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Analysing neighbourhood health inequalities in England, 2011-21

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Abstract

Social and spatial inequalities in health have been recognised in England for centuries. Yet, despite their significant moral, economic and societal costs, multi-government efforts have largely failed to address them, too often focusing on individual behaviours and inadequate access to healthcare instead of the well-evidenced social determinants of health. Excluding these determinants from political and public discourse has meant they are generally misunderstood and viewed as insignificant by the public. Therefore, this dissertation aims to bridge the gap between rhetoric and reality by emphasising the importance of ecological perspectives when analysing neighbourhood health inequalities. The 2011 and 2021 Census are examined using descriptive statistics, Moran's I (Global and Local), correlation analysis, linear regression modelling, and absolute and relative inequality measures. The results reveal persistent health disparities, a North-South divide with clusters in post-industrial urban and mining areas and coastal communities, and different layers of determinants on self-rated illness and poor health. This is important as interest in public health is at a once-in-a-generation high and on its 75th birthday, the NHS values of equitable health outcomes are more relevant and popular than ever. Therefore, policy recommendations are offered to improve neighbourhood health inequalities in England.

Key words: Health Inequalities, Self-Rated Health, Census, Spatial, Clustering, Social Determinants of Health

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I would like to thank Mark Green for his unwavering support and declare that the material presented for this dissertation is entirely my own work, and that all secondary sources are properly acknowledged.

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Abbreviations

AIC – Akaike Information Criterion
IQR – Inter-Quartile Range
LRM – Linear Regression Model
LSOA – Lower-layer Super Output Layer
NHS – National Health Service
OLS – Ordinary Least Squares
RII – Relative Index of Inequality
SD – Standard Deviation
SDH – Social Determinants of Health
SII – Slope Index of Inequality
SRH – Self-Rated Health
TFL – Tobler's First Law of Geography
VIF – Variation Inflation Factor

1 Introduction

Health inequalities are avoidable, systematic, and unfair differences in health status between and within different populations (Williams et al., 2022). They include variations in health outcomes, access to quality healthcare, and opportunities to lead healthy lives (ibid). This research refers to health inequalities as disparities in Self-Rated Health (SRH).

Whilst the public perceives individual behaviours or healthcare access as sole determinants of health inequalities, Marmot et al. (2008: 1) argue they are rooted in the "unequal distribution of power, income, goods and services, globally and nationally" (Kane et al., 2022). These wider societal inequities result in profound disparities in the Social Determinants of Health (SDH): "the conditions in which people are born, grow, live, work, and age" (Marmot, 2010: 16). The SDH offer a comprehensive lens for analysing health inequalities because it highlights various social, economic, and environmental factors that can be influenced by social policies and are shown to have greater impacts on health than healthcare, lifestyle behaviours, or genetics (Marmot, 2005; 2010; Braveman and Gottlieb, 2014).

Public health inequalities in England have been recognised for centuries, manifesting geographically in a North-South divide (Chadwick, 1842; Black et al., 1980; Marmot, 2010). Yet, over 180 years later these social and spatial health inequalities persist (Green et al., 2018). Reducing health inequalities has been a policy priority for over two decades that has fallen flat, overly focusing on healthcare and individual behaviours (Marmot and Allen, 2014). Ignoring the "causes of the causes" is unjust and immoral due to their avoidable nature (ibid). Furthermore, the potent societal and economic cases for addressing the causes of causes are relevant now more than ever.

While regional health inequalities in England were already one of the widest in the developed world, the COVID-19 pandemic exacerbated this problem and underscored the value of understanding SDH and their influence on health disparities (Raikes et al., 2019; Riley and Mensah, 2021). However, analysing regional and local authority health disparities often masks the extent of variation within local areas, as spatial disparities are larger at smaller spatial scales (Overman et al., 2022). Neighbourhoods, where SDH have the most direct impact, shape social cohesion, prosperity, and health outcomes across local, regional, and national scales throughout individuals' lifespans (Rowe et al., 2020; BMA, 2022).

The availability of the 2021 Census at the Lower-layer Super Output Area (LSOA) level presents a once-in-a-decade opportunity to update our understanding of health inequalities and their determinants in England at the neighbourhood level (GDSL, 2021). To build back better and fairer

following the pandemic, a greater understanding of how health in places, communities, and neighbourhoods has changed is needed (ibid). This research is important as the public profile of public health is at a once-in-a-generation high and quantifying health inequalities is vital to better focus spatial policy interventions designed to address them (Kane et al., 2022; Watt et al., 2022).

Therefore, this dissertation aims to quantitively analyse neighbourhood health inequalities, and their determinants, in England utilising the 2011 Census and 2021 Census. The following objectives have been identified as a way of achieving this aim:

1. Explore the overall changes in neighbourhood health inequalities in England over time.
2. Identify and analyse spatial patterns of health inequalities, detecting persistent clusters of areas with similar health outcomes.
3. Investigate key determinants of SRH, comparing their effects over time.
4. Quantify and compare health inequalities over time.

The remainder of this dissertation is organised as follows. Section 2 explores academic and policy literature to understand health geography, spatial patterns of health in England, the determinants of health, and the importance of addressing health inequalities while justifying the place of this dissertation within the wider literature. Section 3 outlines the data sources, research strategy, and methodological framework of this dissertation, with justifications throughout. Section 4 addresses the research objectives by discussing the results of descriptive statistics, spatial analysis, correlation and LRM analysis, and inequality measures in context of the wider literature. Section 5 concludes the dissertation, summarising the key findings while discussing the policy implications, limitations, and aims for future research to build upon this dissertation.

2 Literature Review

2.1 Health Geography

Health geography explores the impact spatial dynamics, societal influences, and cultural-political dimensions on health (Dummer, 2008). Central to this subdiscipline are the concepts of space, place, space-time, compositional effects, and contextual effects.

Space is a multifaceted concept encompassing physical, relational, human, and non-human elements (Roxberg et al., 2020). It extends beyond mere Euclidean distance, serving as both a dimension for distribution and a product of social relations (Kearns and Joseph, 1993; Massey, 2005). Thus, spatial divisions often mirror broader societal and political structures contributing to social exclusion and disparity (Smith 1994; Sibley, 1995).

Place represents a dynamic understanding of the interplay between space and environment, capturing the unique social, physical, and contextual attributes of locales holding different meanings for different people (Curtis and Jones, 1998; Cummins et al., 2007; Petrović et al., 2018). Whilst places can be defined by grid coordinates or administrative boundaries, they are also marked by our sense of place: the emotional bonds, cultural significance, and personal value attributed to locales (Tuan, 1979; Curtis and Jones, 1998). Structuration theory emphasises that locales intentionally and unintentionally shape health in class-specific ways through the interaction of structural factors, individual agency, and social dynamics that influence access to services, community dynamics, and sense of belonging (Giddens, 1984; Thrift, 1992; Lawson, 2017).

Space-time acknowledges the interconnectedness of space and time by considering how different places impact health throughout an individual's life-course (Thrift, 1992; Massey, 2005; Petrović et al., 2018). Examining neighbourhood health inequalities with this multiscale framework unveils the constraints shaping individual actions and underlying processes contributing to these disparities (Curtis and Jones, 1998). However, to comprehend neighbourhood health inequalities with these concepts, a distinction between contextual effects and compositional effects is required (ibid). This dichotomy explores whether spatial health disparities are informed by the people living there or by the places themselves (Macintyre et al., 2002).

Compositional effects postulate that individuals with similar characteristics experience comparable health, regardless of location, and neighbourhoods with similar health profiles share parallel population characteristics (Curtis and Jones, 1998; Macintyre et al., 2002). Nonetheless, the atomistic fallacy underscores the limitations of individual-level analysis, advocating for a broader neighbourhood-level perspective to grasp the structural, contextual, and sociological effects on health (Schwartz, 1994; Curtis and Jones, 1998). Therefore, contextual effects consider the aggregated impact of individual attributes influencing health (Susser, 1994). This perspective

suggests that health is influenced by the social and economic context; thus, similar health outcomes in different locations indicate parallel structural contexts (Curtis and Jones, 1998).

The distinction between compositional and contextual effects has advanced health geography and validated the relevance of place for individual health beyond individual-level effects (Duncan et al., 1998; Petrović et al., 2018). However, the 'relational approach' challenges this rigid distinction, recognizing the intertwining of people's characteristics and the places they inhabit (Cummins et al., 2007). Considering both effects is essential for understanding neighbourhood health disparities and the interplay between individual attributes, geographic settings, and collective influences (Macintyre et al., 2002; Cummins et al., 2007; Bernard et al., 2007). This integrated approach is critical for comprehending the complex relationships between place, space, and health and developing effective policy responses.

2.2 Patterns of Health Disparities in England

Health disparities in England have been recognised in research for centuries, pre-dating 1750 (Marmot, 2001; Kendall et al., 2021). In his 1845 novel *Sybil*, Benjamin Disraeli depicted the socioeconomic and geographical divides in a rapidly industrialising England (Diniejko, n.a.). Landmark studies from Chadwick (1842) and Snow (1856) turned this fiction into reality by linking context (poor living conditions and contaminated water pumps) to health outcomes (increased cholera and disease risk), emphasising the value of integrating geography and public health data to address health inequalities.

Building on this historical context, the Black Report (1980) marked the first comprehensive independent review of health inequalities in England, profoundly influencing public awareness and international policy agendas (Marmot, 2001). Commissioned to address concerns about widening inequalities among social classes 30 years on from the foundation of the National Health Service (NHS), the report attributed persistent health inequalities to structural differences in social class living conditions (ibid). It also revealed that even when adjusting for socioeconomic status, spatial disparities in health endured between the South (including London and the South East) and the North (commonly defined as the North East, North West and Yorkshire and Humber regions) (Green, 1988; Bambra et al., 2014).

