is clear that Higgs (1999) was correct in commenting that simply studying overall mortality rates hides cause-specific variations in health within different locations. Subsequently, numerous researchers have drawn very different conclusions regarding not only the actual incidence of such diseases over the urban-rural continuum, but also the reasons for such variations in terms of contextual or compositional influences.

Regarding respiratory disease and lung cancer, it is widely accepted that rates are significantly greater in urban compared to rural locations (O'Reilly *et al* 2007, Gartner *et al* 2011 and Doll 1991). What is not so clear is the reason for such variations. Many propose that disparities are a direct result of compositional effects (Danielsson, et al 2012, Riaz et al 2011). However, various academic suggest that compositional influences do not provide a full explanation of geographic disparities (Gartner et al 2008, Haynes 1988).

In terms of cancer in general, the distinct rural urban divide becomes a little less clear. However, in the vast majority of cases incidence rates tended to be much higher within urban contexts (Walsh et al 2016, WCISU, 2009). As with lung cancer and respiratory disease the importance of taking into account compositional factors is stressed, with NCIN (2011) suggesting that the bulk of variations between the two contexts is a result of socioeconomic variations.

When studying circulatory disease the geographical pattern becomes more complex. Various academics propose that within England urban areas are clearly disadvantaged (DEFRA 2009, DEFRA 2014, Smith et al 2008). Numerous contextual explanations have been proposed such as air pollution (Anderson, 2009), exposure to green space (Mitchel and Popham 2008, Pretty et al 2005) and crime (Stafford et al 2007). However, not all researchers stand by the notion of a urban-rural divide. In fact, many believe that within Britain mortality rates fail to show any geographic pattern, particularly after controlling for socio-economic composition (Gartner et al 2008). Even so, it is clear that gendered differences in cause-specific mortality might be expected across the continuum.

4.3 Research Questions and Hypothesis

Given the findings of previous investigations, we expect to uncover substantial variations in mortality across the urban-rural continuum for all specified causes.

First, for all of the causes under study we expect to discover a positive urban-rural gradient. That is, we expect mortality to increase parallel to increasing levels of urbanisation. What we are unsure of is how much mortality will differ across the continuum for each disease.

Second, we anticipate that mortality variations will reduce once additional compositional influences are controlled for. However, we are uncertain to what extent these disparities will reduce for each cause, and therefore to what degree differences can be attributed to compositional rather than contextual influences.

Third, we foresee that for each disease males and females will display differing mortality patterns. We expect that males will be more sensitive to their socio-economic status, and females to their residential environment. The differing levels of this sensitivity by cause is unknown.

4.4 Methods and Data

4.4.1 Data

4.4.2 The ONS Longitudinal Study

Data from the Office for National Statistics Longitudinal Study (LS) will be utilised within this investigation. The LS, first established in 1974, is a longitudinal study that consists of linked census data along with vital events data for a 1% sample of the population of England and Wales. Four birth dates were used to draw an initial sample from the 1971 census. This sample has been followed up through subsequent censuses. As the study is a continuous multi-cohort study, additional samples have been drawn from each successive census, using identical selection principles (Portanti and Whitworth, 2009). At each consecutive census individuals are added through one of three pathways: completion of the census, birth registration or registration as a patient with a doctor. The LS study links information from each census with data regarding vital events consisting of entry (immigration and birth) and exit (emigration and death), along with cancer registrations.

4.4.3 Sample Size

The sample for this investigation is similar to that of chapter 3. The original sample consisted of 540,050 Individuals, of these, 206,926 (38%) were dropped as they fell outside of the sample age group, which was 18-65 at the time of the 2001 census. Only those of a working age were included within this investigation, as socio-economic class is only reliably recorded for such groups. A further 2,425 (0.7%) were removed due to being 'untraced'. As untraced individuals records are not found within the NHS Central Register, it is impossible to match census information with any mortality events they may have experienced. Thus, they cannot be studied longitudinally. Finally, 42,450 members (13%) were removed as they were not present at the 2011 census, nor had been recorded as dead between 2001 and 2011. These people were assumed to have completed an unreported emigration or were lost to follow up. This left 288,249 individuals within the study.

4.4.4 2011 ONS Rural-Urban Classification (RUC)

Allan et al (2017b) sought to uncover the influence of the type of Rural Urban Classification utilised within health studies. The paper tested six classifications based upon population size, density, and functional regions. Of all these classifications, the 2011 ONS RUC (with capital city adjustment) was found to produce the best model fit when examining Limiting Long Term Illness levels across urban-rural locations at the Local Authority level. The same classification was successfully utilised in a further investigation undertaken by Allan et al (2017a), examining mortality levels at the finer resolution of Output Areas. DEFRA (2005) has suggested that the ONS RUC classification should become the 'de facto' grouping utilised for statistical analysis of urban-rural differences wherever possible.

The 2011 ONS RUC (with capital city adjustment) classification of Output Areas has been applied to the place of residence of each LS member in 2001. Within this classification, any settlement with over 10,000 individuals is classed as urban, with all others classified as rural (Bibbly and Shepard 2004). Both rural and urban locations are further divided utilising the density profiles of each output area into 'Urban Major', 'Urban Minor' 'City and Town', 'Rural Town and Fringe', 'Rural Village' and 'Hamlet and Isolated dwellings' (Bibbly and Brindley, 2013). An adjustment to the official classification has been made to separate London from the other major urban areas. Output Areas located within the London Metropolitan area are classified as belonging to either Inner or Outer London, following the statutory definition of the two areas.

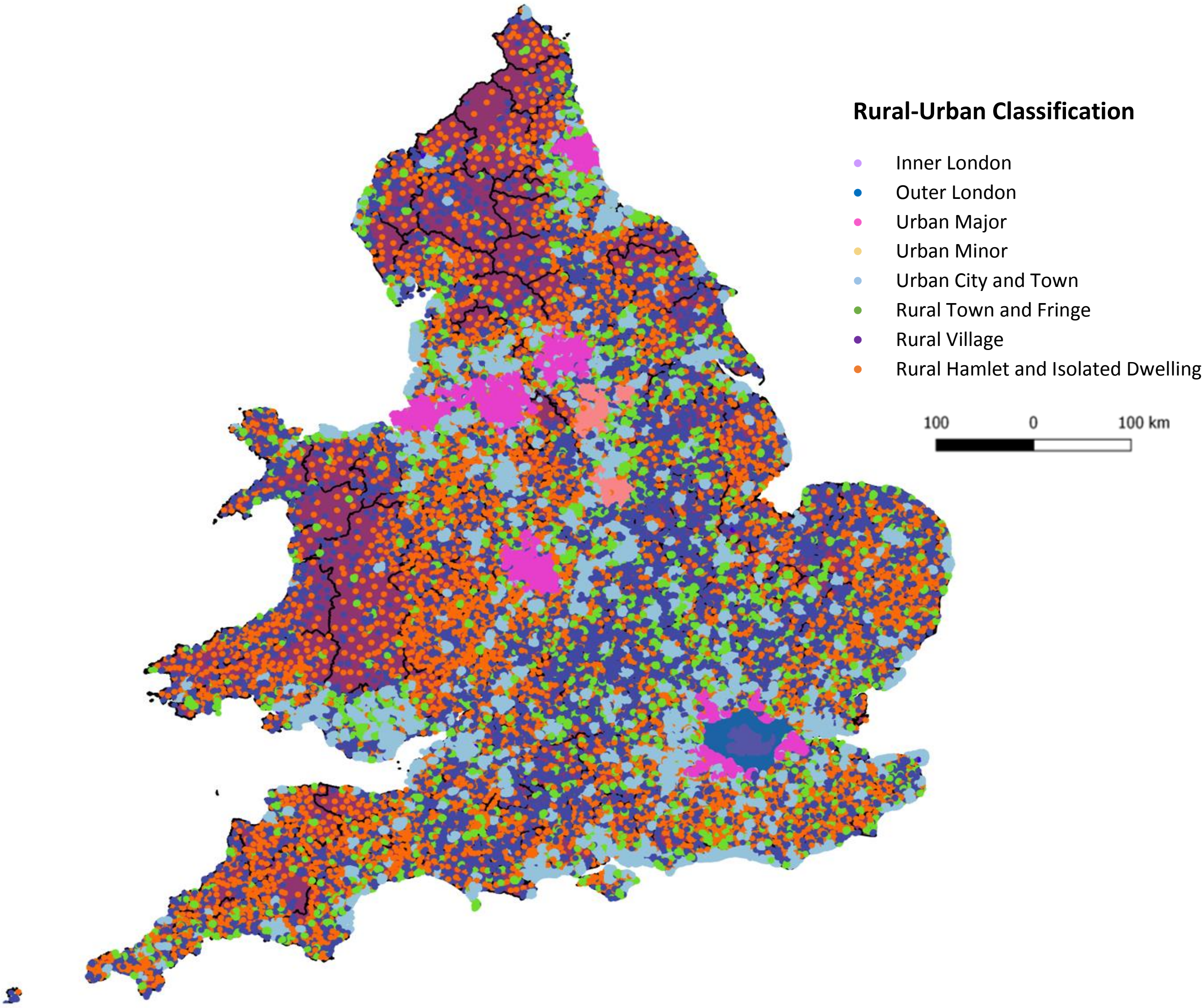


Figure 4.1: England and Wales Rural-Urban Classification

4.4.5 Cause of Death

To represent cause-specific mortality this study utilises underlying cause of death, defined by the World Health Organisation (2016) as the injury or the disease which started the sequence of morbid events which led directly to death, or the conditions of the violence or accident which created the lethal injury. Originally underlying cause of death consisted of hundreds of causes. These were recoded into four more manageable categories: circulatory disease, respiratory disease, lung cancer, and other cancers. A category containing other causes was also created but is not the main focus of this study. The overall number of deaths observed within this investigation was 12,995. The 4 main categories above cover 9,912 (76%) of these deaths.

Table 4.1: Distribution of risk time and deaths

Covariate	Years at Risk	Percent	Deaths	Covariate	Years at Risk	Percent	Deaths
Sex				NSSEC			
Male	1432833	6.88	7530	Higher Managerial and Professional	980123.4	4.71	3144
Female	1529575	7.35	5465	Intermediate Occupation	617758.1	2.97	2528
				Routine and Manual Occupation	1106524	5.32	6181
Age				Never Worked and Long-term Unemployed	119564.3	0.57	924
18-19	66262.83	0.32	43	Student	119152.8	0.57	71
20-24	275302.2	1.32	166	Missing / NA	19284.38	0.09	147
25-29	289204.4	1.39	178				
30-34	356606.5	1.71	401	**Marital Status**			
35-39	386663.8	1.86	611	Single	909697.5	4.37	2296
40-44	361507	1.74	876	Married	1649568	7.92	7549
45-49	328206.2	1.58	1367	Separated	81937.66	0.39	406
50-54	344155	1.65	2180	Divorced	269367.8	1.29	2023
55-59	309577	1.49	3068	Widowed	51836.5	0.25	721

60-65	244922.4	1.18	4105				
Residence				**Ethnicity**			
Inner London	125670.48	0.60	507	White	2684007	12.89	12240
Outer London	260518.28	1.25	960	Black	66636.27	0.32	192
Urban Major	569816.9	2.74	2701	Mixed	24312.41	0.12	53
Urban Minor	103181.05	0.50	480	South Asian	145437.7	0.70	432
City and Town	1339218.3	6.43	5971	Other Asian	28896.97	0.14	59
Rural Town and Fringe	275114.68	1.32	1197	Other	13117.34	0.06	19
Rural Village	178207.28	0.86	734				
Rural Hamlet and Isolated Dwelling	110680.49	0.53	445				
Education				**Cause of Death**			
Level 4+	617557.3	2.97	1593	Respiratory Disease	7428.3333	0.04	1074
Level 3	262310.1	1.26	519	Lung Cancer	8259.75	0.04	1237
Level 2	586734.3	2.82	1472	Other Cancers	28251.667	0.14	4323
Level 1	556944.9	2.68	1655	Circulatory Disease	20435.333	0.10	3287
Other	206606.1	0.99	1362	Other Cause	15838	0.08	3074
No Qualification	717089.7	3.44	6367				
Missing/NA	15165.05	0.07	27				
				Total	20,817,065		103960

Source: Authors' calculations based on the ONS LS

4.4.6 Methods

4.4.7 Statistical Methods

Survival analysis (the Cox proportional hazards model) has been utilised to investigate variations in cause-specific mortality rates by various residential locations. The basic model is as follows:

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

where $\mu_i(t)$ denotes the age-specific hazard (or the 'force') of cause-specific mortality for individual *i* at age *t* and $\mu_0(t)$ denotes the baseline hazard, which is left unspecified. Individuals are under the risk at entry (age 18 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} represents the values of variables measuring an individual's socio-demographic and economic background; β_j is the parameter estimate for the variable

Model 1 investigates cause-specific disparities in the age-specific hazard of mortality over the urban-rural continuum for all those of an economically active age (18-65), controlling for sex. Model 2 investigates the effects of socio-economic status, examining if cause-specific mortality variations persist once we control for occupational status, and how the impact of social class differs for males and females. Model 3 additionally controls for level of qualification. Finally, model 4 incorporates marital status and ethnicity. Each of these models is fitted for each specific cause of death (circulatory disease, respiratory disease, lung cancer, other cancers and other causes).

Social class along with highest qualification are representative of 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 finally Student. Ethnicity and marital status signify socio-demographic characteristics. Ethnicity is categorised as White, Black, Mixed, South Asian, Other Asian, and Other. Finally, marital status is defined as Single, Married and Separated/divorced.

By controlling for gender, we assume that males and females are affected by the surrounding environment and socio-economic factors in similar ways. Consequently, we may lose out on noteworthy information concerning the differing ways male and female mortality are affected by contextual and compositional influences. The second phase of this analysis will repeat models 1-4 for each specific cause, studying males and females separately.