Research spanning the last five decades and five governments has exposed the extent of spatial health disparities in England, among the widest and deep-seated in Europe and the developed world (Bambra et al., 2014; Raikes et al., 2019). Northern England persistently faces lower rates of life, healthy life, and disability-free life expectancies along with higher rates of illness, economic inactivity due to illness, poor health, and premature mortality (Whitehead, 2014; Buchan et al., 2017; Goodair et al., 2020; Munford et al., 2023). This divide is partly attributed to a steeper socioeconomic health gradient in the North and a concentration of deprivation (50% of poorest

neighbourhoods) disproportionate to the national population size (30%), in contrast to affluence clustering in the South (Whitehead, 2014; Rowe et al., 2020).

Moreover, this divide also springs from parallel economic and structural drivers of health disparities in 'left behind' neighbourhoods, located in social housing estates on the peripheries of Northern post-industrial urban areas, mining regions, and coastal communities nationwide (Munford et al., 2022). Mining regions struggle with poor health-related worklessness, unemployment, and limited economic opportunities, driving skilled working-age outmigration and an influx of ageing and ailing populations (Beatty et al., 2019). Similarly, coastal communities, despite some studies associating them with improved health outcomes (Wheeler et al., 2012; Geiger et al., 2023), experience a "coastal excess" of poorer health attributed to ageing and ailing populations, low-paying seasonal tourism economies, and migrations patterns akin to mining regions (Whitty, 2021; Asthana & Gibson, 2022).

These marginalised neighbourhoods face multiple deprivations and inadequate social infrastructure: meeting spaces, physical and digital connectivity, and community engagement opportunities (Munford et al., 2022). Situated peripherally with inadequate transport links and high prevalence of benefits claimants, these neighbourhoods are excluded from job markets and essential services (education and healthcare), contributing to acute needs (Barford and Gray, 2022). Paradoxically, despite rising unmet needs, these areas have witnessed the highest levels of disinvestment and below-average funding, not just for England but in deprived areas generally (LT, 2019). The prevalent "narratives of decline" in these neighbourhoods have bred feelings of powerlessness, collective mistrust, and disenchantment in politicians, resulting in poorer mental health and wellbeing (Whitehead et al., 2016; UoC, 2021).

The introduction of austerity measures in 2010 resulted in the "fraying in the wider role of the state" through deep and lasting cuts to public spending and investment in public services and local authorities, causing key markers of population health and living standards to regress for the first time in post-industrial England (Marmot, 2020; McCartney et al., 2022; Neville and Giles, 2022, para.). While life expectancies have plateaued universally, international comparisons suggest the most unequal societies (UK and US) are falling behind peer countries in health, wealth, and public service investments (Burn-Murdoch, 2022a; Neville and Giles, 2022). The 'Tory belt-tightening' austerity measures have disproportionately affected the North and left behind neighbourhoods, leaving them more susceptible to crises like COVID-19 while amplifying political dissatisfaction with the state's inability to meet basic social needs (Whitehead, 2014; LT, 2019; Barford and Gray, 2022; Burn-Murdoch, 2022a, para.). These political choices, prioritising ideology over evidence, have eroded social safety nets, dismantled local services and civic assets, hindered connectivity, and restricted access to essential services, exacerbating the social health gradient and compromising public health (LT, 2019; Marmot, 2020).

2.3 Determinants of Health

Population health inequalities are multifaceted, extending beyond access to healthcare and the control of individuals themselves (Lovell and Bibby, 2018; Marmot, 2020). Substantial evidence underscores the SDH as pivotal in driving health disparities across various health indicators, settings, and populations (Marmot, 2010; 2020; Braveman and Gottlieb, 2014). Therefore, comprehending these determinants is essential for addressing enduring health inequalities.

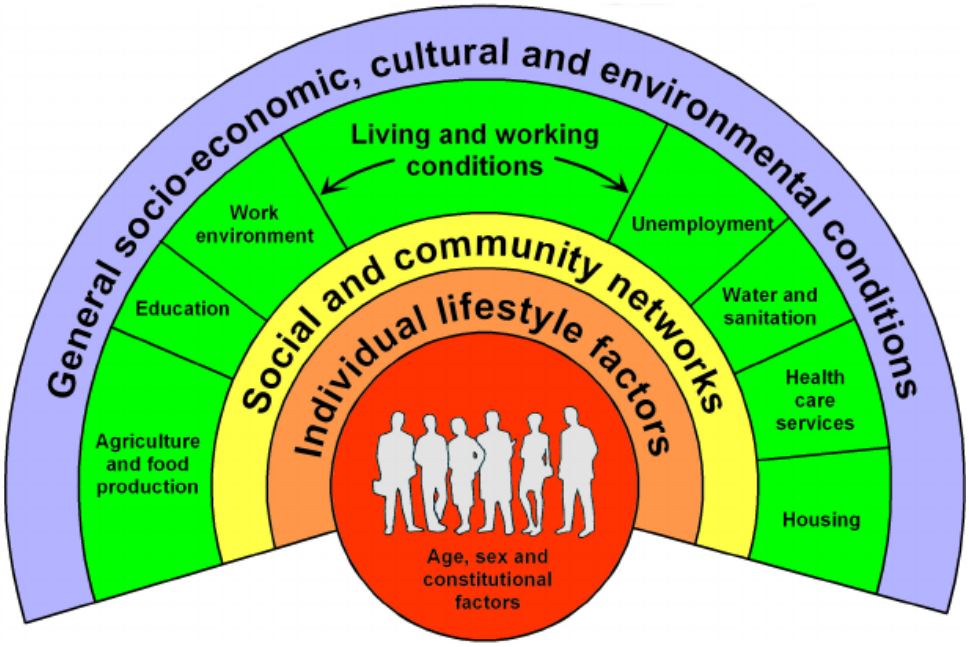

Figure 2.1 Rainbow model of health determinants (Dahlgren and Whitehead, 2021)

Going beyond traditional health models which focus on disease-specific causes, the 'Rainbow Model' (Dahlgren and Whitehead, 2021) offers a holistic framework, categorising five hierarchal layers influencing an individual's health. Acknowledged for its effectiveness in public health inequality research, this model enables the assessment of each layer's impact on health, facilitates targeted interventions, and encourages exploration of SDH within local environments (Bambra et al., 2010; Dahlgren and Whitehead, 2021).

The core layer recognises the fixed and legally protected 'constitutional factors' (Dahlgren and Whitehead, 2007). Age, considered the most important constitutional factor (UNDESA, 2018), heightens the risk of illness and poor health (Raymond et al., 2021). England's population is ageing and ailing, with nearly a fifth aged 65 or over, and two-thirds of those reporting at least one long-term health condition (Raymond et al., 2021; Storey, 2023). While absolute health disparities begin modestly for younger age groups, they accumulate over the life-course, widening significantly beyond the age of 65, reflecting the cumulative impact of disadvantage and chronic stress

contributing to the allostatic load (Guidi et al., 2020; Watt et al., 2022). Research on allostatic load reveals that early-life socioeconomic disadvantage and social stress are associated with psychobiologic impacts manifesting in various poor and chronic health outcomes in adolescence, independent of socioeconomic status (Braveman and Gottlieb, 2014).

Ethnicity is another long-established determinant of health (Acheson, 1998). The COVID-19 pandemic disproportionately affected most ethnic minority groups, amplifying existing inequalities in health and access to health services between ethnic minority and White groups, and between and within different ethnic minority groups (Robertson et al., 2021; Raleigh, 2023; Scobie, 2023). However, the complexity of this issue is often obscured by limited data and broad ethnic group categorisations, masking substantial variation (ibid).

Evidence highlights a complex interplay between social and economic disparities linked to geography and living conditions, socioeconomic deprivation, and health-related behaviours (ibid). While socioeconomic deprivation disproportionately affects most ethnic minority groups, adjusting for these factors significantly reduces numerous ethnic health disparities (Braveman et al., 2005; Robertson et al., 2021). However, socioeconomic factors alone cannot fully explain these disparities, exemplified by 85% of doctors who succumbed to COVID-19 being from ethnic minority backgrounds (BMA, n.a.). Recognising the concept of intersectionality becomes crucial, emphasising the overlapping facets of identity that create different or multiple discriminations and privileges influencing health (NHS, n.a.). Research suggests that structural racism and discrimination, with their negative impact on physical and mental health, perpetuate inequalities, underscoring that ethnic disparities are more a social product than biological ones (BMA, n.a.; Hackett et al., 2020; Powel et al., 2022). Additionally, living in societies with strong legacies of racial discrimination can detrimentally affect health through psychobiologic pathways, even without overt discriminatory incidents (Williams and Mohammed, 2009).

The subsequent layers encapsulate influences amenable to policy interventions (Dahlgren and Whitehead, 2007). From an equity-in-health perspective, the outermost macroeconomic layer emphasises the significance of socioeconomic, cultural, and environmental factors as determinants of population health (Jahnel et al., 2022). Systematic variations in the local, national, and international distribution of power and resources shape daily life conditions, generating health inequalities (IHE, n.a.; Jahnel et al., 2022). These societal inequalities, often considered the causes of the causes, have strengthened due to neoliberal economic policies and globalization (ibid). Furthermore, they have perpetuated in England after a decade of austerity (Marmot, 2020).

The next layer encompasses the living and working conditions central to health, known as the SDH (Marmot, 2010). Systematic differences in the SDH constrain some individuals' opportunities and resources to lead healthy lives, creating a stepwise gradient pattern driving health disparities (CSDH, 2008). This socioeconomic health gradient has been recognised for centuries, whereby health improves incrementally with rising social position, while those at the bottom of the ladder experience twice the risk of illness and mortality (Chadwick, 1842; Marmot et al., 1978; Marmot

and Wilkinson, 2005; Kendell et al., 2021). Whilst socioeconomic class is a consistent and reliable predictor of health; education and work are key SDHs that must be acknowledged.

Education and health are intrinsically interconnected (The Lancet, 2020). The evidence supporting education as an SDH is compelling, beginning in early childhood and continuing throughout life (The Lancet, 2020; Leavy et al., 2021). Education serves a dual role in health, functioning as both an enabler of opportunity and a contributor of inequality (Zajacova, 2018). Higher educational attainment opens doors to high-quality work, improved income, lasting social connections, upward social mobility, and life-long health-promoting behaviours, leading to improved health (Bibby, 2017; Zajacova, 2018; The Lancet, 2020). Conversely, a lack of qualifications is linked to lower income, subsequently resulting in poorer health (Zajacova, 2018).

Work exerts both direct and indirect influences on various health-related factors such as job security, income, and social networks (Tinson, 2020). Although research continually demonstrates the link between poor health and unemployment, near full-employment in the UK over the last decade suggests that not all work is protective of health (ibid). During this period, job-intensification has damaged mental health and wellbeing, resulting in the highest levels of economic inactivity among working-age adults due to long-term sickness and health-related disability benefits claimants on record (ONS, 2022; Joyce et al., 2022; O'Connor, 2022). Mental health conditions now account for half of all work-related illnesses and are partly attributed to 'job strain' - the combination of high demands and inadequate control at work, generating health-damaging stressors (Kuper and Marmot, 2003; Giga, 2018; Liversedge, 2022). Job strain is rampant in the UK compared to peer countries due to weaker labour market safeguards and law enforcement, leaving workers less protected (O'Connor, 2022).

Evidence suggests that one-third of UK employees report low-quality work (Tinson, 2020). Additionally, there is a concerning rise of zero-hour contract work among young, elderly, and migrant groups, now at its record highest (ONS, 2023). Those in low-quality work and zero-hour contracts experience heightened poverty, feelings of powerlessness, precarity, and stress, leading to double the rate of poor health compared to those with no negative job aspects (Tinson, 2020; Wilson and McDaid, 2022). Extended exposure to low-quality work or rejoining low-quality work is associated with higher levels of allostatic load and worse health outcomes than remaining unemployed (Chandola and Zhang, 2018; Tinson, 2020). In contrast, high-quality employment is significant for both employees, ensuring financial security and wellbeing, and employers, ensuring a robust workforce (Lovell and Bibby, 2018; THF, 2022).

Despite being overlooked as a serious public health concern, the social and community networks layer acknowledges the importance of social isolation and loneliness (WHO, n.a.; LGA, 2020). Extensive research underscores their profound impact on physical and mental health, particularly amongst disadvantaged groups, rivalling health-related behaviours (WHO, n.a.; Dahlgren and Whitehead, 2007; LGA, 2020; Emerson et al., 2021). Loneliness and social isolation, for instance, are twice as detrimental to physical and mental health as obesity (Novotney, 2019). Digital

exclusion drives and exacerbates this by weakening social support networks (LGA, 2020; Czaja et al., 2021). In contrast, strong social support, self-esteem, and self-efficacy offer protective effects for individuals and communities against adverse social conditions and declining health outcomes (NIA, 2019; Walsh, 2021).

Loneliness affects individuals of all ages, yet older adults face a heightened risk due to reduced social support, living alone, long-term illnesses, and economic inactivity (CDCP, n.a.; LGA, 2020; Czaja et al., 2021). Before COVID-19, research showed that loneliness was rising, particularly among younger populations, resulting from a deterioration in meaningful relationships following the austerity-induced decimation of community-building institutions and public spaces (Alston, 2018; Walsh, 2021; Brown, 2022; MHF, 2022). Post-pandemic, loneliness was exacerbated and reached record levels, indicating a failure to return to pre-pandemic levels (LGA, 2020; CEL, 2022).

The fourth layer relates to individual resources and lifestyle choices. Autonomy, or the 'control over one's destiny,' is a fundamental aspect of this layer that affects access to resources to promote or maintain health (Whitehead et al., 2016). Freedom in making daily life choices is a luxury some cannot afford. Disadvantaged individuals frequently adopt unhealthier behaviours like smoking, unhealthy eating, or sedentary lifestyles due to socioeconomic and time constraints (Braveman et al., 2005; Jahnel et al., 2022). These constraints generate feelings of inadequate individual agency and powerlessness, increasing chronic stressors that underly socioeconomic health disparities among population groups (Marmot, 2010; Whitehead et al., 2016).

2.4 The Importance of Addressing Health Inequalities

75 years ago, the NHS committed to providing universal, equitable, comprehensive, centrally funded, high-quality healthcare according to need and free at the point of delivery (Delamothe, 2008). This foundation aligns with the principles of social equity and justice, where health is more than a resource for living; it is a fundamental human right, recognised by the World Health Organisation (WHO) and NHS (Lovell and Bibby, 2018; DHSC, 2023). However, the 'inverse care law' has exposed that those most in need of quality healthcare paradoxically receive it the least (Hart, 1971). Despite multi-decade governmental efforts to reduce these inequities, political will has fallen flat and not matched up to the scale of the problem (Fisher et al., 2022). Thus, deprived areas of England remain relatively underfunded, under-doctored, and perform worse on a range of quality indicators than wealthier areas (ibid).

In 2010, the NHS and wider healthcare and social care system had the highest levels of public satisfaction and was globally recognised as the best (Holdroyd et al., 2022; Wellings et al., 2022). Today, the performance is deteriorating, and public discontent has reached historic levels due to concerns over unprecedented waiting times, staff shortages, working conditions, and inadequate government funding (Wellings et al., 2022; Ham, 2023).

This fall from grace is partly attributed to the discontinuation of the English Health Inequalities Strategy (1999-2010) – a pioneering multisector cross-departmental government initiative that set key commitments and indicators to monitor progress (Barr et al., 2014; Robinson et al., 2019; Holdroyd et al., 2022; Ham, 2023). This strategy fostered both 'downstream' initiatives like the significant multi-year NHS funding increases targeting deprived neighbourhoods, and more 'upstream' social policies such as the improved national minimum wage, employment opportunities, and funding for schools, housing, and transport (ibid). By addressing the inverse care law and investing in the SDH, the strategy successfully narrowed absolute, relative, and geographical disparities in health (ibid).

Discontinuing this strategy whilst introducing historically low funding increases and the Social Care Act (2012) has reversed progress in the health and social care system and population health inequalities, resulting in subpar healthcare access, coordination, quality, and outcomes (ibid). These policy decisions have led to dependence on outsourcing private healthcare services and the emergence of a two-tier system of healthcare that excludes those who cannot afford private healthcare and enables those with the financial means to 'opt-out' (Burn-Murdoch, 2022b; Goodair and Reeves, 2022; Thomas et al., 2022). The UK has experienced the fastest growth in out-of-pocket healthcare spending in the G7, approaching levels seen in the US (ibid). However, the poorest now spend relatively as much on private healthcare as the richest, presenting a worrisome development for the NHS, as the increased outsourcing to private healthcare is associated with a decline in quality of care and widening inequalities in health outcomes (ibid).

The unjust existence of avoidable health disparities represents a moral dilemma that questions the essence of egalitarianism (Jones, 2010; Braveman et al., 2011). In England, intersecting and compounding factors create an 'unlevel playing field' where not everyone has access to the same building blocks to live healthily (OHID, 2022). This matters as health inequalities go beyond individual costs, impacting society as a whole (ibid). A flourishing society hinges on the health of its population, and in turn, health catalyses thriving family, community, and societal engagement, integration, and unity (Lovell & Bibby, 2018). Moreover, a healthy population yields substantial economic benefits through various avenues (ibid). For example, good health throughout the life-course increases productivity and engagement whilst curbing early retirement due to ill health, enabling continued workforce participation (ibid).

An unhealthy population imposes avoidable burdens on individuals and the economy through unemployment, lower income, sickness absence, and increased health-related benefits, resulting in lost working days (ibid). Health-related worklessness due to sickness is currently at a record high (ONS, 2023). While some research points to long waiting times, increased poor health, and long COVID-19 as potential drivers, a coalition of key health experts point to the broken Statutory Sick Pay (SSP) system that lags behind the rest of Europe (Tinson et al., 2022; CRP, 2023a; 2023b). This system leaves one-third of people in poverty and neglects two million workers, often in low-quality work like social care, forcing them to choose between working while sick or staying home with financial worries (ibid). Such patterns, along with the unsustainable pattern of patching

up individuals and returning them to unhealthy working environments, result in substantial costs for individual and public well-being, productivity, and the healthcare systems (Lovell and Bibby, 2018; O'Connor, 2022). Pre-COVID-19, the annual cost of poor health ranged between £56-100 billion (PHE, 2021; Merrifield, 2021). These costs are unevenly distributed across England and hinder the North's potential, contributing to the largest regional divide in economic output of any European country, primarily affecting left behind neighbourhoods where health-related worklessness results in a £30 billion annual productivity loss (Whitehead, 2014; Munford et al., 2022).