4.5 Analysis

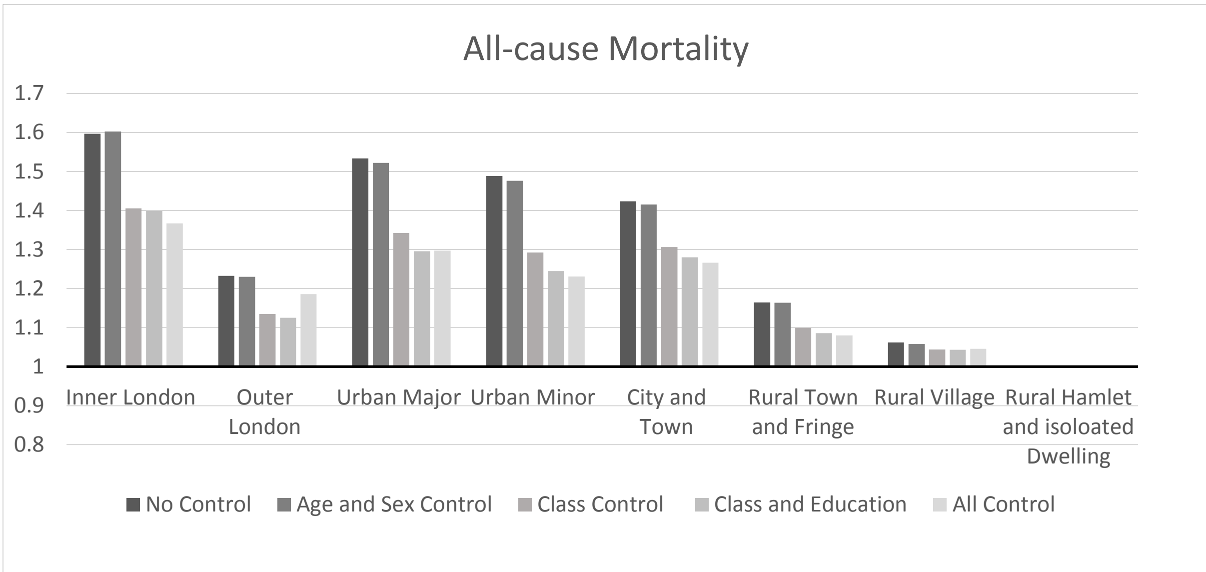
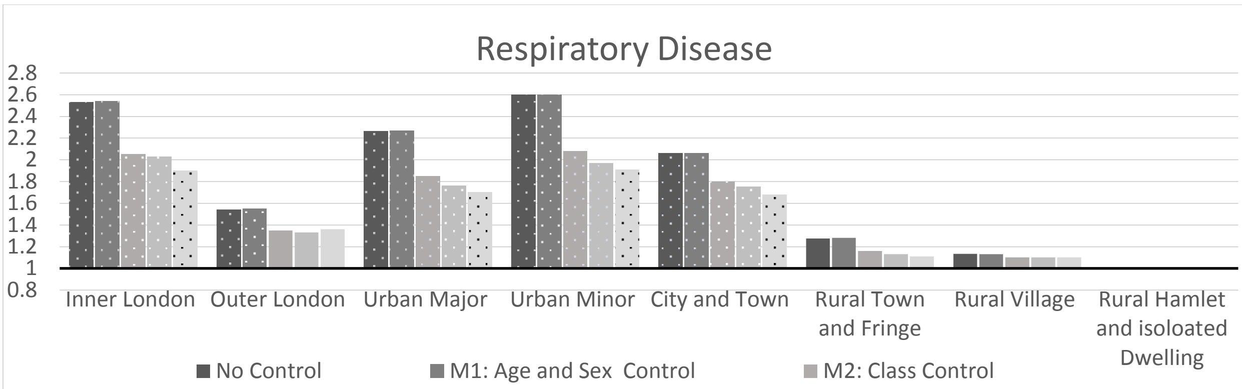
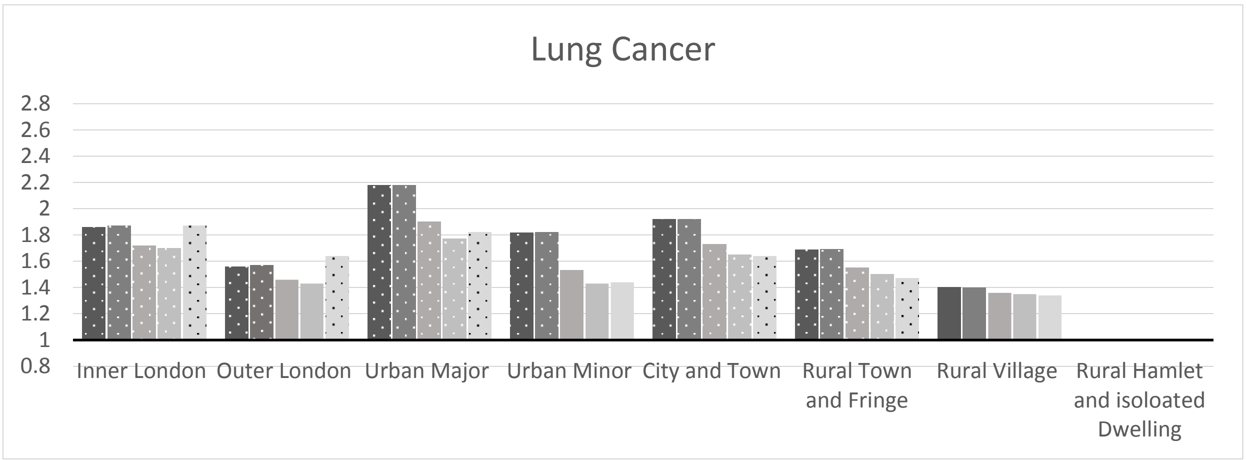


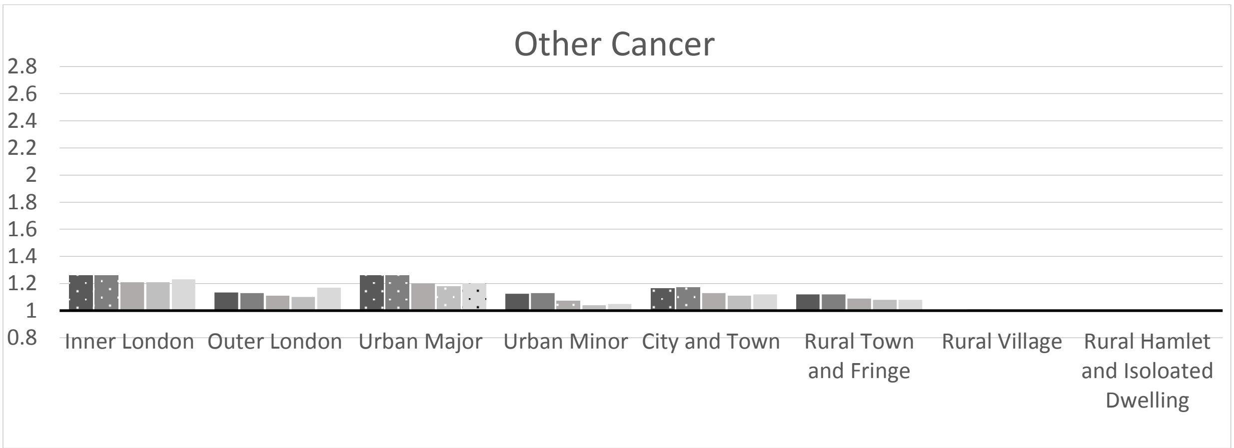
Figure 4.2: Mortality variations across the Rural-Urban Continuum

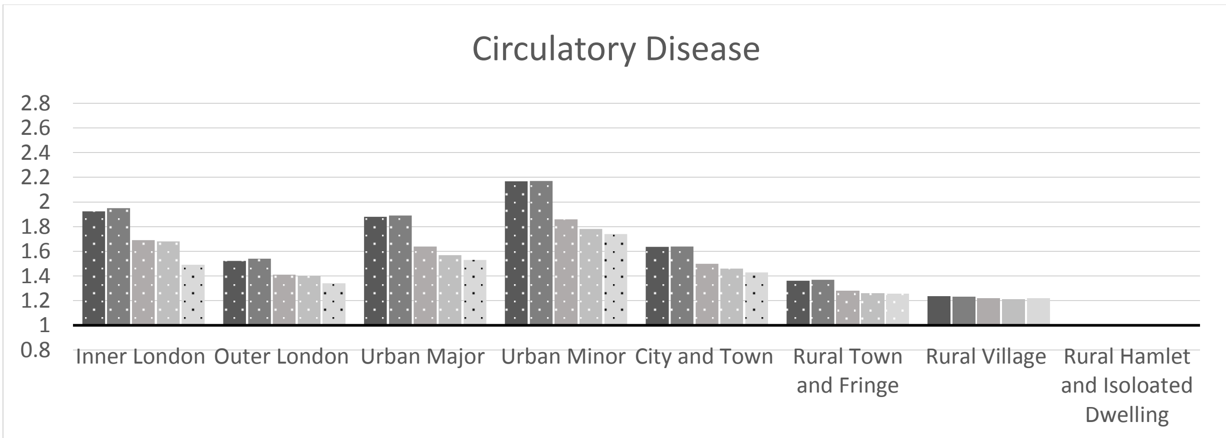
In terms of all-cause mortality (Figure 4.2) a clear positive urban-rural gradient can be identified, with the relative levels of age-specific mortality increasing in line with the degree of urbanisation. The exception is Outer London, which possesses lower than anticipated levels. Once sex, social class, education, marital status and ethnicity are taken into account levels of morality reduce significantly. However, the gradient remains intact. In all residential contexts controlling for social class leads to the greatest reduction in relative mortality.

When mortality is split into specific causes, significant differences between the diseases begin to emerge.


Respiratory Disease
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
Inner London
Outer London
Urban Major
Urban Minor
City and Town
Rural Town and Fringe
Rural Village
Rural Hamlet and isoloated Dwelling
No Control
M1: Age and Sex Control
M2: Class Control


Lung Cancer
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
Inner London
Outer London
Urban Major
Urban Minor
City and Town
Rural Town and Fringe
Rural Village
Rural Hamlet and isoloated Dwelling


Other Cancer
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
Inner London
Outer London
Urban Major
Urban Minor
City and Town
Rural Town and Fringe
Rural Village
Rural Hamlet and Isoloated Dwelling


Circulatory Disease
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
Inner London
Outer London
Urban Major
Urban Minor
City and Town
Rural Town and Fringe
Rural Village
Rural Hamlet and Isoloated Dwelling

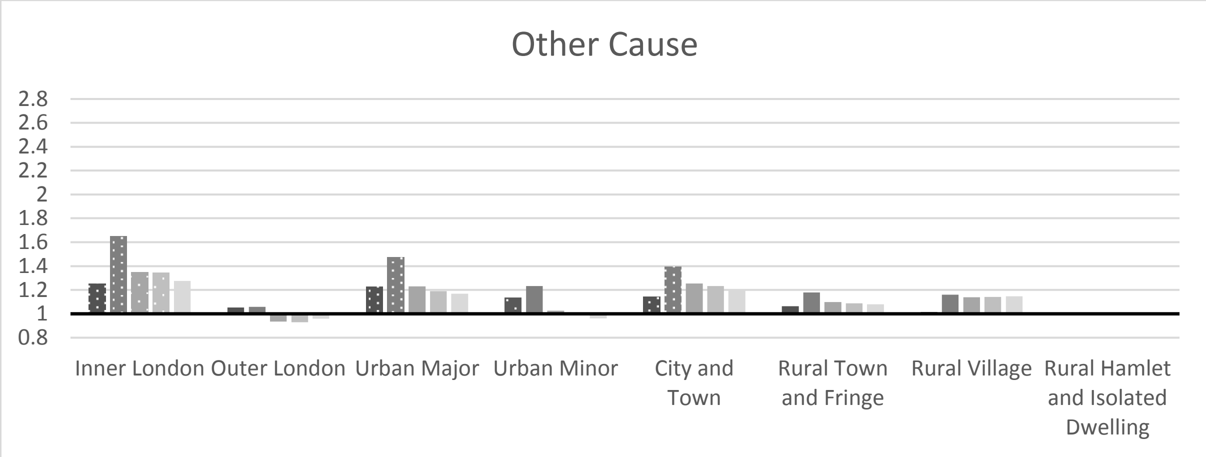


Figure 4.3: Cause-specific Mortality Variations across the Rural-Urban Continuum

(Dots indicate p-values <0.05)

4.5.1 Respiratory Disease

A clear positive urban-rural gradient is identifiable (Figure 4.3), with the risk of dying as a result of respiratory disease reducing from 2.5 times more likely in Inner London to 13% more likely in Rural Villages, relative to the levels of Rural Hamlets. Exceptions to this gradient exist in the form of Outer London and Minor urban areas. Those residing within the latter have larger than anticipated relative mortality, being over one and a half times more likely to die as a result of respiratory disease compared to their most rural counterparts. In fact, those residing within Urban Minor locations experience the highest relative mortality of all the residential categories. As expected, due to its high levels of population density, Inner London possesses large mortality levels compared to other residential categories. It is Outer London that is surprising, as residents possess much lower levels than we would anticipate, despite still being highly urban, with relative mortality being just 55% higher than the most rural residents. However, it must be stated that differences connected with results from Rural Town and Fringe and Village settings, are not statistically significant.

Once social class is controlled variations across the urban-rural continuum reduce substantially. For example, the relative risk of dying for those residing in Urban Major and Minor locations reduces in relative terms by 20% and 22% respectively.

The reduction is somewhat tapered in the more rural locations, with relative mortality in Rural Town and Fringe and Rural Village locations reduced by just 9% and 2%. After additionally controlling for education variations are reduced once again, however, to a much lesser extent. For example, for those residing within Urban Major and Minor locations the relative mortality reduced by 5%. After controlling for marital status and ethnicity, variations across the continuum reduce once more for the majority of residential categories, again to a lesser extent than for social class and education. For Outer London, the incorporation of demographic factors leads to a slight increase in relative mortality levels; however, these results are not statistically significant. Importantly, variations across the continuum persist, along with the previously discussed anomalies.

4.5.2 Lung Cancer

As with respiratory disease, for lung cancer a positive urban-rural gradient is distinguishable (Figure 2). However, the variations across the continuum are shallower than for the previous cause. Mortality relative to levels in Rural Hamlets reduces from a high in Urban Major locations of 118% more likely, to 40% more likely in Rural Villages. Again, exceptions are found in the form of City and Town locations and the capital city. City and Town locations have slightly higher relative mortality levels than would be expected. With regards to London, again relative mortality levels are lower than would be expected, more so for Outer London. Those residing within Inner London possess the second largest relative mortality levels, whereas those residing within Outer London have significantly smaller rates, with mortality lower than those in Rural Town and Fringe locations.

Incorporating social class into the analysis once more leads to a reduction in variations across the continuum, with the relative mortality for those residing in Urban Major and Minor locations reducing by 13% and 17% respectively. As before, the level of reduction is greatest for the more urban locations, and compared to respiratory disease, the influence of social class appears to be smaller for lung cancer. Once education has been incorporated into the analysis, as with respiratory disease variations reduced yet again, albeit to a lesser extent. The relative likelihood of dying for those located in Urban Major and Minor residence reduced from 90% and 53% more likely to 77% and 43%. After additional demographic influences have been controlled variations across the continuum reduce once more for City and Town, Rural Town and Fringe locations and Rural Villages. However, for the remaining categories relative mortality levels actually increases. Crucially, again, although at a reduced rate, variations across the continuum remain intact. However, the difference from Isolated Rural and Urban Minor and Rural Village are not statistically significant.

4.5.3 Other Cancers

In contrast to the previous disease categories, no clear trend can be identified when it comes to studying other cancers, with the differences between Isolated Rural areas and the majority of other residential locations being not statistically significant (Figure 4.3). The level of relative mortality appears to be similar across the urban-rural continuum, with variations contained within a 25% range. Once social class is controlled relative mortality reduces, but only marginally by between one to five percentage points. The same can be said for when educational influences are incorporated. In complete contrast, after controlling for demographic factors, variations increase slightly for all locations, which the exception of Rural Villages locations, where no change is experienced.

4.5.4 Circulatory Disease

As with respiratory disease and lung cancer, when studying circulatory disease, a strong positive urban-rural gradient can once again be seen. For example, compared to Rural Hamlets, Inner London exhibits mortality rates 95% higher and Rural Villages have rates 23% higher. Variations across the continuum are shallower than for respiratory disease, with levels similar to those of lung cancer. Again, Outer London and Urban Minor residence stray from the pattern. As with respiratory disease, mortality within Urban Minor areas is greater than expected, with the greatest difference (117%) from those in Rural Hamlets. Outer London however, has relatively low mortality, with levels falling in-between that of City and Town and Rural Town and Fringe locations. Of all the results regarding circulatory disease it is only those related to Rural Villages that are not statistically significant.

After controlling for social class, variations across the continuum reduce considerably, more so for the more urban locations. For example, relative mortality for those residing in Urban Major and Minor locations reduces by 14% and 15% respectively, compared to a 6% and 1% reduction for Rural Town and Fringe and Rural Village locations. Compared to respiratory disease and lung cancer, social class appears to have the smallest influence in terms of mortality. Crucially, after controlling for class, mortality variations across the continuum persist. Once education is included variation decreases, once again by less than for social class. The effect of additional compositional influences reduces variations across the continuum for the most part, albeit only slightly.