The current levelling up agenda commitment to improving health disparities has been described as 'not fit for purpose' for failing to scale up to inequalities in England; unfairly distributing funding up to 10 times higher in some wealthy areas over deprived areas with greater health needs (McIntyre et al., 2022; Ogden et al., 2022). This disconnect between rhetoric and reality is most compelling in the social care system where promised reforms to funding have continually been delayed since 2010, leaving the system under intense pressure with an unstable provider market, subpar working conditions, a workforce crisis, and high levels of unmet need (EAC, 2019; Wickens, 2023). Without addressing these issues, the system will continue to fail to keep up with the pace of an ageing and ailing population (ibid).

Coinciding with the NHS's 75th birthday, the profile of public health and health inequalities is at a once-in-a-generation high, and its mission to 'universalise the best' has retained enduring near-universal public support since its inception (Wellings et al., 2022). Addressing the disconnect between public perceptions of health influences (individual behaviour and healthcare access) and the well-established evidence of SDH is crucial (Kane et al., 2022). This dissertation can bridge the gap using the Rainbow model to emphasise the importance of an ecological perspective and the SDH on illness and poor health.

3 Methodology

3.1 Research Strategy

This dissertation employs a positivist quantitative multimethod approach to analyse neighbourhood health inequalities using the 2011 and 2021 Census. The "bottoms up" approach ensures the research aims, objectives, and strategy guide the method selection, resulting in a more comprehensive explanatory framework and enhanced understanding (Johnson et al., 2007: 122). By employing a multimethod approach, this dissertation achieves within-methods triangulation, validating and corroborating the results obtained from diverse quantitative methods and data sources (ibid).

This comprehensive approach provides a more profound and internally consistent understanding of neighbourhood health inequalities, resulting in richer insights while bolstering the dissertations' reliability and validity (ibid). Moreover, it contributes to social justice by offering valuable insights for targeted policies aimed at reducing unjust health disparities.

3.2 Data Collection and the Census

Data collection involved downloading 2011 and 2021 LSOA-level Census CSV files (containing variables) and shapefiles (containing boundaries) for England and Wales from open-source websites, including NOMIS, ONS Geography Linked Data Portal, and the UK Data Service.

The Census, conducted decennially by the Office for National Statistics (ONS) since 1801 (except during WWII), offers a comprehensive count of people and households through surveys and questionnaires, providing detailed insights into the English population across geographical scales (Buckner, 2021; Roskams, 2023). The 2021 Census achieved a target-exceeding 97% participation rate among households, offering a once-in-a-decade opportunity to quantitively analyse neighbourhood health inequalities in England with the only accurate and reliable small-area geographical data (GDSL, 2021; Roskams, 2023). Examining data from both the 2011 and 2021 Census reveals insights into long-term socioeconomic structures, inequalities, and societal changes (GDSL, 2021).

LSOAs are homogenised geographical units dividing England into neighbourhoods with similar populations (around 1500 residents or 650 households) and robust estimates, enabling meaningful comparisons of neighbourhood health across space and over time (MHCLG, 2019). This is important as local-level inequalities receive less attention than the wider geographical units, which often mask variations and sometimes result in false conclusions due to the Modifiable Areal Unit Problem (Openshaw, 1984; Pickett and Pearl, 2001). Therefore, LSOAs are optimal for accurately analysing neighbourhood health inequalities.

To enhance the validity of findings, this dissertation considers two outcome variables measuring SRH:

1. 'illness' – the percentage of residents reporting a long-term (over 12 months) health problem or disability limiting daily activities 'a lot' or 'a little'
2. 'poor health' – the percentage of residents reporting 'bad' and 'very bad' general health.

SRH is a popular holistic measure of general population health status due to its simplicity, validity, reliability, and strong association with objective health and future morbidity (Wu et al., 2013; Wuorela et al., 2020).

Ethical guidelines strictly govern the preservation and anonymity of Census data, with data confidentiality ensured.

3.3 Data Analysis

3.3.1 Data Preprocessing

Data preprocessing involved filtering English LSOAs in Excel and calculating percentages for variables using their unique denominators. Percentages are appropriate in health geography as they offer a more comprehensive format for representing standardised values, enabling comparison across neighbourhoods over time (Sinayev et al., 2016). Some variables were redefined to better represent SDH (refer to **Table 7.1** Variable definitions).

For analysing SRH change between Censuses, multiple imputations handled missing data (1034 NA's or 3%) caused by changes in LSOA structure from 2011 to 2021. This approach preserves uncertainty and natural variability while ensuring reliable results (Rubin, 1987; Kang, 2013).

For spatial analysis, datasets were transformed into 'sf' objects to efficiently handle both spatial and non-spatial data. Additionally, one missing neighbourhood was removed from both the 2011 (18,536) and 2021 (18,094) datasets to calculate Moran's I.

The prepared dataset was then compiled into a final CSV file, containing relevant outcome and predictor variables, which was joined by "geo_code" or "LSOA11CD/LSOA21CD" to the shapefile. These steps ensured a well-prepared dataset for subsequent univariate and multivariate analysis, maintaining data integrity and enabling seamless integration of geographic information for accurate results.

3.3.2 Descriptive and Summary Statistics

Descriptive statistics are crucial for univariate data analysis, helping quantify and summarise the magnitude and basic characteristics of illness and poor health (May, 2017; SAGE, 2021). By visualising data through histograms and employing measures of central tendency (mode, median, and mean), spread (range, interquartile range (IQR), and skewness), and variation (variance and standard deviation (SD)), corroborated insights improve the dissertation validity (ibid). This approach ensures a comprehensive understanding of central tendencies and distribution shape, aiding in identifying patterns, outliers, and variations of SRH in neighbourhoods across England (ibid).

3.3.3 Spatial Analysis

Spatial analysis is valuable for understanding neighbourhood health inequalities and is widely adopted in health geography research (Highberger & Merriman-Nai, 2021). Mapping is particularly powerful for visualising illness and poor health, enabling the exploration of national to neighbourhood-level patterns (ibid.).

To effectively communicate spatial data, red colour schemes are avoided due to issues related to overuse, colour-blindness, and unwanted emotional responses (Tufte, 1985; VDRI, 2019). Instead, we apply ColorBrewer's 'YlBlGn' sequential classed colour palette to emphasize data variation (Tufte, 1985; ColorBrewer 2.0, n.a.). While Tufte (1985) advocates for quantile classifications, Jenks natural breaks are chosen as they accurately identify clusters in skewed data and normalise the distribution in a representative way (Jenks, 1967; Tufte, 1985; Slocum et al., 2022). LSOA boundaries are transparent to “remove chart junk,” uncover patterns beyond neighbourhoods, and demonstrate that LSOAs are more than geographically bound units (Tufte, 1985).

Tobler’s First Law (TFL) (1970) underpins spatial autocorrelation, emphasising that proximity implies higher relatedness. Moran’s I, a widely-used test of spatial autocorrelation quantifies average neighbourhood similarity in SRH, addressing cross-boundary boundary leakages (Moran, 1950; Anselin, 1955; Anselin, 2020). While used interchangeably, distinguishing between Global Moran’s I and Moran’s I is crucial: the former evaluates overall geographic clustering using a rook contiguity matrix, while the latter measures linear relationships between variables and their spatial lags through a queen contiguity matrix (Anselin, 2020). Both metrics range from -1 (dissimilar values clustering) to 1 (similar values clustering), with 0 indicating random spatial distribution. While these measures offer insight into the magnitude and direction of spatial clustering, they do not pinpoint specific cluster locations. For such precision, Local Moran’s I is used, categorising values into spatial clusters (HH, LL) and spatial outliers (HL, LH), effectively revealing suggestive evidence of spatial patterns (Anselin, 1995; 2020).

3.3.4 Correlation Analysis, Linear Regression Modelling and Model Validation

To examine the associations between SRH and key predictor variables across each time period (2011, 2021, and the change between them), Spearman's Rank Correlation was employed. After identifying key predictor variables, LRM were fitted using Ordinary Least Squares (OLS), a widely adopted, unbiased, and powerful approach assuming linear associations and normally distributed, independent, and homoscedastic residuals (Dearden et al., 2020). Multiple regression models were constructed to explore the evolving dynamics between illness, poor health, and the predictor variables over time.

Initially, baseline models for illness and poor health in the three time periods were created, incorporating theoretically justified variables: Economic activity, Low-quality work, No qualifications, Lone persons, and Over 65. Subsequently, Crawley's (2007) 'Backwards elimination' regression model fitting strategy was adopted. Crawley (2007: 339) suggests that "all models are wrong" as errors will occur whatever the model adopted. Therefore, the 'best' model balances predictive accuracy (fitting data optimally) and parsimony (a simple, replicable model) (Kabacoff, 2020: 231). On that note, a 'maximal' model was created containing all variables of theoretical interest, even if statistically insignificant. Insignificant variables were systematically removed one-by-one using a data mining approach until a 'minimal adequate' model emerged (Chowdhury et al., 2020). This model balances model fit and model complexity to create the simplest possible model providing an adequate level of explanation. While forward stepwise regression was considered, the backwards approach aligned better with the research aims due to its simplicity and flexibility in selecting predictor variables for the final model.

Subsequently, a final model was developed, following a rigorous validation process encompassing interpretability, model fit, normality of residuals, and multicollinearity. Diagnostic tests such as R-squared (R^2), Akaike Information Criterion (AIC), p-value, skewness, Variance Inflation Factors (VIF), and Bonferroni Outlier Tests were applied. High multicollinearity among predictor was assessed via correlation matrices, leading to the removal of variables with high VIF (See **Appendix A** – Supplementary Graphics). These variables, including White, Higher education, Economically inactive and Working class, were omitted due to near-perfect collinearity with the other ethnic groups, economic activity, and the other socioeconomic/occupational classes. All variables included in these final models are statistically significant (p-value<0.001), indicative of their robust predictive power for SRH. These model check tools are recommended as a robust means of comparing models and results (Anselin et al., 2006).