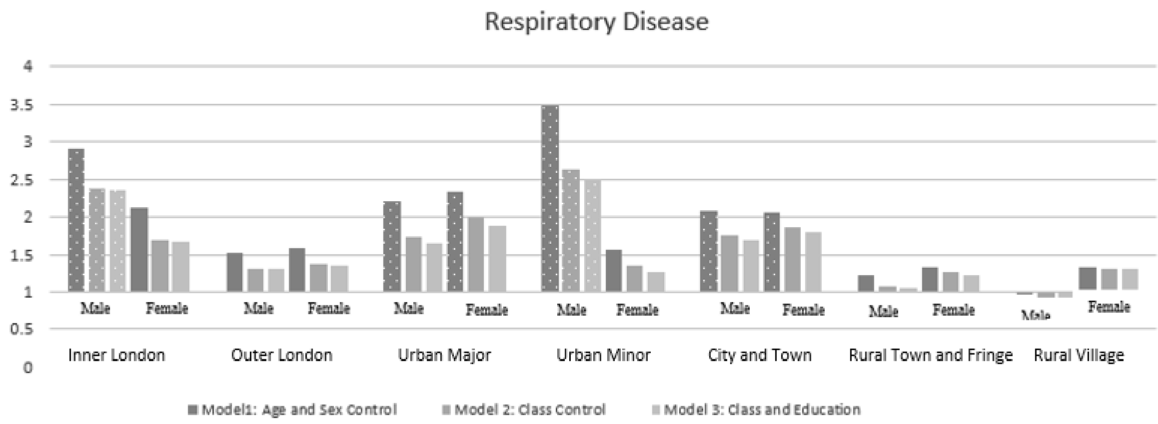
4.5.5 Other Causes

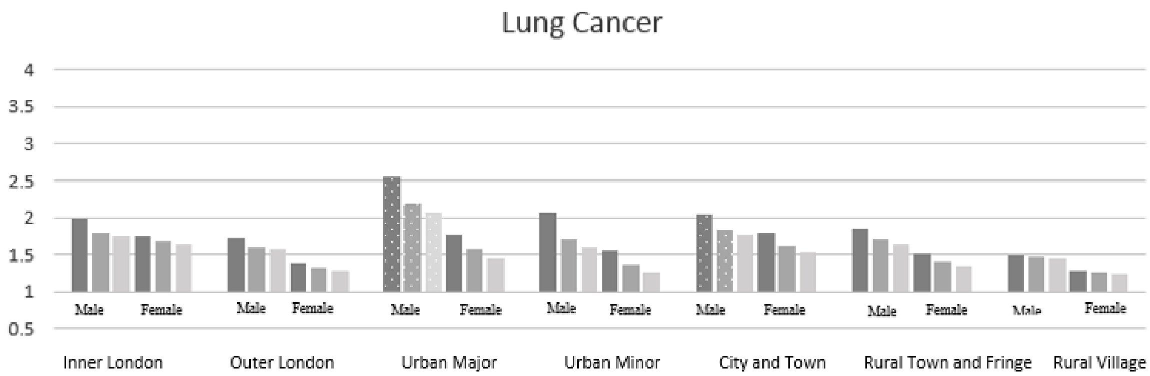
Positive urban-rural mortality gradient is identifiable for 'Other Causes'. Compared to those living in the most rural locations, those residing within Inner London are 65% more likely to die from other causes. This is substantially larger than the relative mortality of those living in rural villages, who are just 15% more likely.

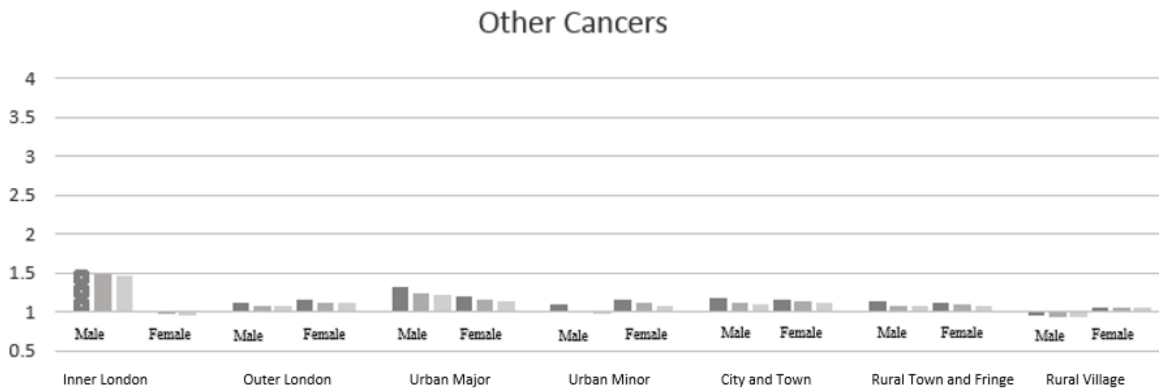
As with the previously discussed causes, some residential categories stray from the continuum. Those residing within Outer London and Urban Minor locations possess superior expectations than would be anticipated. Such individuals are just 6% and 23% more likely to die as a result of other causes, compared to their most rural counterparts.

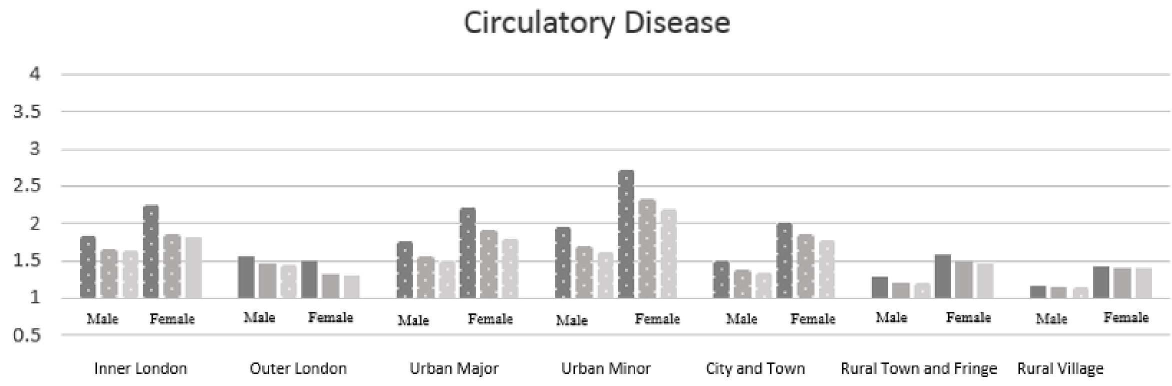
Once social class is controlled differences across the continuum reduce substantially. For example, the relative mortality of those residing within Inner London and urban Major locations reduces from 65% and 47% more likely to just 35% and 23% more likely, a reduction of 30 and 24 percentage points respectively. Again, the incorporation of social class seems to have a larger impact on the more urban locations, with mortality reducing by just 8 and 2 percentage points after controlling for class for these residing in rural town and fringe locations and rural villages. Importantly, although at a reduced level, after controlling for class mortality variations across the continuum persist. Once education is incorporated variations across the continuum reduce however, only slightly. Additionally, controlling for ethnicity and marital status reduces variations once more albeit only marginally.

Results for other causes discussed above must be treated with caution. For the vast majority of models observed differences are not statistically significant. Consequently, results point to the existence of a positive urban-rural health gradient however, we cannot be statically certain of this.









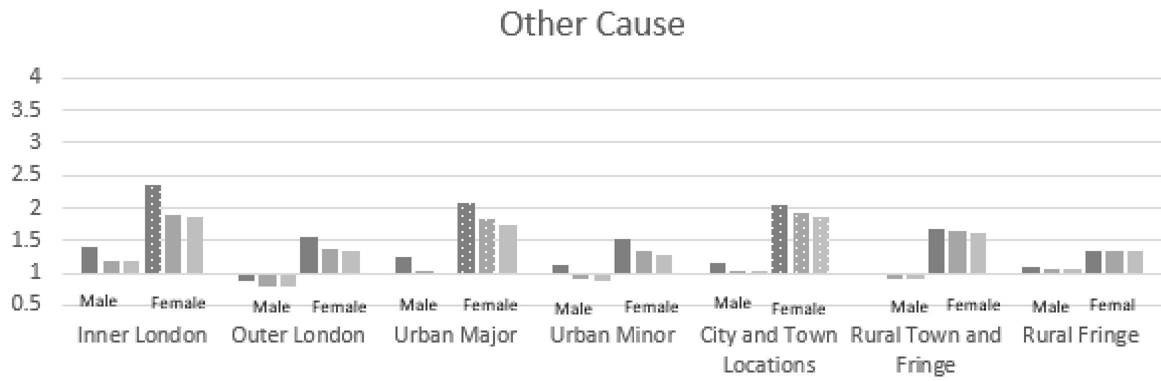


Figure 4.4: Male and Female Cause-Specific Mortality Variations across the Urban-Rural Continuum

4.5.6 Gender

For every cause under investigation, when simply controlling for gender (male as the reference category), variations across the continuum reduce substantially once social class is also controlled. From previous investigations we are aware that it is possible for male and female health to be effected by social class differently. It is suggested that males are affected by class to a greater extent, whilst females tend to be influenced more so by the surrounding environment. We do not know whether the large reduction experienced here is a result of both male and female health being equally effected by class, or if the impact of class on male health is so large that it overrides the lack of effect on female health. It is for this reason that the series of models above were refitted separately for males and females. Figure 4.4 displays the results for gender-specific variants of models 1-3 only. Model 4 is not included as the influence of controlling for marital status and ethnicity were almost unidentifiable.

To begin with lung cancer, it is clear that for those of working age males are clearly disadvantaged, as greater mortality can be seen in each corresponding urban-rural category in comparison to females. In contrast, when it comes to circulatory disease and other causes it is females who are disadvantaged in every urban-rural category, with the exception of Outer London regarding circulatory disease. For respiratory disease and other cancers no clear gender advantage can be seen. Once the influence of social class is controlled, substantial reductions in mortality variations across the continuum can be seen for all causes for both genders. For lung cancer, respiratory disease and other cancer larger reductions are experienced by males than by females. For circulatory disease however, larger reductions are noted for females. For other causes males and females experience similar mortality reductions. In comparison, controlling additionally for education leads to only minor further reductions in mortality. Even so, in every residential category the reductions experienced by females are slightly larger than for males for those suffering from circulatory diseases, other cancers and other causes; and larger in most residential categories for those suffering from respiratory disease. Once additional influences are controlled for (marital status and ethnicity), for all diseases under study residential mortality variations again reduce marginally for females. Conversely, for males the inclusion of these additional influences actually leads to an increase in variation for respiratory disease, lung and other cancers. Again, all reference to other causes must be treated with caution due to the lack of statistical significance across every model.

4.6 Conclusion and Discussion

This study assessed the cause-specific risks of dying amongst members of the ONS England and Wales Longitudinal Study between the years of 2001-2011, using Cox survival models. Taking account of age and gender, for both respiratory disease and lung cancer a clear positive urban-rural mortality gradient was uncovered, although at a much shallower rate for the latter. For both diseases the risk of dying was found to increase with each successive levels of urbanisation. Those located in the most urban location possessed the worst mortality expectations, whilst those residing in the most rural possessed the best. Anomalies to the gradient were discovered however, in the form of Outer London, Urban Minor and City and Town locations. Rather than possessing relatively high mortality as would be expected, Outer London residents actually had relatively low mortality from respiratory disease and lung cancer. For respiratory disease, those residing in Urban Minor locations experienced higher than anticipated mortality, possessing the largest levels of all residential categories. For lung cancer relative mortality levels were found to be much higher than expected in City and Town locations. As with respiratory disease and lung cancer results suggest the existence of a positive urban-rural gradient with regards to other causes. Again anomalies to the gradient exist, with outer London and urban minor locations possessing substantially lower relative mortality than would be anticipated. We must however be cautious when interpreting such results, as some observed differences were statistically insignificant.

For both respiratory disease and lung cancer the observed urban-rural mortality gradient reduced substantially once the influence of social class was incorporated, although much more so for respiratory disease than for lung cancer. After further controlling for education, marital status and ethnicity variations across the continuum reduced once more; however, to a much lesser extent. This suggests that the economic (social class) composition of an area is a key driver of relative area-specific mortality risk. Various mechanisms can be put forward to explain this observation. Within the UK it is widely accepted that urban areas tend to contain a much greater proportion of deprived individuals (Senior et al 2000), whilst smoking habits are known to vary significantly by social class (ONS 2013). It has been suggested, therefore, that spatial variations in respiratory disease and lung cancer are a direct results of spatial variations in smoking habits. Along with smoking, poor housing conditions such as dampness and overcrowding, poor nutritional status and specific occupations are said to independently impact upon the development of respiratory diseases (Halvorsen and Martinussen 2014).

Crucially, once compositional factors have been controlled, urban-rural variations in respiratory disease and lung cancer remain, suggesting that urban-rural residential context also plays a part. Spatial variations in air pollution arising from the combustion of fossil fuels are the most likely explanation for this observation.

In contrast to all of the other diseases under study, other cancers display no clear urban-rural trend. Mortality levels were found to be relatively similar across all residential categories. Once additional compositional influences are incorporated relative locational differences in mortality reduce, albeit only marginally, reinforcing the absence of urban-rural differences. Such results are relatively surprising, as according to previous research we would expect to uncover much higher rates within urban locations before compositional effects are taken into account. In contrast, once social class and the other socio-demographic influences in the model are incorporated we would expect variations across the continuum to reduce or disappear altogether, as researchers have often determined that such variations are likely a consequence of behaviour, such as alcohol consumption, smoking and sexual promiscuity (Doll 1991 and Schouten *et al* 1996), all of which are broadly linked with lower social classes, who tend to be concentrated in urban areas.

For circulatory disease a strong positive health gradient is uncovered. Relative mortality reduces from its highest level in Major Urban locations to its lowest in the most rural. Levels of relative mortality were similar to those of lung cancer, and much lower than for those reported for respiratory disease. As with the other causes two anomalies to the gradient were identified, both in line with those identified for respiratory disease. Relative mortality in Urban Minor locations was greater than anticipated, once again displaying the highest levels of mortality, whilst Outer London possessed relatively low levels of mortality, falling in-between that of City and Town and Rural Town and Fringe locations.

Once social class was included within the analysis disparities across the urban-rural continuum reduced substantially, although social class had a smaller influence than on mortality from circulatory disease than from respiratory disease and lung cancer. Controlling for education, ethnicity and marital status reduced the observed spatial variation once more, but only slightly. This implies that socioeconomic composition is once again a significant explanation for spatial variations in mortality, this time from circulatory disease. As with the previous causes, variations in smoking are believed to play a significant role. However, even after controlling for compositional effects, the urban-rural gradient remains intact, albeit attenuated. Consequently, residential context must play a noteworthy part. Numerous explanations have been offered regarding how the influence of the surrounding environment on the development of circulatory disease. These include local levels of crime, pollution, and green space.

For both respiratory and circulatory disease, Urban Minor locations have been found to be an exception to the health gradient, with mortality levels being much larger than anticipated. What might then be the reasons for such an anomaly? Using the ONS RUC (2011) Urban Minor locations consist of areas located within Yorkshire including Barnsley, Sheffield and Nottingham. Such areas are deprived, with Barnsley classed as the 39th most deprived area within England. Further, 60% of LSOA's within Nottingham were found to be within the top 2 categories of the Index of Multiple Deprivation (DCLG, 2015). Hence it might be possible that the inclusion of social class and education in the models only partially accounts for the levels of deprivation experienced by respondents. Alternatively, it is possible that the increased mortality is related to levels of ambient air pollution, as Sheffield and Nottingham were recently named within the four top urban areas within the UK in breach of safe air quality levels. Nottingham and Sheffield were found to have PM0 levels 5ug/m3 and 3ug/m3 over the 20ug/m3 limit (WHO, 2016). However, further investigation is needed to draw any conclusion.