3.3.5 Inequality Measures

There is a growing consensus on the importance of combining multiple inequality measures, like the Slope Index of Inequality (SII) and Relative Index of Inequality (RII), to comprehensively gauge progress in both absolute and relative health disparities while avoiding misleading conclusions (Houweling et al., 2007; Marmot, 2010; Renard et al., 2019; NICE, 2020).

The SII, derived from population-weighted linear regression, captures the social gradient in health outcomes and summarises it into a number (ibid). Complementing the SII, the RII offers a contextual measure by comparing the extent of health inequality with the overall level of the indicator (ibid).

4 Results and Discussion

4.1 Descriptive and Summary Statistics

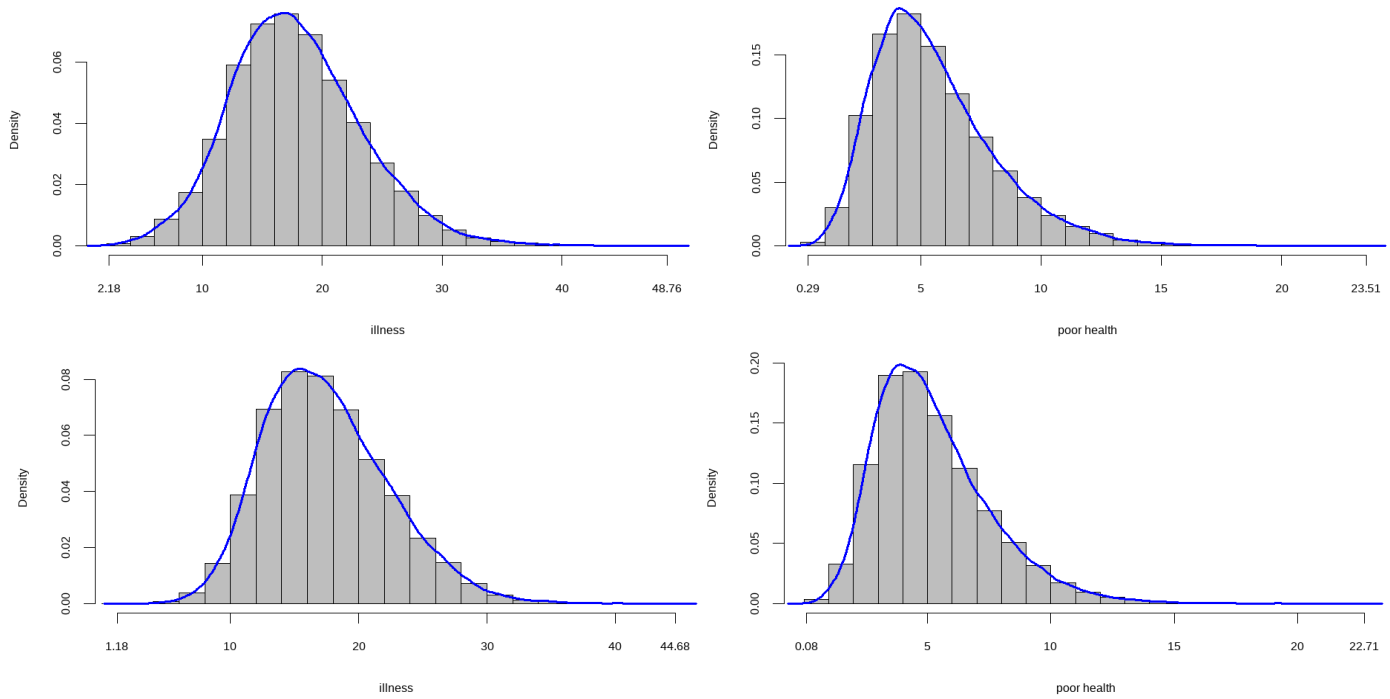

Figure 4.1 Histogram for illness and poor health in 2011 (top) and 2021 (bottom)

Figure 4.1 illustrates the frequency distribution of illness and poor health for 2011 and 2021, showing unimodal shapes with moderate skewness and long tails, representing outliers and extreme values especially pronounced in poor health. In 2011, illness exhibited a distribution twice as wide as that of poor health, with a peak bin of 16-18% for illness and 4-5% for poor health. In 2021, the distribution slightly narrowed but maintained a similar shape. This is because people perceive and rate their health differently and illness is a broader measure encompassing a wider range of health outcomes, from minor to severe, compared to poor health which can be influenced by relative derivation, cultural factors, and social desirability bias (Todorova et al., 2014).

Table 4.1 Descriptive and summary statistics for illness and poor health, 2011-21

Variables		Min	Median	Mean	Max	Skew	Range	IQR	SD	Variance
illness	2011	2.18	17.42	17.84	48.76	0.43	46.58	7.17	5.45	29.70
	2021	1.81	17.00	17.49	44.68	0.52	42.87	6.61	4.85	23.51
poor health	2011	0.29	5.10	5.54	23.51	0.98	23.22	3.19	2.50	6.25
	2021	0.08	4.82	5.21	22.71	0.99	22.63	2.93	2.31	5.32

Table 4.1 confirms that neighbourhood illness and poor health are positively skewed. In 2011, the median (17.42%), mean (17.84%), and calculated skew (0.43) for illness falls within the threshold for symmetrical distribution (-0.5 to 0.5). Conversely, the median (5.10%), mean (5.54%), and extremely positive skew (0.98) for poor health points to a non-symmetrical distribution. The slight increase in skewness for both illness (0.52) and poor health (0.99) in 2021 indicates persistent values and similar distributions across time periods.

This persistence is demonstrated in the notable variations in neighbourhood SRH outcomes across England. In 2011, a substantial gap (46.58%) separates the most-ill (48.76%) and least-ill (2.18%) neighbourhoods, reflected in high SD (5.45), IQR (7.17), and variance (29.70) values. While the gap is almost half as narrow for poor health (23.22%), the SD (2.50), IQR (3.19), and variance (6.25) suggest disparities remain pronounced. Central tendency, spread, and variation indicators in the table decrease somewhat between 2011 and 2021, indicating a slight improvement in health outcomes. This improvement is more pronounced in illness. These indicators, however, continue to demonstrate substantial disparities in neighbourhood SRH across England, highlighting the pervasiveness of health inequalities that have been documented for over 250 years (Kendall et al., 2021).

4.2 Spatial Analysis

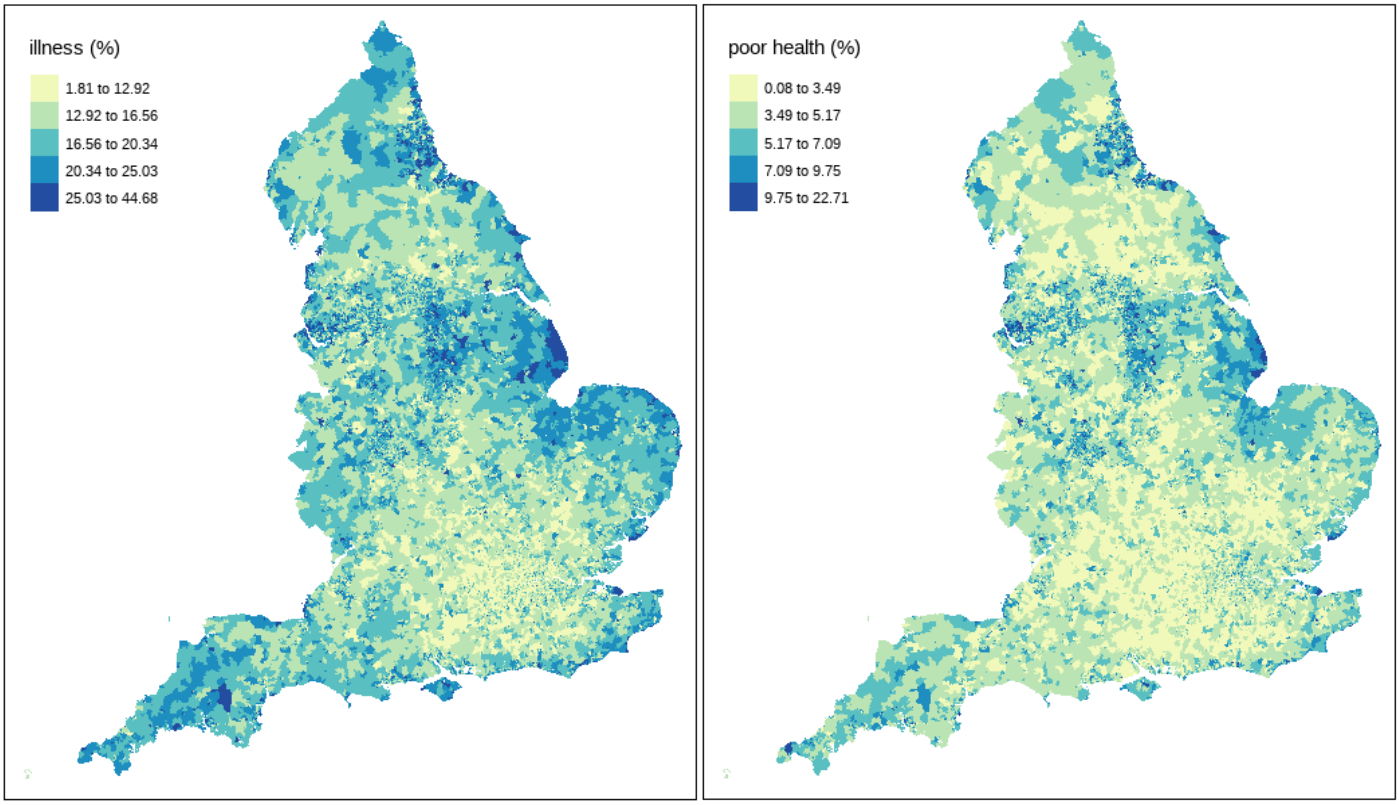

Figure 4.2 Spatial distribution of illness and poor health, 2021

Figure 4.2 maps illness and poor health in 2021, highlighting a North-South divide. While this finding is not new, as the North-South health divide has been recognised since the 19th century, it highlights enduring spatial health disparities in England rooted in historical inequalities in power and resources (Chadwick, 1842; Buchan, 2017). SRH is lower in the South East and London regions, particularly around London's commuter belt, and higher in the North West, North East, and Yorkshire and the Humber regions. This spatial distribution aligns with extensive prior research using various objective health measures and mortality data (Buchan et al., 2017; Dearden et al., 2019; Munford et al., 2023), bolstering SRH's validity and reliability as an accurate indicator of objective health (Wuourela et al., 2020).