A further anomaly within this investigation is the observed 'Outer London' effect. Based on contextual theories (e.g. pollution and crime), those residing within London should be expected to experience the highest levels of mortality for all of the causes investigated. Whilst this was broadly found to be the case for Inner London, Outer London was found to have far lower levels of mortality than anticipated. These results are similar to those uncovered by Allan et al (2017a) and Allan et al (2017b), who discovered that for all-cause mortality, those Output areas and Local authority districts located within Outer London possessed better than anticipated health, with LADs within the outer borough possessing levels similar to those located in the most rural locations.

One possible explanation could be related to levels of deprivation. Levels of social deprivation are lower in Outer than in Inner London. Outer London preserves this mortality advantage even once social class and education are controlled for. This may be due to these factors failing to adequately capture between-area heterogeneity in disposable income. For example, residents from a given social class living in Outer London might earn more than their inner London counterparts. However, average post-tax incomes in Inner and Outer London are similar (ONS 2016). Alternatively, therefore, the issue might relate to housing costs. Within Inner London (even excluding the prime estate areas of Kensington, Chelsea and Westminster) average house prices are higher than in Outer London (£530,017 in comparison to £402,282) (ONS 2017). Thus, individuals living in Inner London will spend increased amounts on housing, being left with less disposable income. Another possible explanation relates to the healthy migrant effect. An initial expectation might be that the healthiest individuals migrate to Inner London to study and work, with those in poor health migrating away, most likely to other cities. However, over their life course many individuals relocate from Inner to Outer London. These migrants tend to hold enhanced health, when compared to those left behind (cf. Tunstall et al 2015). Other explanations have been proposed in the form of the residential environment within the inner capital, with higher levels of pollution and greater amounts of housing in a state of disrepair, resulting in increased respiratory disease (Haynes, 2016; Halvorsen and Martinussen 2014 King and Brook, 2016).;

A further aspect of our study touches upon urban-rural differentials in male and female cause-specific mortality. With regards to a gender difference, for lung cancer it is males of a working age who are clearly disadvantaged. In contrast, for circulatory disease and other causes it is females. For respiratory disease and other cancers no gender advantage can be identified. Once social class is controlled substantial reductions in mortality are experienced by both men and women. For lung cancer, respiratory disease and other cancers, in most residential locations men experience slightly larger reductions than women. A similar story was uncovered within an investigation by Allan et al (2017b) into all-cause mortality across the rural urban continuum at the OA level. The investigation concluded that socioeconomic composition accounted for a larger proportion of the male health gradient compared to females. This suggested that male mortality is more sensitive to socio-economic status, and female mortality to the residential environment. This applied to all of the causes of death considered here, except for circulatory disease. Unexpectedly, in this current study, once social class is controlled for, somewhat larger reductions are noted for females as opposed to males.

An issue arises relating to such findings is that they may be related to the intrinsic difficulty in examining female health using socio-economic classifications based upon occupation. As women tend to possess weaker attachments to the labour market, the efficiency of basing class upon employment is reduced (Langford and Johnson, 2009). The gender pay gap additionally confuses matters, along with female family responsibilities resulting in occupational downgrading (Geiler and Rennebong 2015). Johnson (2011) goes as far to suggest that it is vital for investigations to continue founded upon alternative means of classification, which assess the role of non-occupational and social capital based factors such as education. The results from this investigation partially support such a notion, as once educational influences are controlled, variations reduce slightly more so for females as opposed to males in the majority of cases, with the exception of a few residential contexts in terms of lung cancer and respiratory diseases. It must be stated however, that the effect of education is minimal for males and females compared to the influence of social class.

This study has contributed to the research of geographic disparities in cause-specific mortality in numerous ways. Firstly, this study examines urban-rural mortality differences, whilst adjusting for individual-level compositional characteristics. This permits for the exact measurement of the association between an individual's place of residence and specific mortality probability. This contrasts with the majority of existing studies which have utilised area-based deprivation measures such as the IMD as a proxy for deprivation (Gartner et al 2008). Secondly, rather than utilising a simple urban-rural dichotomy, as in most existing studies, the

ONS RUC has been used with capital city adjustment. This enabled the identification of an urban-rural gradient and a 'capital city' and 'Outer London' effect along with Urban Minor anomalies. Finally, advancing upon previous studies, which have tended to ignore gender, this investigation has fitted models for males and females independently.

Although this investigation provides further insights into cause-specific residential mortality, it is not without its weaknesses. The most important of these is the lack of incorporation of selective migration. The challenge remains to integrate migration fully into future analyses, in order to further enhance our understanding of urban-rural mortality differentials.

4.7 Acknowledgments

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4.9 Appendix

Table 4.2 Cause Specific Mortality variations across the Urban-Rural continuum (Hazard Ratios) (Model 4)

Residence	Respiratory Disease	Sig	Lung Cancer	Sig	Other Cancer	Sig	Circulatory Disease	Sig	Other Cause	Sig
Rural Hamlet and Isolated Dwelling	1		1		1		1		1	
Inner London	1.9	0.008	1.87	0.008	1.23	0.065	1.49	0.003	1.28	0.112
Outer London	1.36	0.171	1.64	0.015	1.17	0.086	1.34	0.011	0.96	0.772
Urban Major	1.70	0.008	1.82	0.001	1.2	0.028	1.53	0	1.17	0.215
Urban Minor	1.91	0.006	1.44	0.117	1.05	0.669	1.74	0	0.96	0.815
City and Town	1.68	0.008	1.64	0.005	1.12	0.153	1.43	0.001	1.2	0.128
Rural Town and Fringe	1.11	0.638	1.47	0.047	1.08	0.391	1.25	0.052	1.08	0.571
Rural Village	1.1	0.693	1.34	0.158	1	0.978	1.22	0.116	1.15	0.346
Sex										
Male	1		1		1		1		1	
Female	0.75	0	0.65	0.038	0.96	0.203	0.42	0	0.52	0
NSSEC										
Managerial and professional	1		1		1		1		1	
Intermediate Occupation	1.16	0.174	1.04	0.637	0.98	0.693	1.12	0.042	1.06	0.444
Routine and Manual Occupation	1.63	0	1.38	0	1.08	0.057	1.33	0	1.46	0
Never Worked and Long-term Unemployed	3.14	0	1.48	0.017	1.29	0.002	2.23	0	3.54	0
Student	1.20	0.763	0.46	0.443	0.55	0.053	1.12	0.681	1.35	0.08
Missing / NA	3.67	0	2.08	0.02	1.78	0.002	3.73	0	5.27	0
Education										
Level 4	1		1		1		1		1	
Level 3	1.06	0.791	1.36	0.106	1.06	0.459	1.17	0.142	1.05	0.626
Level 2	1.37	0.03	1.26	0.098	0.99	0.805	1.25	0.004	1.11	0.2
Level 1	1.29	0.089	1.54	0.001	1.05	0.461	1.35	0	1.33	0
Other	1.48	0.009	1.74	0	1.10	0.118	1.34	0	1.07	0.5
No Qualification	2.03	0	2.36	0	1.24	0	1.83	0	1.63	0
Missing/NA	0.86	0.882	3.23	0.132	0.53	0.298	0.76	0.568	0.90	0.801
Marital Status										

Single	1		1		1		1		1	
Married	0.36	0	1.04	0.715	0.78	0	0.47	0	0.35	0
Separated	0.75	0.101	1.97	0	0.88	0.207	0.72	0.002	0.66	0
Divorced	0.87	0.195	1.68	0	0.88	0.051	0.80	0	0.83	0.005
Widowed	0.80	0.105	1.74	0	0.99	0.9	0.97	0.753	0.62	0.001
Ethnicity										
White	1		1		1		1		1	
Black	0.50	0.033	0.51	0.035	0.96	0.781	1.10	0.495	0.65	0.015
Mixed	0.59	0.365	1.03	0.951	0.61	0.087	0.80	0.441	0.92	0.748
South Asian	0.82	0.232	0.28	0	0.62	0	1.04	0.666	0.91	0.377
Other Asian	0.85	0.682	1.01E-20		0.45	0.002	0.87	0.513	0.54	0.042
Other	2.93E-20		0.27	0.197	0.48	0.052	0.53	0.517	0.65	0.289

Chapter 5

It is clear that whether studying health, overall or cause specific mortality, a positive urban-rural gradient is identifiable across England and Wales, with rural individuals experiencing superior health compared to urban. It is now apparent that such mortality and health differentials cannot be explained by compositional influences alone, and that contextual factors play a significant role when it comes to rural-urban variations. Whilst previous chapters have considered context and composition, they have failed to consider migration as a potential influential factor. This study aims to understand how the health of internal migrants differ from their non-migrant counterparts. If migrants appear to hold improved health, it Is clear that the healthy migrant hypothesis is at play, and that the theory can be applied to migration within the internal field. This chapter also aims to understand migrant health in terms of the impact of distance and direction of movement, in terms of rural-urban, urban-rural and so on. If the incorporation of such migratory factors leads to a reduction in the positive urban-rural health gradient, migration can be classed as an explanatory factor alongside context and composition.

Rural Urban Health Variations: Health Selective Migration?

Studies show that in industrialised countries health inequalities vary geographically. Rural areas are found to possess better health expectations and lower overall mortality than urban locations. Contextual and compositional influences have been suggested as causes of such variations. However, the potential health-selective influence of migration has yet to be investigated.

This study investigates urban-rural differences in self-rated health across England and Wales, whilst controlling for the influence of internal migration. Further, we compare the health of non-migrant and migrants, testing the validity of the healthy migrant hypothesis. Finally, we investigate how the health of migrants differs by area of origin and destination.

Analysis of the British Household Panel survey revealed a clear positive urban-rural health gradient, with the risk of an individual reporting their health status as fair or poor increasing with each level of urbanisation. Exceptions to this trend were the capital city and minor urban locations, with those living in London consistently possessing better health than anticipated, and those residing in minor urban minor locations worse. Internal migrants were consistently found to possess worse health than their non-migrant counterparts. In terms of movement pathways, those who relocate from urban to rural locations appear to be healthier than those travelling in the opposing direction. Once internal migration is controlled for, variations in health across the urban-rural continuum remain unchanged, leading us to believe that migration has little to no impact upon the geographic distribution of health inequalities.

5.1 Introduction

The majority of studies agree that in England and Wales rural areas experience more favourable health outcomes than urban areas (Defra, 2014). Researchers have attempted to explain these variations in terms of compositional and contextual factors. One potential explanatory factor that has been for the most part been overlooked is migration (Geronimus *et al,* 2014).

Boyle (2004) suggested that the reason why there is limited evidence regarding the role of migration in shaping the rural-urban health distribution is that a big dataset is required, containing a large sample of individuals and information upon mobility and illness. Only seldom are these demands satisfied. Further, according to Lu (2010) the vast majority of work that there has been on the links between migration and health has focussed on international rather than internal migration. The degree to which findings from studies of international migration apply to internal migration has yet to be thoroughly investigated.

This study investigates health variations over the rural-urban continuum within England and Wales, and the extent to which observed disparities can be attributed to internal migration. Specifically, we focus on working age members of the British Household Panel, tracking individuals aged 18 to 65 from 1991-2009. Multilevel models are used to examine variations in health according to migrant status, residential location within the rural-urban continuum, and movement pathway.

Our study is distinctive in three ways: the fine-grained approach it takes to classifying areas within the rural-urban continuum; its foundation upon the analysis of individual- rather than aggregate area-level data; and its study of health-selective migration in terms of internal (rural-urban) rather than international mobility.

5.2 Literature Review

5.2.1 Post-Move Environment

Health of migrants can improve or deteriorate due to the properties of their post-move residential environment. These can include physical influences and behavioural aspects. With regards to the former, it is widely accepted that the living conditions of new residential locations will substantially differ from places of origin, thus such environmental change (pollution, housing conditions, access to green space) will undoubtedly result in significant alterations to an individual's health. The impact of such changes is something that is often overlooked in heath and migration literature (Delavari, 2015). In terms of behavioural change, through the process of acculturation (in which migrants adapt their behaviours to conform more closely to social and cultural expectations of the mainstream society in which they now reside) (Urquia and Gagnan, 2011) both positive and negative health outcomes can transpire (Wallace and Kulu, 2014). For example, rural to urban migration is thought to lead to reduced uptake of physical exercise and an unhealthy diet (Carrillo-Larco 2016), associated with obesity, diabetes, cardiovascular and circulatory disease (Ebrahim *et al*, 2010 ; Bernabe-Ortiz *et al,* 2012 Bowen *et al*, 2011). In terms of healthful behaviours, it is believed that migration to urban locations will lead to improved health seeking behaviours, due to improved access to healthcare facilities (Mungall, 2005 Tam 1994). It must be stated that the majority of research upon acculturation is based within the field of international migration. Nevertheless, there is reason to believe that such mechanisms are applicable in the context of internal migration.

5.2.2 Health Selective Migration

Understanding the health consequences of migration is challenging. It is difficult to distinguish between the health impacts of the post-move residential environment, and possible health selection effects in the decision to migrate. Health selective migration can materialise as a result of one or more of five possible mechanisms: positive and negative health selection; salmon bias; age and distance selectivity.

Migration is far from a random process, as the propensity to move varies in relation to differing demographic and socio-economic variables, most significantly health (Kennedy et al 2015). The idea that certain types of migrations are facilitated by good health, and others necessitated by inferior health is far from new (Brimblecombe *et al*, 2000). Norman *et al* (2005) go further, supporting that the health characteristics of movers within the UK differs from that of the general population, such that the processes of migration can be classed as health selective.

The vast majority of literature focuses on the links between health and international migration (Halliday and Kimmitt 2008). This is astonishing considering the majority of moves occur within national boundaries. If the health of internal migrants significantly differs from that of non-movers, then the average morbidity levels of an area can be substantially altered (Connolly and O'Reilly, 2007).

The healthy migrant hypothesis suggests migrants are a selectively healthy group, unrepresentative of all potential movers (Lu and Qin, 2014, Wallace and Kulu, 2014). The hypothesis has principally been studied in the context of international migration. (Tunstall *et al,* 2014). However, recently studies have begun to investigate within the internal field. Examples of this are Halliday and Kimmitts (2008) investigation into the healthy migrant hypothesis in America with regards to internal migration, and Drefhal and Anderssons (2017) study in Sweden. Nonetheless, research within this field remains limited. Tong and Piotrowski (2012) have noted that the intensity of positive health selection may vary, with selection being more extreme for international movement. Nevertheless, generally those in poor health are found to have a lower propensity to migrate than those with good health (Tong and Piotrowski, 2012). It is vital to fully understand the healthy migrant hypothesis within the internal context, as the movement of healthy individuals has the potential to lead to serious implications upon the spatial distribution of health. It is believed that areas which suffer from high levels of out migration will display higher levels of morbidity, as the healthy leave and the ill remain behind (Larson et al, 2004). Those areas with high population growth will display lower levels of illness, due to the influx of healthy individuals (Larson *et al* , 2004).

It is believed that migration is positively health selective both directly and indirectly. Indirectly, individuals possessing higher socioeconomic status (larger income) along with education levels are more likely to migrate, both attributing to lower morbidity (Kennedy et al, 2015). Directly, good health supports the ability to move as migration leads to considerable disturbance upon an individual's life (Lu and Qin, 2014, Deri, 2005, Kibele *et al,* 2008). The healthy migrant hypothesis is generally cited in terms of younger migrants (Lu, 2008). This is important as migration is dominated by the movement of young adults (Wallace and Kulu, 2014).

A study from the US provides supporting empirical evidence. Halliday and Kimmitt (2008) discovered that for younger males, migration was restricted to such an extent that when moving from the middle to the bottom of the heath distribution, mobility was reduced by 32-40%.

The Salmon Bias is a competing explanation of the health-migration link. It posits that unhealthy migrants have a greater propensity to return home (Turra and Ela, 2008). It is believed that migrants experiencing health issues after they have arrived are incapable of attaining high productivity in the destination labour market, making returning home an attractive option (Lu and Quin, 2014). Consequently, there is an issue with data artefact, as the deaths of those returning home are omitted from data in the area they have left behind, thus individuals become statistically immortal, resulting in an artificial downwards bias in mortality of migrants in destination locations (Turra and Ela, 2008). Investigation of the Salmon Bias are scarce and evidence has proven inconclusive, with the majority of studies focusing upon international migration (Lu and Quin 2014 Sander 2007).

In contradiction to the Salmon Bias and the healthy migrant hypothesis, various studies have indicated that in developed countries numerous movements are in fact associated with poor health (Tunstall *et al,* 2014). Bentham (1988) a leading academic within the field, distinguishes between two types of such migration. Firstly, the movement of sick individuals away from an area presumed to be hazardous to health. Secondly, the movement of those who are ill to be better placed in terms of both formal and informal medical care, known as assistance migration (Wallace and Kulu, 2014). Theoretically, this will lead to the elevation of mortality and morbidity rates in destination areas, whilst origin areas will display more favourable health levels (Norman *et al,* 2005).

The health selectivity of migration is further influenced by the age of the migrant and the distance of the move. Selection as a result of poor health is generally cited for older migrants (Boyle, 2004). Despite the rate of movement of elderly individuals being just half that of the general population, in recent decades post retirement moves are becoming progressively more common (Walters, 2002).

In terms of distance, research consistently concludes that those who migrate over longer distances are healthier than both those who remain and those who move short distances (Boyle et al 2001). Distance is viewed as an intervening obstacle for movers, as it is associated with greater financial costs, a loss of social networks and generally a more difficult process (Thomas et al 2015). This explains why long-distance moves are found to be less common than those of short distance (Champion and Shuttleworth 2015). Long distance migration is most common amongst those who are younger, better educated and of a higher social standing, all of which are indirectly associated with good health. Directly, such individuals are also more likely to be free of long-term healthcare needs and constraints on physical mobility (Wilding et al, 2017). A Study of the England and Wales conducted by Wilding et al (2017) provided supporting evidence, concluding that the healthy migrant effect is only apparent somewhere between 20 and 50km distances. With regards to short distance moves, Wilding et al (2017) finds supporting evidence for negative health selection, with shorter moves associated with poor health over the majority of working age groups. The healthy migrant effect is evident for only the youngest (16-24) and oldest (55-64) working groups. Wilding et al (2017) emphasised the idea of what constitutes long and short distance moves, and its impact upon an individual's health. The Rural-Urban context was not a focus of the study, thus leaving a substantial gap within the literature. Further, Wilding et al (2017) failed to take into consideration the effect of socio-economic status, thus not controlling for a substantial health influence.

5.2.3 Health Selective Migration in the Context of the Rural Urban Continuum

Within the UK investigations into the links between health selective migration and rural urban health variations remain partial at best. In spite of this, there is evidence that migration has a significant impact upon existing spatial health inequalities (Tunstal, 2014). Migration is believed to have such an impact that between 1981-2001 within England, the internal movement of individuals was said to account for around 30% of the mortality inequalities observed between rural and urban areas (Riva *et al,* 2011).

5.2.4 Rural to Urban Migration

Since the turn of the twentieth century metropolitan areas have experienced major economic expansion, whilst the greatest declines have been felt in rural locations (Litwak and Longino, 1987). From as far back as 1872 through to the present-day, due to the smaller number of rural employment opportunities available, younger persons have been pushed towards metropolitan locations. This has led to positive health selection, since those migrating have been found to be much healthier than those who remain behind (Welton, 1872 Riva *et al* 2011). Champion (2004) concluded that younger healthier individuals have been migrating from rural to urban locations, seeking higher educational and employment opportunities. Consequently, the apparent health advantage of movers will reduce health inequalities between the two area types (Riva *et al,* 2011).

In contrast, the parents of young migrants have less of an incentive to leave until they experience declining health, when they often migrate to be closer to their family (Walters, 2002). The fact that formal medical care institutions are often concentrated within urban locations is also a major draw (Riva *et al,* 2011). Such a movement is not simply restricted to the old but to people experiencing chronic health conditions in general (Larson *et al,* 2004). This negative health selection will lead to a rise in mortality within urban locations, with origin areas displaying more positive health profiles (Riva *et al,* 2011).

5.2.5 Urban to Rural Migration

Off-setting these rural-urban flows, within most developed countries the prevailing redistribution of the population over the past 20 years~~,~~ has been the migration of individuals out of major urban settlements. Within the UK population increase is faster in many rural compared to urban locations (Department for Environment Food and Rural Affairs, 2014), a consequence of internal migration (Riva *et al,* 2011). Riva *et al* (2011) discovered that within the UK those migrating into rural areas had substantially lower mortality risks compared to their urban counterparts, supporting the theory of entrapment of those in poor health within urban locations, and suggesting a positive health selection effect.

Conversely, a negative health selection effect has been observed in the movement of individuals with chronic illness away from cities towards more rural location. This may be in an attempt to remove themselves from areas seen as hazardous to their health, and/or the return of individuals to their rural roots once health begins to fail them (Bentham, 1988). The overall effect would be to reduce levels of mortality in metropolitan areas, whilst increasing levels in rural destinations.

5.2.6 Summary

From the literature it is clear that the association between health and migration is intertwined. In terms of acculturation, the movement of individuals from rural to urban locations is associated with both positive and negative behaviour. However, it must be considered that those who have investigated internal migration in terms of acculturation have done so in the setting of developing nations. Thus~~,~~ results from the UK may prove significantly different. In terms of migrant health-selection there are numerous competing theories, including the healthy migrant hypothesis, the salmon bias, and the negative health selection (Lu, 2008 Lu and Quin, 2014 Tunstall *et al,* 2014). Further, there are also numerous competing migrant flows, the net effect along with the drivers of such movements remain unclear.

5.3 Research Questions and Hypothesis

Firstly, we presume that the health of migrants and non-migrants will differ significantly. What is not clear is whether migrants will experience better or worse self-reported health in comparison to their non-migrant counterparts.

Secondly, we foresee that the health of migrants will differ according to their flow of movement from and into urban and rural areas. However, it is not clear how the differing directions of flow will influence an individual's self-rated health.

Finally, given the findings of previous investigations, we expect that the influence of migration upon rural-urban health inequalities will be substantial. However, we are unaware to what extent migration will account for health differences across the urban-rural continuum.

5.4 Data and Methods

5.4.1 Data

5.4.2 BHPS

The British Household Panel survey, established in 1991, is a nationally representative multipurpose study, unique in its ability to follow the same representative sample (the panel) over a period of years (waves). The BHPS is collected annually and consists of a sample of approximately 10,000 individuals (16+) who were recruited in 1991. The sample was first selected utilising a stratified clustered design sourced from the Postcode Address File. All individuals residing at these addresses during the first wave were elected as panel members (Original Sample Members), being re-interviewed at each consecutive year. Children born to OSM's automatically become original members and are interviewed and followed once they turn 16. By 2009 (the last wave of BHPS) a total of 18 waves of data had been collected, making the BHPS one of the longest running panel surveys in the world (Taylor et al 2010).

The BHPS with its longitudinal aspects provides a rich source of data for exploring both variations and transitions over time. The data is unique in its ability to identify and quantify different types of moves that contribute to migration and its effects upon an individual's health, along with the impact of socio-demographic factors. As the study is continuous rather than a snapshot, it adequately captures moves within the UK of all sample members. If a person moves, they are followed to their new address. Thus, the BHPS is capable of facilitating valuable analysis of migration (Bramley et al 2006).

5.4.3 Sample Size

For this investigation our sample is restricted to those aged between 18 and 65 living within England in 1991 (140,490 individuals, 66,663 males and 73,827 females). Our investigation is focused purely on those of a working age for various reasons. Firstly, social class is only reliably coded for those under retirement age. Of all individuals aged 66 and over within the dataset, only 6% have a social class assigned to them (either still in employment or previous employment to retirement), the other 94% simply possess missing values (retired). Consequently, social class as a compositional influence cannot be controlled adequately when studying older age groups. Another reason relates to the sheer amount of migration, with the volume of moves of older individuals being just half that of the general population (Walters, 2002) Although the movement of such individuals is important, it is not the focus of this study. Thus It must be noted that limiting the age boundaries within this study by not including the elderly may change results. Individuals within this investigation are be followed over all waves, thus censoring occurs at 2009, or at the point in which a person drops out of the dataset for good or dies. If an individual was lost to follow up but then returned to the study, the location in which the individual resided in the previous wave is utilised, as this is likely to be a good indicator of where such an individual was located in the missing time period.

5.4.4 Health Indicator

Due to the small number of death events, this investigation focuses upon changing health status. Individuals were asked to rate their health over the past 12 months, compared to others of their age, on a five point scale. To meet the requirements of multilevel logistic regression, answers were subsequently grouped creating a binary variable consisting of good (good- excellent) or poor (fair- very poor). On average, across all waves 24% of respondents reported themselves as having poor health. The creation of such a variable follows similar groupings implemented in previous investigations, such as that of Riva et al (2009). Further tests were completed to ensure the robustness of such a categorisation. Probabilities of an individual rating their health status as fair or poor were found to mirror those of individuals reporting to possess a limiting long-term illness in the 2001 Census (SAR), although at a higher level (Allan et al, 2017). This proxy for individual health relies solely upon self-assessment, thus its objectiveness can be questioned. However, previous studies have reinforced the validity of utilising such measures (Rees et al 2009), as individuals are thought to be excellent judges of their own health, with self-rated health derived as a powerful indicator of subsequent mortality (Drever et al 2004)

5.4.5 2011 ONS Rural-Urban Classification (RUC)

This investigation utilises an adapted version of the ONS 2011 Rural Urban Classification (RUC) of Lower Super Output Areas (LSOA), applied to the place of residence of each original sample member at each wave. Within this classification, any settlement with over 10,000 individuals is considered urban, with all others classified as rural. Rural and urban LSOAs are then additionally classified into 'Urban Major', 'Urban Minor' 'City and Town', 'Rural Town and Fringe' and 'Rural Village' using LSOA density profiles (Bibbly and Brindley, 2013). Allan *et al* (2017) establish that separating out the Capital City from the other 'Urban Major' areas better mirrored the observed district-level rural-urban gradient in self-reported illness. They also discovered an inner/outer London health effect. Consequently, for this study of self-reported health, LSOAs falling within the capital were likewise reclassified from 'Urban Major' to 'Inner' and 'Outer' London. In contrast to Allan et al (2017), the classification is of LSOAs rather than districts, on the basis that districts may contain within them smaller zones with urban or rural traits. An LSOA has on average a population of approximately 1,500 individuals.

Table 5.1 Descriptive Statistics

	Overall		Good Health		Poor health	
Variable	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Age						
18-19	5907	4.2	4787	81.0	1075	18.2
20–24	15101	10.7	11991	79.4	3110	20.6
25–29	15716	11.2	12566	80.0	3150	20.0
30–39	16664	11.9	13295	79.8	3369	20.2
40–49	16922	12.0	13193	78.0	3729	22.0
50–59	16110	11.5	12319	76.5	3790	23.5
60–65	15204	10.8	11303	74.3	3901	25.7
Sex						
Male	66,663	47.5	51,844	77.8	14,819	22.2
Female	73,827	52.6	54,801	74.2	19,026	25.8
Marital status						
Married	79,514	56.6	60,457	76.0	19,057	24.0
Separated	2,690	1.9	1,969	73.2	721	26.8
Divorce	12,896	9.2	9,019	69.9	3,877	30.1
Widowed	2,647	1.9	1,788	67.5	859	32.5
Ethnicity						
White	21,986	95.9	16,921	77.0	5,074	23.1
Black	256	1.1	188	73.4	68	26.6
Asian	445	1.9	314	70.6	131	29.4
Other	183	0.8	145	79.2	38	20.8
Mixed	67	0.3	48	71.6	19	28.4

RUC						
Inner London	4564	3.2	3513	77.0	1051	23.0
Outer London	8257	5.9	6488	78.6	1769	21.4
Major Urban	20502	14.6	15198	74.1	5304	25.9
Minor Urban	6451	4.6	4702	72.9	1749	27.1
City and Town	69551	49.5	52476	75.4	17075	24.6
Rural Town and Fringe	17610	12.5	13474	76.5	4136	23.5
Rural Village	13555	9.6	10794	79.6	2761	20.4
Rural Hamlet and Isolated Dwelling	4564	3.2	3513	77.0	1051	23.0
Social Class						
Upper Class	5,519	5.4	4,696	85.1	824	14.9
Middle Class	77,684	75.8	63,387	81.6	14,297	18.4
Lower Class	19,065	18.6	14,679	77.0	4,386	23.0
Education						
Degree or Higher	17,950	13.4	14,903	83.0	3,047	17.0
Post Compulsory Education	8,940	6.7	7,320	81.9	1,620	18.1
A-level	27,905	20.9	22,038	79.0	5,867	21.0
GCSE/O-Level	46,006	34.4	35,761	77.7	10,245	22.3
No qualification	32,976	24.6	21,579	65.4	11,397	34.6
Migration						
Short Distance Move (Moved LSOA)						
No	127,199	90.5	96,522	75.9	30,677	24.1
Yes	13,291	9.5	10,123	76.2	3,168	23.8
Long Distance Move (Moved Region)						
No	138,119	98.3	104,760	75.8	33,359	24.2
Yes	2,371	1.7	1,885	79.5	486	20.5
Moved RUC						
No	136,004	96.8	103,164	75.9	32,880	24.2
Yes	4,446	3.2	3,481	78.3	965	21.7
Direction						
Non Mover	128,453	97.8	97492	75.9	30691	23.9
London to Urban	248	0.2	208	83.9	40	16.1
London to rural	58	0.0	48	82.8	10	17.2
Urban to London	326	0.2	260	79.8	66	20.2
Urban-rural	1,077	0.8	833	77.3	244	22.7
Rural- London	92	0.1	69	75.0	23	25.0
Rural to Urban	1132	0.9	885	78.2	247	21.8
Total	**1,373896**		**1,048,436**	**76.3**	**325,194**	**23.7**

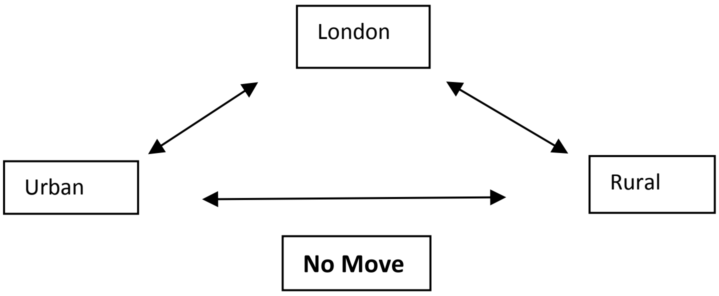
5.4.6 Methods

5.4.7 Statistical Methods

Multilevel modelling (mixed effects logistic regression) is utilised to investigate the self-reported health outcomes of internal migrants, and its influence upon health variations across the urban-rural continuum.

As with simple logistic regression, prediction models were generated producing odds (against a reference category) that a particular outcome would occur. In this case, the model predicted the likelihood of an individual reporting their health as fair or poor. Due to the longitudinal structure of the BHPS repeated measures are taken for each individual. Further within this investigation observations are nested within individuals, which are then nested within residential contexts. The issue with such data is that there is within subject observation dependence and between subject variation. Ignoring this would lead to an underestimation of standard errors of regression coefficients and an overestimation of statistical significance. Multilevel modelling was utilised to account for this, allowing for both fixed and random effects (Wang et al 2011 Antony and Lott, 2012).