Counties like Durham and Tyne and Wear in the North East, containing Newcastle and Sunderland, exhibit high rates of illness and poor health. The North West's counties of Lancashire and Merseyside, containing Blackpool, Liverpool, and Wirral, also mirror these SRH outcomes. This aligns with research using age-standardised variables, suggesting that contextual factors, not compositional ones, may underlie these findings (Munford et al., 2023). Both regions share socioeconomic histories of concentrated deprivation and declining labour demand due to the lasting repercussions of deindustrialisation, disproportionally impacting residents' lives, and

opportunities (Dearden et al., 2019; 2020). Given that relative socioeconomic disadvantage affects illness and poor health over the life-course and many of these industries shut down in the 1980s, these findings reflect the long shadow of deprivation and inequality in England.

The historical legacy of concentrated deprivation and societal inequalities is glaringly evident in the North West, with Wirral standing out for having some of the widest inequalities in neighbourhood health and biggest budget cuts in England – 85% since 2010 and rising (WIS, 2012; HC Deb, 2022). In 2021, Wirral 016E, an Eastern neighbourhood in the former shipbuilding communities of Seacombe, Birkenhead, and Tranmere, faced extreme levels of illness (37.85%) and poor health (18.88%). These communities grapple with high levels of air pollution, deprivation, overcrowding, unemployment, lack of qualifications, jobseekers allowance claims, and unhealthy behaviours (WIS, 2012; 2013; 2020; WBC, 2019; HC Deb, 2022). In contrast, just a few kilometres West in Heswall, where affluence and educational outcomes are concentrated and air pollution is less prominent, illness rates are three times lower, and poor health rates are six times lower (WIS, 2012; 2013). This stark East-West divide within close proximity questions the validity of TFL as nearby neighbourhoods exhibit vastly different health outcomes. It also raises concerns about a postcode lottery in social mobility and health, where one's place of residence significantly impacts health and opportunities for a healthy life (Carneiro et al., 2020).

Similar disparities are observed in Greater Manchester. Some neighbourhoods in the urban North, like Salford 020A, report three times the illness and eleven times the poor health compared to more affluent Southern suburban neighbourhoods, such as Trafford 028A, which surpasses national health averages (Codling and Allen, 2020; Marmot et al., 2021). These disparities are partly attributed to differences in child poverty, income, home ownership, housing quality, overcrowding, educational outcomes, and low-quality jobs (ibid).

Maps for 2011 illness and poor health are omitted due to their consistent geographic patterns that do not provide new insights (see **Appendix A** – Supplementary Graphics).

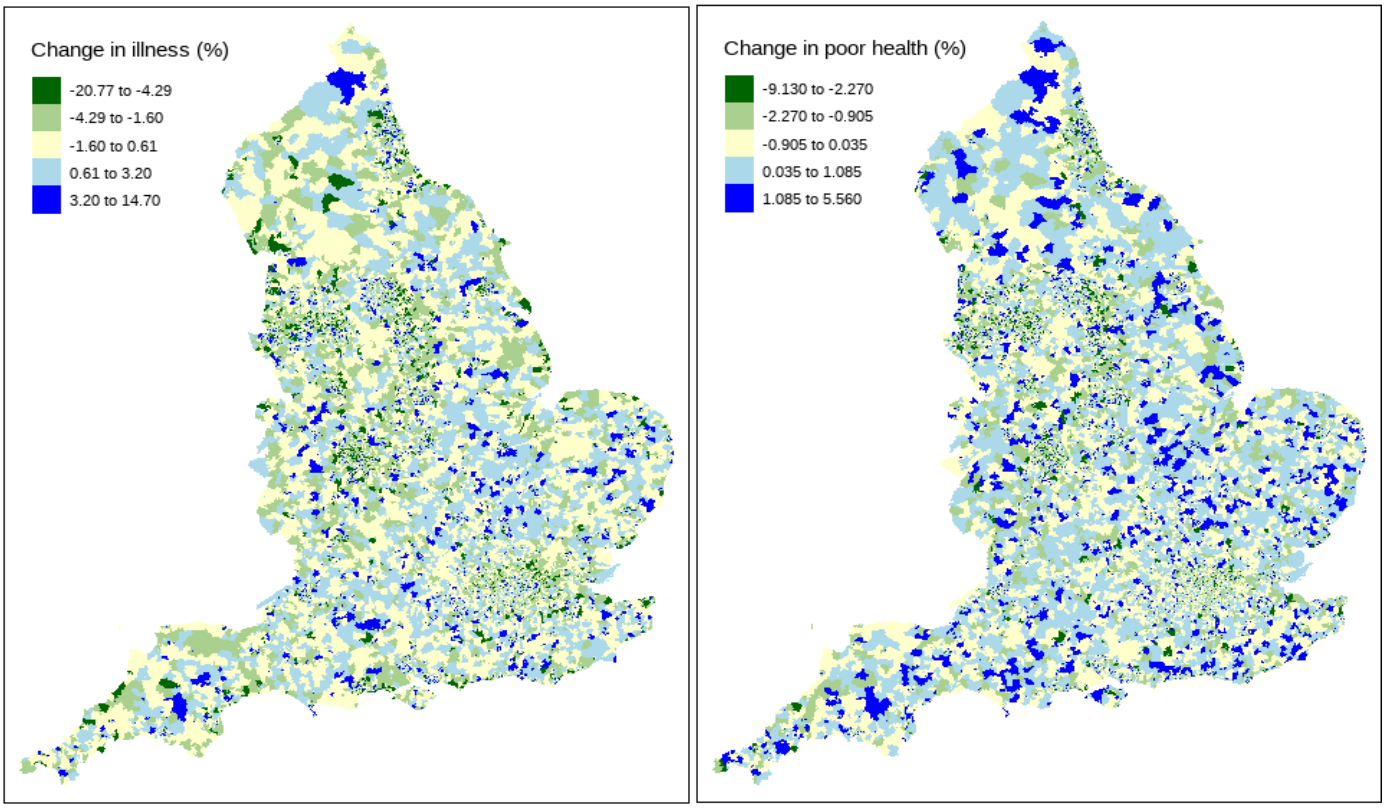

Figure 4.3 Spatial distribution of illness and poor health change between 2011-21

Figure 4.3 maps illness and poor health changes between 2011 and 2021. Darker colours indicate more significant differences scattered throughout England. No obvious North-South divide or spatial pattern emerges except for a greater variability in illness than poor health. The average change in illness (-0.21%) and poor health (-0.27%) between Censuses indicates a slight overall improvement in neighbourhood SRH. Notable improvements occurred in London, South Yorkshire (Barnsley, Doncaster, and Rotherham), the East Midlands (Leicester), and the West Midlands (Birmingham). While LSOAs are consistent over time, the characteristics within the LSOAs may have changed, reflecting migration patterns or lifestyle changes, i.e., smoking in adults decreased from 19.8% in 2011 to 13% in 2021 (OHID, 2022). Non-uniform SRH change suggests that neighbourhoods, being small and diverse, are influenced by unique locale characteristics, social capital, and SDH that vary from place to place (Pickett and Pearl, 2001).

Table 4.2 Moran's I calculations, 2011 and 2021

Variable		Moran's I	Global Moran's I
illness	2011	0.47***	0.51***
	2021	0.56***	0.56***
poor health	2011	0.46***	0.51***
	2021	0.49***	0.48***

**p-value<0.05, **p-value<0.01, ***p-value<0.001*

Table 4.2 presents the Moran's I values for neighbourhood illness and poor health across England in 2011 and 2021. Both illness and poor health, in both years, statistically significant positive values (p-values<0.001) indicate that neighbourhoods with similar SRH outcomes tend to cluster in England. Research suggests that this clustering is influenced by a variety of collective, compositional, and contextual factors, including environmental factors, SDH, and demographic characteristics (Diez-Roux, 2001; Schiltz et al., 2022).

The Moran's I value for illness (0.47) increased from 0.47 in 2011 to 0.56 in 2021, while poor health increased from 0.46 to 0.49. This suggests a growing degree of spatial clustering in neighbourhood SRH over time, especially in illness, consistent with previous research (Dearden et al., 2019). Although this trend is not as evident in poor health, it is important to note that clustering in SRH remains stable across both Censuses, with slight increases in illness clustering indicating more spatially continuity over time (ibid).