Control variables within this investigation consisted of Age, Sex, Social Class, Qualification, Marital Status, Ethnicity, Move LSOA, Move RUC, Move Region and finally Direction of RUC move. The relationship between age and self-reported health was non-linear, but captured well by adding the additional polynomial term age^2. Social Class is made up of four categories namely, Upper class (professional), Middle Class (managerial/skilled), and Lower Class (semi-skilled/unskilled). Highest level of qualification consists of five categories: Degree or Higher, Post Compulsory Education, A-Levels, GCSE or O-Levels and No Qualifications. Ethnicity includes: White, Black, Asian, Other and finally Mixed. Marital status is made up of: Married, Separated, Divorced, Widowed and Single. The move variables (move LSOA, move RUC and move region) are all binary comprising of yes or no categories, indicating the type of change in address (if any) compared to the previous wave. Region within this investigation is the highest tier of sub-national division. This variable consists of 9 regions made up of North-East, North-West, Yorkshire and Humber, East Midlands, West-Midlands, East of England, London, South-East and South-West. If an individual is situated in a different region in the following wave, they are classes as having changed region. Direction of RUC move consists of the seven categories depicted below.



In order to conduct our investigation we constructed a series of models:

Model 0 examines variations in the health of individuals across the urban-rural continuum, controlling only for age and sex. Model 1 additionally controls for migration, where migration is defined as a move from one LSOA to another. Since the vast majority of LSOA to LSOA moves are short distance, this model acts as a proxy for exploring the impact of short distance migration on health across the rural-urban continuum. Model 2 also controls for migration, investigating the impact of moving between regions (a proxy for long distance migration). Model 3 controls for migration classified as a move to a different rural-urban category, whilst Model 4 controls for the Direction of move between rural-urban categories. Two variants of each model were fitted. The second variant controls additionally for the compositional influences of social class, qualification, marital status and ethnicity. To ensure that model results were not biased by mortality-related attrition, sensitivity analysis was performed. Multinomial multilevel logistic regression models were fitted including death as an additional outcome category. No differences of note were observed, so only results based on the original binary health outcome variable are reported here.

Table 5.2 Variations in self-reported health

Covariate	Model 0		Model 1				Model 2				Model 3				Model 4			
Controls	Age and Sex		Age Sex and LSOA Move?		Age Sex LSOA Move & all other variable		Age Sex and Region Move?		Age Sex Region Move & all other variable		Age Sex and RUC Move?		Age Sex RUC Move & all other variable		Age Sex and Direction of Move?		Age Sex Direction of Move & all other variable	
		sig	**A**	Sig	**B**	sig	**A**	Sig	**B**	sig	**A**	sig	**B**	sig	A	sig	**B**	sig
Residence (Rural Village)	Coefficients		Coefficients		Coefficients		Coefficients		Coefficients		Coefficients		Coefficients		Coefficients		Coefficients	
Inner London	1.27	0.010	1.27	0.010	1.23	0.023	1.27	0.009	1.23	0.023	1.27	0.008	1.23	0.022	1.32	0.004	1.26	0.013
Outer London	1.10	0.218	1.10	0.209	1.11	0.175	1.10	0.205	1.11	0.178	1.11	0.199	1.11	0.173	1.15	0.094	1.15	0.087
Urban Major	1.46	0.000	1.46	0.000	1.38	0.000	1.46	0.000	1.38	0.000	1.46	0.000	1.39	0.000	1.50	0.000	1.42	0.000
Urban Minor	1.83	0.000	1.83	0.000	1.69	0.000	1.83	0.000	1.69	0.000	1.84	0.000	1.69	0.000	1.87	0.000	1.72	0.000
City and Town	1.35	0.000	1.35	0.000	1.32	0.000	1.36	0.000	1.33	0.000	1.36	0.000	1.33	0.000	1.38	0.000	1.34	0.000
Rural Town and Fringe	1.16	0.012	1.16	0.010	1.15	0.016	1.16	0.011	1.15	0.017	1.16	0.011	1.15	0.017	1.16	0.011	1.15	0.016
Sex (Male)																		
Female	1.36	0.000	1.36	0.000	1.27	0.000	1.36	0.000	1.27	0.000	1.36	0.000	1.27	0.000	1.35	0.000	1.24	0.000

Moved LSOA (No)																		
Yes	Not Controlled		1.15	0.000	1.12	0.000	Not Controlled		Not Controlled		Not Controlled		Not Controlled		Not Controlled		Not Controlled	
Moved Region(No)																		
Yes	Not Controlled		Not Controlled		Not Controlled		1.12	0.092	1.06	0.373	Not Controlled		Not Controlled		Not Controlled		Not Controlled	
Moved RUC (No)																		
Yes	Not Controlled		Not Controlled		Not Controlled						1.09	0.086	1.05	0.276	Not Controlled		Not Controlled	
Direction of Movement (Non-Mover)	Not Controlled		Not Controlled		Not Controlled		Not Controlled		Not Controlled		Not Controlled		Not Controlled					
London to Urban															0.80	0.314	0.80	0.321
London to rural															1.33	0.507	1.45	0.386

Urban to London											1.06	0.750	1.03	0.886
Urban-rural											1.04	0.653	1.02	0.801
Rural- London											1.42	0.262	1.36	0.322
Rural to Urban											1.29	0.008	1.22	0.034
Class (upper class)	Not Controlled	Not Controlled			Not Controlled			Not Controlled			Not Controlled			
Middle Class			1.10	0.114		1.10	0.116		1.10	0.115			1.12	0.083
Lower Class			1.23	0.002		1.23	0.002		1.23	0.002			1.25	0.002
Qualification (degree or higher)	Not Controlled	Not Controlled			Not Controlled			Not Controlled			Not Controlled			
Post Compulsory			0.90	0.157		.89	0.146		0.89	0.146			0.89	0.138
A level			1.29	0.000		1.28	0.000		1.28	0.000			1.30	0.000
GCSE/O Level			1.27	0.000		1.26	0.000		1.27	0.000			1.28	0.000
No Qualification			1.60	0.000		1.59	0.000		1.59	0.000			1.60	0.000

Marital Status (Married)	Not Controlled	Not Controlled			Not Controlled			Not Controlled			Not Controlled		
Separated			1.19	0.007		1.21	0.004		1.21	0.004		1.15	0.049
Divorced			1.21	0.000		1.22	0.000		1.21	0.000		1.23	0.000
Widowed			1.05	0.572		1.05	0.537		1.05	0.541		1.04	0.648
Single			1.44	0.000		1.45	0.000		1.45	0.000		1.44	0.000
Ethnicity (white)	Not Controlled	Not Controlled			Not Controlled			Not Controlled			Not Controlled		
Black			1.13	0.526		1.13	0.538		1.13	0.537		1.11	0.588
Asian			1.01	0.943		1.01	0.942		1.01	0.942		0.99	0.954
Other			0.73	0.187		.73	0.181		0.73	0.182		0.74	0.203
Mixed			1.18	0.640		1.18	0.643		1.18	0.645		1.24	0.555
			1.03	0.131		1.04	0.060		1.04	0.063		1.04	0.060

5.5 Analysis

After controlling for age and sex the results from model 0 reveal a positive urban-rural health gradient, with levels of ill health increasing with each level of urbanisation. Self-reported poor health is 16% more likely in Rural Town and Fringe locations than in the most rural residence, rising to 46% more likely in Urban Major areas. Anomalies to this gradient are the capital city and Urban Minor locations. Inner and Outer London confound expectations by having lower relative risks of ill health than any other urban area. Indeed, the health outcome for Outer London is better than that of any other area type except for Rural Village; and even in this case the slightly elevated risk of ill health in Outer London (10% higher) is not statistically significant. In contrast Minor Urban areas exhibit the highest levels of ill health of all the residential categories, being 83% more likely to report their health as fair or poor than those in the most rural locations.

Model 1

Model 1a controls additionally for whether or not an individual has moved lower super output area in the past year (a proxy for a short distance move). Movers were 15% more likely to report their health status as fair or poor. Controlling for this migration variable, the observed variations in health across the urban-rural continuum remain unchanged. Once all other additional influences are controlled for (social class, qualification, marital status and ethnicity) (model 1b), variations in health across the continuum reduce for all categories, with the exception of Outer London, although the basic urban-rural health gradient is left unchanged. Larger reductions are felt by Urban Major and Minor locations, reducing by 8 and 14 percentage points respectively. For Inner London, City and Town and Rural Town and Fringe areas reductions are slight, falling by under 4 percentage points. For Outer London, the inclusion of additional influences surprisingly leads to an increase in poor health, but only by 1 percentage point. Even so, the heightened risk of ill health in Outer London relative to the risk in Rural Villages remains statistically non-significant. In terms of the migratory influence, controlling for additional covariates reduces slightly (3 percentage points) the likelihood of a migrant reporting their health as fair or poor compared to non-migrants. Nevertheless, migrants who have changed LSOA continue to possess higher levels of ill health than non-migrants.

Model 2

Model 2 studies the health of those who have relocated from one region to another, to assess if the distance an individual has migrated has an impact upon their health status. As with short distance moves (LSOA), results suggest that the health of long-distance movers is relatively poor compared to their non-migrant counterparts, with such individuals being 12% more likely to report their health as fair or poor ($p = 0.09$). The inclusion of this migration variable appears to have no effect upon health variations across the rural-urban continuum, as health remain unchanged. Once additional covariates are incorporated, variations across the continuum reduce in exactly the same manner as observed for model 1. Controlling for these additional covariates again leads to a reduction in ill health between migrants and non-migrants, with regional movers becoming just 6% more likely than non-movers to report ill health. However, the differences are not statistically significant ($p=0.37$).

Model 3

Model 3 views migration in terms of whether an individual has moved from one Rural-Urban category (RUC) to another in the past 12 months. As with models 1 and 2, in model 3a internal migrants are found to possess unexpectedly poorer health than those who remain, with movers being 9% more likely to report their health status as poor ($p=0.09$). Controlling for socio-economic factors reduces the differences in ill health between movers and non-movers. Migrants are 5% more likely to report ill health, but once again the differences are not statistically significant($p=0.28$). For urban-rural health gradients observed, models 3a and 3b very closely mirror those observed in their counterparts from models 1 and 2.

Model 4

Model 4 investigates whether the direction of migration between differing Rural and Urban categories within the past 12 months has an impact on ill health. In models 1, 2 and 3 migrants were universally found to possess poorer health than non-migrants.

When classifying migrants by type of flow the picture becomes more complex. Urban-to-rural and urban-to-London movers appear to possess health similar to those held by non-migrants, whilst estimated odds of having poor health are 20 percentage points lower for London to Urban movers; however, the differences are not significant. To achieve a net negative health outcome across all migrants, the implication is that these neutral and positive health expectations must be outweighed by the overwhelmingly negative health associated with the remaining types of migrant flow. Individuals who relocate from rural to urban location possess the poorest relative health, being 34% more likely to report their health as fair or poor compared to non-movers. Those moving from rural areas to the capital, and those moving from London to rural areas possess similarly poor health, being 28% and 33% more likely to report poor health. Only the negative health of rural to urban moves were found to be statistically significant from those of non-movers.

The effect of controlling for socio-economic factors is to slightly exaggerate the already observed pattern of relative health by move type. The flow associated with the highest risk of ill health, London to Rural, increases by a further 12 percentage points. The other flows associated with poor health (Rural to London and Rural to Urban) see a decrease in relative risk, but continue to experience poor health. The 'health neutral' flows (Urban to London and Urban to Rural) become even more neutral (i.e. closer to matching the relative health risk of non-movers). Finally, the positive health outcomes for London to Urban movers remains unchanged. As a result the overall spread of relative risk from healthiest to unhealthiest flow is stretched by 12 percentage points. However, as for model 4a, the only statistically significant effect found was that associated with Urban to Rural flows.

The impact on the urban rural health gradient of disaggregating migration by direction of flow is an increase in health inequality by 3 to 5 percentage points across each rural-urban category. The exception to this is the relative risk of residents in Rural Town and Fringe, which remains unchanged from that observed in models 0 to 3. Despite these increased relative risks, the urban rural health gradient observed in previous models remains. Once all additional covariates are controlled for, relative risks fall as observed in models 1 to 3, and the positive health gradient remains intact.

Socio-economic factors

The impact of the socio-economic covariates resembles expectations for the most part. As anticipated lower levels of social class and education are accompanied by increased levels of poor health. Furthermore, married individuals possess better health than those who are single, divorced, separated or widowed. Men exhibit better self-reported health than females, regardless of the fact that females consistently outperform men in terms of life expectancy. This is related to the female paradox: women report worse self-rated health and utilise health services more frequently, yet are less likely to die than their male counterparts, a phenomenon explained by the differences in the distribution of chronic conditions (Case and Paxson, 2005). Surprisingly there is no clear pattern in terms of ethnic categories.

5.6 Conclusion and Discussion

This study investigated variations in self-reported health by residential context and migrant status, amongst individuals aged 18-65 in the 1991 to 2009 waves from the British Household Panel. To account for the use of repeated measures a set of multilevel logistic regression models were fitted, which in all cases controlled for the effects of age and sex. The results revealed a clear positive urban-rural health gradient, with the relative probability of an individual reporting their health status as fair or poor increasing with each level of urbanisation. Two anomalies to the gradient were discovered in terms of the capital city and Urban Minor locations. Rather than possessing high levels of self-reported health, as would be expected given the high levels of population density, residents of the capital, particularly Outer London, possessed relatively positive health expectations. Minor Urban locations, rather than falling in line with the gradient, reported the highest levels of poor health.

In terms of the health of movers, it was found that for each of three measures of migration (change LSOA; change region; move between rural-urban area types), migrants possess poorer health expectations than non-movers. For the most frequent type of move (change LSOA), this finding was statistically significant ($p < 0.005$). For the other move types the finding was not statistically significant, although the consistency of finding across the three measures of migration remains striking. Such findings are a contradiction to the healthy migrant hypothesis, which posits that migrants are a selectively health group, unrepresentative of all potential movers (Lu and Quin 2014 and Wallace and Kulu,2014). Instead these results lend support to the negative health selection theory, which suggests that migration in developed nations is associated with poor health. Bentham (1988) distinguishes between two types of movement for those in poor health: towards better formal and informal medical care (assistance migration); and the movement of those who are ill away from areas presumed to be hazardous to health. Our results may also lend partial support to the Salmon bias hypothesis (Turra and Ela, 2008). However, only if the levels of return migration of those who are ill far outstrip those of healthy out migrants. Unfortunately, our data do not permit the assessment of the levels of return migration to places of origin that pre-date 1991.

Although all internal migration within this investigation is associated with poor health, it is clear that those who simply move LSOAs possess relatively larger probabilities of reporting poor health compared to those who change RUC category or relocate to a different region. This is not so surprising, as results mirror those discovered by Wilding et al (2017). They concluded that short distance moves within England and Wales were in fact associated with poor health across the majority of working age groups. This may relate to a theory proposed by Tong and Piotrowski (2012) when comparing internal and international migrants. They suggest that health selection may be more extreme for international migrants, due to the longer distances and the need to cross boundaries. The same could be applied here in terms of internal migrants. It is generally acknowledged that those moving longer distances possess better health, and higher educational and social standing than those moving short distances. Whilst individuals moving from one region or RUC category to another still possess poorer health than non-movers, it is possible that those moving longer distances and into significantly different locations may require better health than those simply moving from one LSOA to another. This is understandable considering the small size of such spatial units and the social/environmental homogeneity between bordering zones.