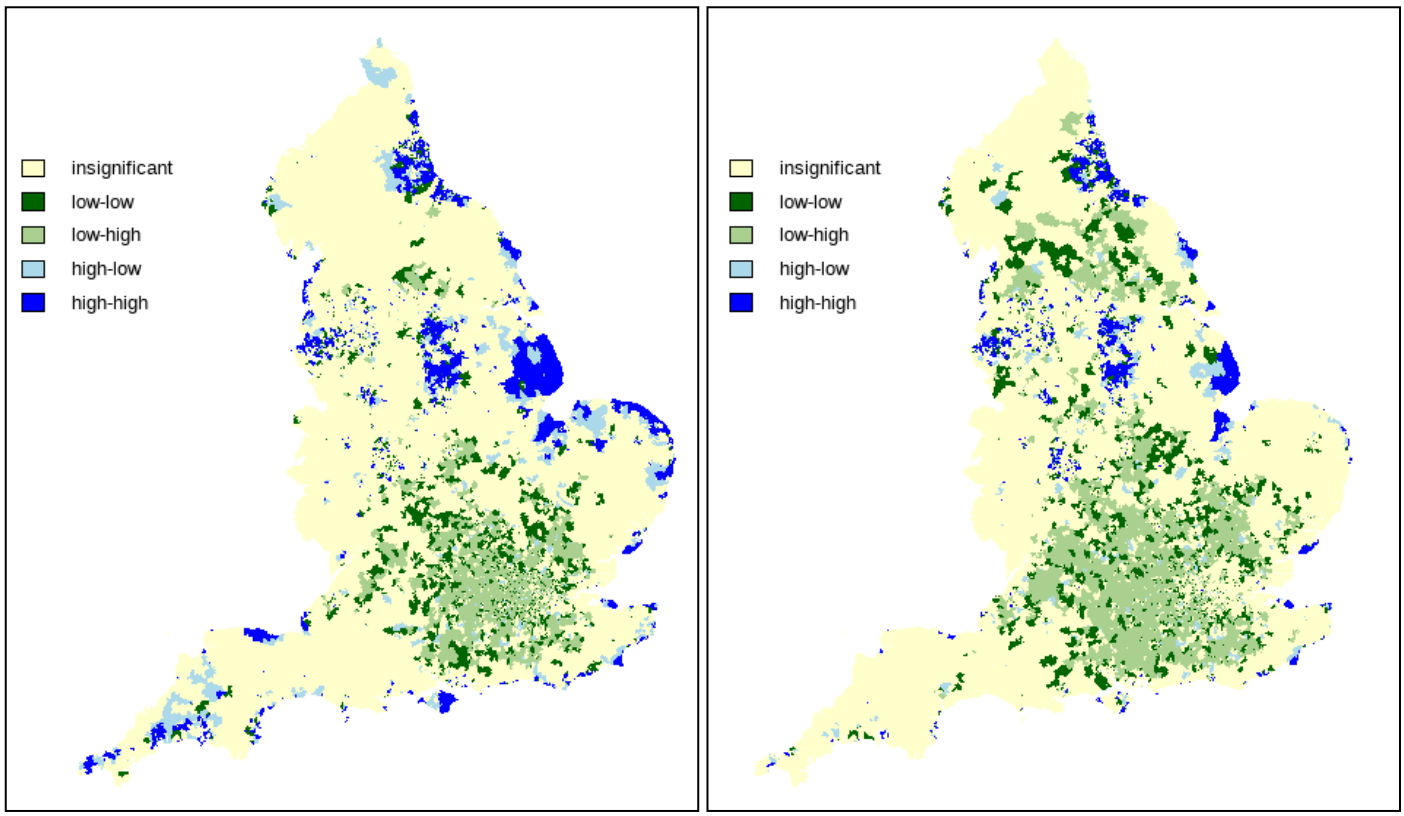

Figure 4.4 Spatial distribution of Local Moran's I for illness (left) and poor health (right), 2021

Figure 4.4 visualises the Local Moran's I for neighbourhood illness and poor health in 2021. Low-low/high-high quadrants, represented by dark green and dark blue, denote, while low-high/high-low spatial outliers are depicted in light green and light blue. Both SRH variables exhibit low-low

spatial clusters in the South around the London commuter belt, coinciding with clustered affluence (Rowe et al., 2020). In contrast, the high-high spatial clusters are evident in the North East, North West, Yorkshire-Derbyshire-Nottinghamshire coalfield mining regions, and coastal communities, consistent with **Figure 4.2** and previous research (Dearden et al., 2019). There is a higher prevalence of low-high spatial outliers compared to high-low areas, indicating an uneven distribution of extreme values, as highlighted in **Table 4.1**. This distribution underscores regional disparities, with low-high outliers concentrated in the South. while high-low outliers are more dispersed.

Certain areas in the North East and North West display diverse and pronounced spatial patterns, including both high-high and low-low clustering, along with presence of low-high and high-low spatial outliers in close proximity. Furthermore, the presence of high-high illness clusters in coastal communities, both in the North and South, reveal unique spatial patterns of "coastal excess," driven by a complex interplay of ageing and ailing populations, multiple deprivations, tourism-related economic dynamics and lack of opportunities, underinvestment in social infrastructure, and insufficient autonomy (LT, 2019; Whitty, 2021). For instance, despite being over 500 kilometres apart, Brighton 031C (38.70%) and Sunderland 016A (34.52%) exhibit remarkably similar illness rates. However, when comparing the coastal neighbourhood Brighton 031C to a neighbourhood three kilometres inland, Brighton 010D, the rates of illness differ significantly (10.91%). These findings challenge the ecological validity of TFL by revealing that nearby locations do not consistently exhibit greater similarity in health outcomes.

While some of the high-high clusters overlap with illness, fewer high-high spatial clusters of poor health exist in coastal communities. Furthermore, low-low clusters and low-high outliers are more prevalent in the South compared to illness. One explanation for higher illness rates but lower poor health rates in coastal communities may be their peripheral location and lack of connectivity, leading to exclusion from vital healthcare and education services, as well as labour markets (ibid).

Maps for 2011 illness and poor health Local Moran's I are excluded, as they reveal consistent geographic patterns that do not provide new insights (see **Appendix A** – Supplementary Graphics).

Table 4.3 Moran's I calculations for SRH change, 2011-21

Variables	Moran's I	Global Moran's I
illness change	0.26***	0.28***
poor health change	0.13***	0.14***
**p-value<0.05, **p-value<0.01, ***p-value<0.001*		

Table 4.3 offers insights into the clustering of SRH changes between 2011 and 2021, revealing a non-random distribution. For illness, the Moran's I (0.26) and Global Moran's I (0.28) values signify statistically significant positive spatial autocorrelation (p-value<0.001). For poor health,

Moran's I (0.13), and Global Moran's I (0.14) values are all positive and statistically significant (p-value<0.001), although weaker. Importantly, the results emphasise that spatial clustering is more prominent in changes in illness than poor health, consistent with prior research (Schiltz et al., 2022).

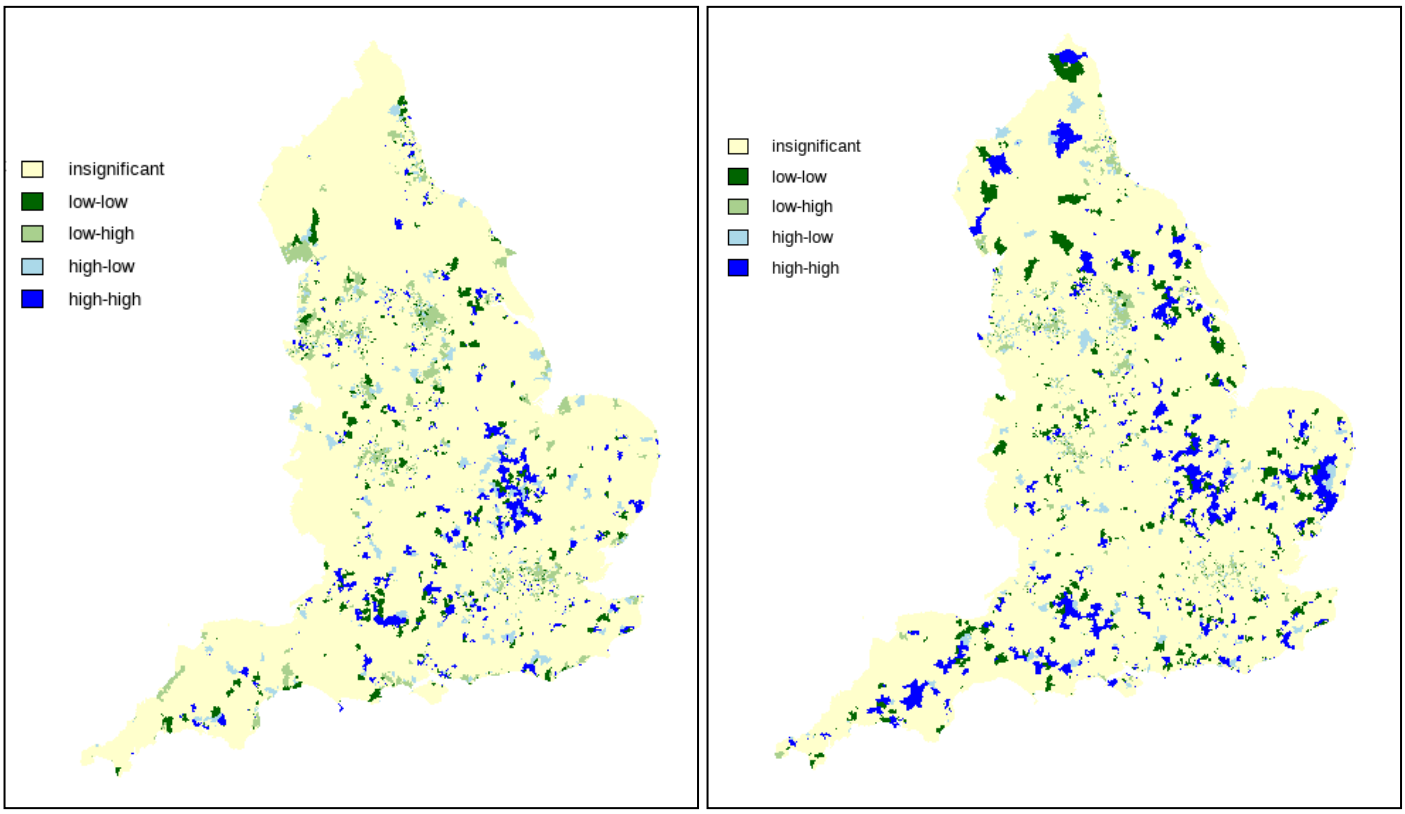

Figure 4.5 Local Moran's I for illness (left) and poor health (right) change between 2011-21