According to the discussion above migrants possess worse health than their non-migrant counterparts. However, they are not homogenous, as the direction of movement has a direct impact upon the health experienced by such individuals. From the results, it is clear that those who relocate from rural to urban locations possess the poorest health. Such results are in line with the theory of assistance migration, with individuals enduring declining health moving from rural to urban locations be close to their family for informal care (Walters, 2002). Furthermore, the majority of general and specialised health care facilities are concentrated within urban locations, with rural areas lacking such amenities (Riva *et al,* 2011). This is a major draw for those suffering from chronic health conditions, making urban areas an attractive option (Larson *et al,* 2004 Ellis, 1996). Results also suggest that those who relocate from London to rural areas also possess negative expectations. Such a result may be explained by those with chronic conditions moving towards rural areas in an attempt to remove themselves from areas seen as hazardous to health (Bentham, 1988), although we now know London to be healthier than what would be anticipated.

With the caveat that only the results for the rural-urban migration flow type were statistically significant, some interesting observations were made regarding other types of migration flow. Those who repositioned themselves from urban to rural locations experienced more positive health, better than those travelling in the opposing direction, and similar to those of non-migrants. It is possible that such improved health is related to the prevailing redistribution of healthier individuals out of urban major locations and into rural, with the entrapment of those in poor health within the urban setting (Riva *et al,* 2011). Of all the directions, it is only those who move out of the capital towards other urban locations who possess relatively positive health expectations. Consequently, the positive health of such individuals and the neutral effect of those who relocate from urban to rural locations must be overwhelmed by the negative health possessed by all over types of movers. This would explain why previous models suggest that generally non-migrants exhibit better health compared to their migrant counterparts.

The inclusion of the above migration variables had little effect upon health variations across the continuum, with the exception of direction of movement, which leads to widening inequalities. Consequently, from such results we can be clear that internal migration has little impact upon rural-urban health differentials. Thus, migration effects cannot be considered as a competing explanation to compositional and contextual influences. Such a conclusion is starkly different to those reported by Riva et al (2011), who suggested that internal migration accounted for around 30% of the mortality inequalities between rural and urban areas. Reasons for such contradictory findings may be due to the methods of investigation. Firstly, Riva et al utilises the Longitudinal Study, as opposed to the BHPS. Moreover, the time frame in which both studies were conducted also differ, with Riva examining between 1981-2001 as opposed to 1991-2009 here. The most significant divergence is in the methodology. Rather than employing multilevel modelling, Riva et al examined the pattern of age standardised death rates of urban and rural areas in 2001, comparing this with the pattern which would have been seen if the observed survival of individuals had occurred in their original place of residence in 1981 and 1991. Such differences go some way to explaining the differing results obtained.

Within every model the inclusion of all additional compositional influences (socio-demographic and economic factors) leads to a reduction in health inequalities across all residential categories, with the exception of London. Consequently, it is apparent that compositional influences do have a role to play when it comes to residential health inequalities. Nevertheless, even after these additional compositional influences were considered, substantial variations in health across the urban-rural continuum remained intact. Thus, the surrounding residential environment appears key to explaining urban rural health inequalities. So what are these environmental influences? Previous investigations have suggested numerous explanations including pollution, crime, levels of green space and proximity to others (Bowler *et al* 2010, Coutts *et al* 2013, Higgins *et al* 2010, Lorenc *et al* 2012, Ruckerl *et al* 2011, Alirol 2011).

From this investigation we can be sure that a positive urban-rural health gradient exists, even after controlling for additional compositional factors. We can also be sure that short distance migrants possess poorer health than their non-migrant counterparts, at least immediately after the move. Further, it is clear that those who relocate from rural-urban areas possess substantially worsened health than those who don't. It also appears that controlling for migration, in whatever form, has a very limited impact upon health variations across the continuum. The research suggests that all migrants, whether they have moved LSOA, region or rural-urban category, possess poorer health than non-movers. It also suggests that there is considerable heterogeneity in health by type of flow, with rural to urban movers having the poorest health.

This investigation has contributed to the study of urban-rural health variations, expanding our understanding of the interactions between internal migration and health in a number of ways. Firstly, unlike existing studies we have utilised individual longitudinal self-reported health data, adequately adjusting for individual level rather than area level socio-economic characteristics. Secondly, areas were classified using a more fined grained geography, that of Lower Super Output Areas. Previous investigations have employed larger spatial units of analysis, such as that of Local Authority Districts (Allan et al 2017), which have often been criticised as being too spatial coarse, being unable to adequately comprehend local environmental contexts. Finally and most importantly, this investigation has taken on the challenge of studying the health of internal migrants, and the effect such movements have upon health variations across the urban-rural continuum. Until now, the vast majority of interest in migration has focused upon the international field, and those who have investigated within the internal realm have done so in the context of geographic variations in socio-economic fortune, as opposed to urban-rural contrasts (Richardson *et al* 2010; Riva *et al* 2011; Norman *et al* 2004).

Whilst this investigation vastly improves our knowledge of the causes of rural urban health variations, along with the health status of internal migrants, it is not without its limitations. This study is focused upon those individuals of an economically active age, for reasons related to issues of classifying 65+ in terms of social class and levels of migration. Health selection is suggested to significantly alter across age dimensions, as the relationship between age and propensity to migrate differs (Lu and Quin, 2014). Movement as a result of poor health is general cited as a factor for those of an older age, whilst the healthy migrant hypothesis is related to younger individuals (Lu, 2008 Boyle, 2004). Although the volume of movement of retirement age is just half of that of the economically active, such migration is increasing as the population ages (Walters, 2002). Thus, future research should look to study differences across age dimensions in the context of rural-urban health variations, ideally including social class as a compositional influence if it can be measured adequately for those of retirement age. Furthermore, within this study health was measured after the move thus, it is possible that reported health may be related to the process of the move itself. Further research is needed to determine whether migration leads to a temporary change in health conditions or in perceived health (related to the event of move), or migrants indeed have poorer (long-term) health than non-migrant. Finally, previous investigations have emphasised the role of international migration in shaping geographic health inequalities. This investigation has ignored international migration due to its modest contribution in comparison to internal migration, to the overall volume of migration. However, future research should nevertheless consider the relative impacts of international and internal migration, given that international migration is known to be more health selective.

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Chapter 6

6 Conclusion

6.1 Introduction

This thesis has investigated morbidity and mortality variations across the urban-rural continuum. Chapter 1 provided an overview of the academic context for this work, reviewing previous literature on the urban-rural health divide and outlining the methodological issues that exploring this divide raises. Three main theories exist regarding the urban-rural health divide. The first is that there is a positive urban-rural health gradient, such that morbidity and mortality levels increase with increasing levels of urbanisation (Chilvers 1978). The second is that there is a U-shaped health continuum, with poorer health outcomes in large cities and remote rural locations than in suburban and semirural areas in-between (Barnett et al 2001). The final theory is that there is a negative urban-rural health gradient, with morbidity and mortality levels decreasing as population density increases (Lankila *et al* 2012). In addition to these conflicting theories, there has been a lively and as yet unresolved debate regarding the causes of such variations: are they contextual (surrounding environment), compositional (socioeconomic/demographic makeup) or an outcome of selective migration?

Previous investigations of urban-rural health variations have also been criticised for a series of methodological and analytical flaws. Firstly, many studies have involved the analysis of aggregate area-level data, rather than of individual-level data, making it hard to fully tease out the role of composition over context. Secondly, existing studies have been accused of gender blindness, as they have failed to consider the ways in which health, composition and context interact with gender (Macintyre, 2001. Stafford et al 2005). Thirdly, results from previous investigations have been critiqued as being simply ‘data artefacts’, sensitive to the way in which ‘urban’ and ‘rural’ have been defined. This reflects the lack of a universal definition of what constitutes rural/urban and the use of pragmatic approaches (Higgs, 1999)

As a result of these theoretical and methodological issues it remains uncertain if and how health and mortality differs over the urban-rural continuum, and what are the causes of any such variations.

Consequently this thesis had three broad aims:

1. *To explore health and mortality variations across the Urban-Rural continuum within England and Wales*
2. *To investigate the underlying causes of observed urban-rural variations in health and mortality, namely the extent which such disparities are attributable to context (the environment), composition (specifically socio-economic status, education, marital status and ethnicity) or selective migration*
3. *To assess the extent to which the patterns and causes of urban-rural variations in health and mortality are resilient to differences between the sexes, to specific causes of mortality and to the nature of the urban-rural classification used.*

To achieve these aims this thesis has explored urban-rural variations in health, mortality and cause-specific mortality through the analysis of a series of individual-level datasets. The use of individual rather than area level data made it possible to assess the extent to which residential variations in health and mortality can be attributed, variously, to compositional, contextual and migratory influences. Differences between the sexes were explored by conducting separate analyses for males and females. Finally, some analyses were repeated using a range of urban-rural classifications in order to clarify the robustness of findings to the type of classification used. The following section outlines the range of analyses undertaken in more detail, identifying the methods and datasets used and relating them back to the relevant chapter of the thesis where full details are provided. The findings arising from these analyses are then summarised in Section 6.3. Section 6.4 provides a summary of the key contributions made by this this thesis, and flags potential areas for future research.

6.2 Summary of investigations

To achieve these aims Chapter 2, based upon Allan et al (2017), investigated urban-rural variations in *limiting long-term illness* across the Urban-Rural continuum. Logistic regression was performed on data from the 2001 Census Small Area Microdata, with geographical areas classified at Local Authority District level. The first model controlled simply for the core demographic factors of age and sex, and disaggregated investigation into working and none working age. Further models controlled for economic status and education levels, in an attempt to observe the impact of social class, and to discover if rural-urban variations could be explained away by socio-economic differences. Further compositional influences were then incorporated in the form of marital status and ethnicity, to assess the impact of socio-demographic factors upon morbidity variations across the continuum. After this analysis the chapter then turned its attention towards the impact of the rural-urban classification used. In order to discount the theory that any variation observed was simply a 'data artefact', sensitivity analysis was performed. Six alternative urban-rural classifications were utilised based upon Local Authority Districts. The different classifications were based upon varying factors including settlement size, built form, density and commuting flows.

Chapter 3, based upon Allan et al (2018), investigated mortality variations across the urban-rural continuum. This study used the ONS Longitudinal Study from 2001-2011, performing survival analysis utilising the gompertz distribution. Locations were classified in terms of rural-urban at the geographical spatial scale of Output Area. As with chapter 2 models were conducted with and without controls for compositional influences in the form of socioeconomic and demographic factors. This analysis was performed to assess the extent to which *mortality* variations could be attributed to compositional or contextual influences. The main focus of Chapter 3 was to assess the interaction of health, composition and context with gender, as it has previously been suggested that males and females will be influenced by the surrounding environment and socio-demographic factors in substantially different way. Models were implemented separately for males and females, with and without additional compositional influences.

Chapter 4 extends previous chapters by investigating disparities in *cause-specific mortality* over the continuum, identifying which diseases drive the high levels of all-cause mortality found in urban locations, and clarifying whether it is possible for low levels of all-cause mortality in rural locations to coincide with high levels of mortality for specific causes. As in chapter 3, the ONS LS is utilised between 2001-2011 again performing survival analysis however, on this occasion Cox models were used as opposed to Gompertz. Again, as in the previous chapter, geographic locations were classified using Output Areas. Cause-specific mortality was modelled separately for respiratory disease, lung cancer, other cancer, circulatory diseases and other diseases. Again, models were fitted with and without controls for socio-economic and demographic factors, assessing the extent to which variations could be attributed to compositional influences. Potential gender differences were explored by fitting models of cause specific-mortality separately for males and females.

Chapter 5 aimed to investigate the impact of migration upon *self-rated health* variations across the continuum, as multiple competing theories exist in terms of the health of migrants and the impact of migration on spatial health inequalities. Multilevel models were performed on data from the British Household Panel Survey over the waves of 1991-2009, with geographic locations defined at the Lower Super Output Areas. Self-rated health was modelled for migrants and non-migrants, with controls added for socio-demographic and economic factors. Migration was defined variously as an individual changing LSOA (local neighbourhood), Region or RUC (type of area on the urban-rural continuum). These alternative definitions of migration were used to aid understanding of the impact of distance of move upon migrant health status. The health of a migrants was then modelled according to their direction of travel whilst again controlling for current location, socio-economic and demographic factors. The purpose of this was to aid understanding of how the health of migrants differs according to their origin and destination. Finally, self-rated health was modelled across the continuum whilst controlling for socioeconomic and demographic factors, the direction of movement and type of migration (change in LSOA, RUC and Region). This allowed an assessment of the impact of migration, distance and direction of movement upon rural-urban health variations.

6.3 Summary of Findings

6.3.1 Chapter 2

Chapter 2, in support of Chilvers (1978) and DEFRA (2016), uncovered a positive urban-rural health gradient, whilst controlling for age (specified by the Gompertz model) and sex. Levels of ill health increased with increasing levels of urbanisation, regardless of age group under study. As anticipated, according to the positive health gradient theory, Individuals residing in the most rural locations consistently possessed the best self-reported health, and those in the most urban the worst. For example, compared to the most rural residents, those of a working age located in major urban areas were 54% more likely to report poor health. An anomaly to this gradient existed in the form of the capital city, as unexpectedly residents of London were found to possess better than predicted health. This is surprising, as according to contextual theories and the positive health gradient, the capital city would be expected to experience the poorest health, given its high population density, pollution and crime levels and lack of green space. These superior health findings were particularly the case for residents of Outer London, with such individuals being just 13% more likely to report a limiting illness, compared to the most rural. Such health prospects are substantially better than those experienced in major, large and other urban categories. Once the additional compositional influences of occupational status and education were incorporated into the model, the positive urban-rural health gradient was substantially reduced. Those located in major urban locations were now just 28% more likely to report poor health compared to the most rural, a reduction of 26 percentage points. It must be stated, however that the rural-urban positive health gradient remained intact, albeit at a reduced level. Controlling for the additional socio-demographic factors of marital status and ethnicity had minimal additional effect in reducing observed health variations across the continuum. Such results suggest that although compositional factors such as social class and education account for a significant portion of the positive urban-rural health gradient, they do not fully explain this gradient. Thus, contextual influences must play a substantial role.   According to exiting literature such influences consists of environmental factors, including a greater availability of green space in rural locations, and reduced levels of pollution and crime (Coutts et al, 2013; Ruckerl et al, 2011; Lorenc et al, 2012).

So what then is the explanation for the Capital city anomaly? According to contextual theories the Capital City would be expected to possess the poorest health, however, this was found not to be the case. In line with Riva et al (2009) London residents were found to possess better than anticipated health, particularly in Outer London. One possible explanation may be that lower levels of deprivation are experienced in Outer London than in Inner London or in other urban areas. However, socio-economic factors were controlled for and, although the difference narrows, Outer London retained its mortality advantage. Nevertheless, it may be that the compositional variables used within this study fail to accurately capture between area heterogeneity. Another suggested explanation relates to pollution, as levels of pollution are substantially lower in Outer London when compared to Inner London (King and Brook, 2016). Finally, much of the housing stock and residential environment within Inner London are believed to be in poor condition with residential, transport and workplace overcrowding, permitting the spread of infectious diseases (Haynes, 2016).

The second part of this chapter focused upon the issue of rural-urban classifications. Overall the results from the sensitivity analysis found that, regardless of the classification implemented, a positive urban-rural health gradient was observed. It was also found that this gradient persisted, if in an attenuated form, once individual level socio-economic and demographics factors were controlled, irrespective of the urban-rural classification adopted. These results suggest that the overall findings of this chapter are robust, and not simply a consequence of the method used to define rural areas. Further, they go some way to refuting the critique that the results from studies of urban-rural health variations are simply an artefact of the urban-rural classification adopted.

6.3.2 Chapter 3

Chapter 3 aimed to understand if the positive health gradient discovered in chapter 2 was applicable to mortality. Rather than the 2001 census, the ONS LS was utilised between 2001-2011. This study also investigated geographical areas at the Output area level, rather than LAD. Results from this study closely mirror those of chapter 2, as a positive urban-rural mortality gradient is uncovered, whilst controlling for age (via gompertz model) and sex, regardless of the fact that a different dataset, dependent variable, and geographical scale was utilised. As anticipated, the relative probability of dying was found to increase from its lowest levels in the most rural locations to its highest in the most urban. For example, those of a working age located in major urban areas were found to be 54% more likely to die compared to those in the most rural location. This is significantly larger than the relative likelihood of dying in rural village locations. In turn, residents of rural villages were found to be just 6% more likely to die than their most rural counterparts. As in Chapter 2, the capital city was again found to be an anomaly to the urban-rural gradient. Unlike in Chapter 2, in this study it is only Outer London which possessed better than anticipated mortality levels. As with self-reported health, mortality variations were found to substantially reduce once socio-economic factors were incorporated, more so for occupation as opposed to education. Once education and class were controlled for, the relative likelihood of dying for Major Urban residents reduced from 54% to just 31%. As for the models of ill-health reported in Chapter 2, marital status and ethnicity accounted for little of the between-area mortality variations. Even so, from such results it is clear that the socio-economic composition of a residential location is of great importance in terms of mortality risk. However, as the urban-rural mortality gradient remained intact after controlling for these factors, this also suggests that residential context also plays a role. The same environmental influences are suggested as before, consisting of availability of greenspace, pollution and crime.

As well as extending the findings from Chapter 2 by examining a different measure of health (mortality), at a different spatial scale (OA), Chapter 3 also extended the findings from chapter 2 by paying more careful attention to the gender dimension, which has for the most part been ignored within existing literature regarding rural-urban health differentials. As proposed by Stafford et al (2005), Chapter 3 discovered that male and female health is effected by their residential environment and socio-economic status in significantly different ways. Although a positive urban-rural mortality gradient was discovered for both sexes after controlling for age, the gradient appeared steeper for women of a working age. For example, females residing in major urban locations were found to be 57% more likely to die, than those in the most rural areas. This relative likelihood reduced to 11% more likely for those in rural villages. This difference is substantially greater than that experienced by males, with those residing in major urban areas being 52% more likely to die than those in the most rural, reducing to just 3% more likely in rural villages. Moreover, as expected according to Raleigh and Kiri (1997), socio-economic composition of the residential location was found to account for a greater proportion of the male mortality gradient. For example, once socio-economic factors were controlled, the relative likelihood of dying for those residing in major urban locations compared to the most rural reduced from 57% to 30%, a reduction of 27 percentage points. For females the reduction experienced was much less substantive at just 14 percentage points. Such results support the theory that that female mortality is more sensitive to residential environment, and male mortality to socio-economic status (Macintyre 2001; Kavanagh et al 2006). This suggest that males and females interact with their resident environment differently, as women spend increased time in their local area due to primary caregiver responsibilities for children and the elderly. Further, women are more likely to be in part time employment thus leading to them spending more time than men undertaking domestic chores in the local area. Females are also thought to be more vulnerable to the effects of their surroundings, with area safety found to be highly correlated with female health, yet completely unrelated to male. Male health on the other hand is believed to be influenced to a much greater extent by socio-economic factors, with social inequalities in health tending to be much steeper for men than for women (Raleigh and Kiri (1997). However, it is possible that the results from Chapter 3 are due to the inherent difficulties in access female social status (Langford and Johnson, 2009). As females possess weaker attachments to the labor market and are more likely to be in part time employment, unreflective of their skills and qualifications, occupational status may not adequately reflect a females economic status (Leaker 2008; Booth et al 2003, Arulampalam et al 2007, Geiler and Rennebong 2015). Johnson (2011) suggested that educational attainment provides a better measure for female status, but the inclusion of education within this study had limited effect.

6.3.3 Chapter 4

It has been suggested that by focussing on urban-rural variations in all-cause mortality or general health, it is possible that important variations may be missed when it comes to specific causes (Higgs, 1999). It is for this reason that Chapter 4 investigated urban-rural variations in cause specific mortality. For some causes, but not all, a positive urban-rural mortality gradient existed when controlling for age and sex. For respiratory and circulatory disease along with lung cancer, as expected a clear positive gradient was identified, with the probability of dying increasing with each level of urbanisation. For example, when studying respiratory disease the relative risk of dying reduced from 2.5 times more likely in Inner London, to 13% more likely in rural villages, compared to the most rural setting. A similar story was uncovered for circulatory diseases, with relative mortality reducing from 95% more likely in Inner London, to just 23% more likely in rural villages. For lung cancer, relative to hamlets and isolated dwellings those living in Major urban locations were found to be 118% more likely to die, and 40% more likely to die in rural villages. From this it is clear that mortality variations across the continuum are the largest for respiratory disease, followed by circulatory disease, with lung cancer possessing the smallest variations.   As all-cause mortality and self-reported health, for lung cancer, respiratory and circulatory disease Outer London was found to be an anomaly to the gradient, possessing relatively positive expectations. Urban minor locations were also found to provide an exception to the overall urban-rural health gradient, at least in terms of respiratory and circulatory disease. For these diseases Urban Minor locations possessed the largest mortality levels of all areas. In contrast, the same areas experienced relative lung cancer mortality that was slightly lower than would be predicted. As with all-cause mortality, once socio-economic factors were incorporated the gradient significantly reduced, yet persisted. For example, for respiratory and circulatory disease and lung cancer relative mortality for those living in major urban areas reduced by 20%, 14% and 13% respectively. From reductions in relative mortality across all the residential categories, it appears that class has the greatest influence upon respiratory disease, followed by lung cancer, with circulatory disease being least effected. The reduction in mortality suggests that socio-economic influences are a key driver in mortality variations across the continuum for such diseases. Likely explanations relate to deprivation (Senior et al, 2000). Urban areas in the UK are known to contain larger proportions of deprived individuals and families. Along with this, smoking habits are known to vary by social class (ONS, 2013). Thus, it is possible that such variations are a direct result of geographic variations in smoking habits. On top of this, poor urban housing conditions of deprived individuals have a direct impact on such diseases, along with poor nutritional status (Halvorsen and Martinussen 2014). As previously stated, although at a reduced level, variations in mortality across the continuum continue. Consequently, residential context must play a noteworthy part. Numerous environmental explanations suggest themselves, such as pollution and levels of greenspace, along with levels of crime for circulatory disease (Sunyer et al 2006; Viegi *et al* 2006; Mitchel and Popham 2008). In complete contrast to the other causes of death considered, for Other Cancer no rural-urban trend is identifiable, as mortality levels remain relatively stable across the continuum. Surprisingly, once additional influences are included, mortality marginally reduces (by between 1-5 ppts). However, again a pattern fails to emerge. Such findings are unexpected and in complete contrast to research completed by DEFRA, which suggested that the potential years of lost life to cancer was 15 years lower in predominantly rural wards. However, such research was inclusive of Lung Cancer, which may have Influenced results (DEFRA 2014). From the results of this chapter it is clear that low all-cause mortality for rural locations coexists with low respiratory and circulatory disease along with lung cancer.

Turning to gender, it appears that males of a working age are clearly disadvantaged when it comes to lung cancer, as increased mortality can be seen in each corresponding urban-rural category in comparison to females. For circulatory disease however, it is females who are more at risk. In terms of respiratory disease and other cancer no gender advantage is identifiable. As for all-cause mortality, once social class is incorporated greater reductions are felt by males for lung cancer, respiratory disease and other cancer. Such results are in line with Macintyre (2001) and Kavanagh et al (2006) who suggest that females are influenced to a greater extent by the surrounding environment, whilst males are affected by socio-economic factors. Unexpectedly and in complete contrast, for circulatory disease once social class is controlled larger reductions are noted for females as opposed to males, the reason for this is unknown.

6.3.4 Chapter 5

The previous chapters focused on the cause of such health and mortality variations in terms of context or composition, failing to consider the impact of selective migration. Thus In Chapter 5 the focus was turned to the influence of migration on the observed positive urban-rural health gradient, in which levels of ill health increased as the level of urbanisation increased. After controlling for age and sex chapter 5 discovered that short distance migrants (moved LSOA) possess poorer health than their non-migrant counterparts, being 15% more likely to report their health status as fair or poor. Similar results were discovered for those who performed long distance moves (moved region), and those who relocated from one Rural-Urban category to another, being 12% and 9% more likely to report poor health than their non-migrant counterparts. Given the widely accepted health migrant hypothesis, it would be expected that migrants would possess superior health compared to their non-moving counterparts. This however, was found not to be the case. It must be stated however, that of all the migration types, it is only short distance moves in which results are statistically significant to a 95% level. The inclusion of such migration variables had no effect upon the positive urban rural health gradient observed before migration was controlled for, as the likelihood of fair or poor health remained unchanged for each residential category.

As with the previous investigations, incorporating compositional variables led to a reduction in health variations across the continuum, along with reductions in levels of ill health for migrants. For example, the likelihood of reporting fair to poor health for short and long-distance migrants and those who relocated from one rural-urban category to another reduced by 3% 6% and 4% points respectively. The poor health experienced by migrants within the study can be explained by the negative health selection theory in which migration in developed nations, such as England and Wales, is associated with poorer health. Bentham (1988) suggests that individuals with failing health will move to be better placed in terms of medical care known as assistance migration, or relocate away from areas presumed to be hazardous to health.

Although all migrants within this study possessed poorer health, it is clear that distance moved has an impact upon the level of poor health. Those who simply moved from one LSOA to another were more likely to report poor health status, compared to those who relocated over greater distance, in terms of Region or Rural Urban Category. When comparing internal and international migration, Tong and Piotrowski (2012) suggested that health selection could be more extreme for international migrants, a consequence of the longer distances and the need to cross boundaries. The same theory might reasonably be expected to apply to longer-distance internal migrations. It is commonly recognised that those relocating over longer distances hold improved health expectations, and higher social and educational standing than those moving short distances. Whilst migrants relocating from one region or RUC category to another possess inferior health than non-movers, it is conceivable that those moving longer distances may need better health. This is comprehensible given the small size of LSOA units and the social/environmental homogeneity between them.

Along with distance, direction of movement was also found to have a direct impact upon an individual's health. After controlling for age and sex, those who moved from Rural to Urban areas possessed the poorest health, being 34% more likely to report their health as fair or poor compared to non-movers. Such results may be explained by the theory of assistance migration discussed above. According to such a theory, individuals with declining health are found to move away from rural towards urban locations to be closer to their family and general and specialised health care facilities, which rural areas lack (Walters,2002; Riva et al 2011). Similar negative results were discovered for those relocating from London to Rural areas, and those moving from rural areas to the capital. However, such results should be treated with caution as they were statistically insignificant. With the understanding that only the results regarding the movement from Rural to urban areas were statistically significant, other migrant flow observations were made. Those who moved from urban to rural locations had better health, an improvement on those moving in the opposing direction, and similar to that of non-migrants. Of all flows, it is just those who relocate from the capital to other urban locations that possess relatively positive health. Such individuals were found to be 20% less likely to report their health as fair or poor compared to their non migrant counterparts. However, such results were found to be statistically non-significant. These results suggest that the poor health held by all other directions of movement overwhelm the better health of those leaving the capital for other urban locations. This provides an explanation for why non-migrants exhibit better health than movers.

As already noted, the incorporation of all of the migration variables discussed above had limited effect upon the positive urban-rural health gradient, with the exception of direction of moment, which resulted in widening inequalities. Thus, it can be concluded that internal migration cannot be considered as a competing explanation to compositional and contextual impacts resulting in rural-urban health variations.

6.4 Conclusion

6.4.1 Summary of key findings and contributions

The key contributions and findings of this thesis can be summarised as follows. First, this thesis has established that within England and Wales a clear positive urban-rural health gradient exists, with better health and lower mortality in the most rural areas and poorer health and higher mortality in the most urban areas. This gradient persists regardless of the age group or gender under study, although variations in gradient steepness are apparent. Second, this thesis has established that the urban-rural gradient does not apply to the capital city, and in particular to Outer London, where health and mortality is substantially better than expected given the high level of urbanisation. Third, this thesis has shown that the positive health gradient is real. The idea that the gradient is a 'data artefact' generated by the definition utilised to classify urban and rural areas can be discounted. Fourth, this thesis has found that compositional factors, particularly social class and to a lesser extent education, play a major role in the urban-rural inequalities in health and mortality experienced across England and Wales. Fifth, it has been shown that compositional influences fail to fully account for the observed rural-urban health variations. Thus contextual influence still has a vital role to play. Sixth, this thesis has addressed the under-examined interaction between gender and spatial inequalities in health. Results presented in this thesis clearly demonstrate that sex interacts with compositional and contextual factors, with male health being influenced to a greater extent by socio-economic circumstances, and female health to a greater extent the surrounding environment. Seventh, this thesis has demonstrated that although high urban all-cause mortality and morbidity levels are often driven by high cause-specific mortality (respiratory and circulatory disease and lung cancer), this is not always the case. 'Other cancer' provides an exception in which high urban mortality is accompanied by low cause specific rates. Eighth, this thesis has managed to demonstrate that rather than migrants possessing better health than non-movers, as the healthy migrant hypothesis advocates, there is actually a negative health selection effect. Hence, although the health of short distance movers is poorer than that of long distance movers, all migrants have negative health expectations. Ninth, the direction of movement was found to have an impact upon health, with those who move from Rural-Urban and London-rural areas possessing negative health, and those who move from urban-rural areas possessing similar expectations to non-movers. Of all directions of flow, it is only those who relocate from the capital to other urban locations that possess superior health than their non-moving counterparts. It should be acknowledged, however, that only rural to urban migrants experienced a statistically significant reduction in health compared to non-movers. Tenth, and finally, this thesis has found that the inclusion of migration had little or no effect on the positive urban-rural health gradient.

6.4.2 Limitations/ Future research

This thesis is not without its limitations which future research should aim to address.

A constant finding throughout this research relates to the Capital City. Regardless of dataset, spatial scale, health variable or year studied London continues to be an anomaly to the positive urban-rural health gradient, with the Capital City possessing health expectations superior to what would be anticipated, given the contextual theory. Even after controlling for socioeconomic and demographic factors, the anomaly continues. This is particularly the case for outer London, which at times possess health similar to those found in the most rural locations. The reasons for this irregularity are beyond this study, and as it runs through the entirety of this thesis a more thorough investigation into the Capital City itself is warranted and should be completed in the future.

A second question relates to the applicability of such findings to locations outside of the UK. The main focus of this study was the investigation of health/mortality variations across urban-rural locations within England and Wales. Consequently, it is unclear if such findings can be generalised for different geographical contexts. As the UK is similar to other European counties, due to the resemblances in characteristics of the rural and urban environments, it is possible that findings may be comparable in these locations. Nevertheless, for other industrialised countries, such as Australia and Canada the variations across rural populations may be greater than in the UK, as some rural areas are extremely remote. Moreover, in developing nations rural areas will experience higher levels of poverty in comparison to urban locations, leading to poorer health expectations. Future research such look to investigate the applicability of results on the global scale, utilising individual level data and a rural-urban continuum as opposed to a dichotomy applied in the vast majority of research.

In terms of migration, it is vital that we fully understand the impact age can have on the health of internal migrants. With an ageing population, the movement of those post retirement is growing. Thus, if the health of such individuals differs significantly from those of a working age, it may put added and unanticipated pressure on the health services in specific locations. Within this investigation migration of older generations is ignored, thus the health expectations of such individuals, along with their direction of movement is unknown, thus future needs '/unidentified. It is for this reason that research should look to study differences across age dimensions in the context of rural-urban health variations.

Finally, this investigation fails to take into consideration the impact of external migration, instead choosing to focus upon internal movement. Future research should look to incorporate international migration into analysis, given such migrants are known to be more health selective.

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