Figure 4.5 maps Local Moran's I for illness and poor health changes between 2011 and 2021, revealing spatial clustering in both variables, albeit weak and non-uniform. The majority of England exhibits insignificant change, emphasising the enduring nature of SRH disparities even at the neighbourhood level, where greater variation is expected (Diez-Roux, 2001). High-high spatial clusters for illness are primarily located in the South, while poor health clusters are more widespread and extend North. Both variables display fewer spatial outliers, suggesting a more even distribution. Calculated skewness for the change in illness (0.01) and poor health (-0.40) confirms this. While poor health exhibits more noise, indicating greater neighbourhood-level change between Censuses, it is also more dispersed across England.

4.3 Correlation Analysis

Table 4.4 Spearman's correlations for illness and poor health in 2011, 2021, and changes in between

Variables	illness		poor health		illness change	poor health change
	2011	2021	2011	2021		
Economically active	-0.57**	-0.59**	-0.57**	-0.51**	-0.28**	-0.19**
Economically inactive	0.57**	0.59**	0.57**	0.51**	0.28**	0.19**
Professionals	-0.53**	-0.58**	-0.66**	-0.68**	0.08**	0.12**
Intermediates	0.13**	0.06**	-0.15**	-0.08**	-0.17**	0.11**
Working class	0.60**	0.63**	0.76**	0.77**	-0.13**	-0.15**
Low-quality work	0.64**	0.65**	0.70**	0.71**	-0.09**	-0.08**
Higher education	-0.63**	-0.63**	-0.65**	-0.63**	0.23**	0.11**
No qualifications	0.79**	0.62**	0.83**	0.77**	-0.32**	-0.20**
Owner-occupied	-0.14**	-0.22**	-0.46**	-0.41**	-0.14**	0.14**
Private renting	-0.32**	-0.19**	-0.12**	-0.08**	0.26**	0.01
Social renting	0.38**	0.43**	0.62**	0.59**	-0.01**	-0.17**
Lone persons	0.39**	0.50**	0.46**	0.48**	-0.05**	-0.12**
Over 65	0.56**	0.33**	0.16**	0.10**	-0.46**	-0.03**
White	0.23**	0.37**	-0.03**	0.07**	0.14**	0.20**
Bangladeshi	-0.06**	-0.12**	0.08**	0.03**	-0.07**	-0.10**
Chinese	-0.29**	-0.27**	-0.13**	-0.20**	0.16**	-0.03**
Indian	-0.15**	-0.30**	-0.05**	-0.15**	-0.17**	-0.11**
Pakistani	-0.05**	-0.14**	0.08**	0.04**	-0.15**	-0.10**
African	-0.16**	-0.20**	0.06**	0.01**	-0.05**	-0.16**
Caribbean	-0.15**	-0.20**	0.05**	-0.03**	-0.07**	-0.16**
Mixed	-0.27**	-0.32**	0.00**	-0.14**	0.05**	-0.14**
Other	0.23**	0.37**	-0.03**	0.07**	0.14**	0.20**

**p-value<0.05, **p-value<0.01*

Table 4.4 presents Spearman's rank correlations for illness and poor health in 2011, 2021, and the change between these years, with several predictor variables showing significant correlations (p-value<0.01). These predictor variables represent the SDH, social and community networks, and constitutional factors visualised in Rainbow model.

At the SDH layer, economic activity negatively correlates with illness (-0.57) and poor health (-0.57) in 2011, underscoring the importance of employment for health (THF, 2022). Conversely, economic inactivity is linked to higher SRH rates. In 2021, the association between economic inactivity and illness strengthened (-0.59), coinciding with rising economic inactivity during the pandemic, primarily driven by long-term sickness and partly attributed to long-COVID and long NHS waiting times (Kirk-Wade and Harker, 2023). However, the associations between poor health and economic activity weakened, potentially reflecting the positive health impacts of enhanced autonomy and job satisfaction during remote work in the pandemic (Niebuhr et al., 2022).

The intrinsic link between socioeconomic status and health is well-documented and demonstrated in the table (Marmot et al., 1991; Marmot, 2010). Professionals show negative correlations with both SRH variables in both years, while working class individuals display positive correlations, aligning with the socioeconomic health gradient, where health improves with higher socioeconomic status (ibid). These associations strengthen between Censuses, suggesting the gradient has steepened (Marmot, 2020). In 2021, working class populations show stronger associations with poor health (0.77) than professionals (-0.68), aligning with research suggesting that COVID-19 exacerbated the health gradient, particularly in working class communities (Paremoer et al., 2021). However, professionals have a positive correlation with SRH change between Censuses, indicating greater SRH increases compared to working class populations exhibiting negative correlations. This phenomenon may be the allostatic load, whereby stress and socioeconomic disadvantage throughout life can manifest into a range of poor and chronic conditions, independent of adolescent socioeconomic status (Braveman and Gottlieb, 2014).

Low-quality work positively correlates with SRH in both years, although these correlations are relatively weaker compared to other variables. The changes in correlations are minimal, indicating that the impact of low-quality work remained relatively stable over the decade. This modest impact on health outcomes is surprising, as research indicates that remaining unemployed can be better for your health than staying in low-quality work (Chandola and Zhang, 2018; Tinson, 2020).

Higher education is negatively correlated with both SRH variables, whilst no qualifications are positively correlated. This finding is not new, as evidence of this SDH is amongst the most compelling (The Lancet, 2020). However, correlations between education and SRH change between Censuses suggest that neighbourhoods with higher education experience larger increases in illness, whilst areas with no qualifications display improvements. Several factors could contribute to this shift, including criticisms that higher education is not leading to better job prospects or greater income (DfE, 2023). It is also possible that the 2021 Census, recorded during a national lockdown, affected the social connections of students in higher education, which are known to influence health (Bibby, 2017).

Housing tenure plays a vital role in health (Tinson and Clair, 2020; THF, 2023). Neighbourhoods with more social housing are more likely to report both illness and poor health than owner-occupied neighbourhoods. This association has strengthened over time in social rented accommodation, coinciding with increases in overcrowding (Clair, 2021). 8.1% of social rented accommodation was overcrowded in 2021 compared to 5.3% in private and 1.1% in owner-occupied (THF, 2023). Overcrowding can directly and indirectly affect health by increasing distress, relationship breakdowns, infectious diseases, and worsening mental health (Tinson and Clair, 2020; THF, 2023). The increase in overcrowding over the decade in social hosing can be attributed to policy decisions such as the ‘bedroom tax,’ benefit cap, and 63% reduction in capital spending (ibid). These decisions, alongside the long-term neoliberal-induced reduction in social housing stock from 31% in 1980 to 17% in 2018, have made social housing less affordable and accessible, despite increased demand (Tinson and Clair, 2020; NHF, 2021).

At the social and community networks layer, neighbourhoods with more lone persons exhibit heightened illness and poor health. These correlations strengthen in 2021, coinciding with the increase in loneliness during the national lockdown when the 2021 Census was recorded (ONS, 2021).

The constitutional factors yield interesting results. Neighbourhoods with populations over 65 are positively correlated with both SRH variables in both years, with the correlation being stronger in illness. This is expected, as the average neighbourhood percentage of those over 65 increased from 16.64% to 18.92%, and ageing increases the risk of poor health (UNDESA, 2018). However, illness change between Censuses shows a strong negative correlation with those over 65 (-0.46), suggesting that neighbourhoods with increasing elderly populations experienced a decrease in reported illness. This was surprising, given the negative associations between ageing and health, and reports suggesting that the state of ageing in England was worsening (CAB, 2022).

Ethnicity is a complex determinant of health, and the patterns between ethnic groups are notable. White populations showed positive correlations with SRH that increased from 2011 to 2021. Conversely, most ethnic minority groups displayed negative correlations with SRH, indicating reduction in SRH outcomes. The SRH changes between Censuses also point to increases in White populations but reductions in several ethnic minority groups, challenging the common view that ethnic minorities have universally worse health outcomes compared to White groups (CRED, 2021). This contrasts with research that suggested the COVID-19 pandemic disproportionately impacted most ethnic minority groups (Lally, 2020). Nevertheless, it is crucial to recognise variations within ethnic minority groups. For example, Chinese (-0.20) and Indian groups (-0.15), who are more commonly in professional occupations, have stronger associations with poor health in 2021 than Caribbean groups (-0.03), which have disproportionate levels of unemployment (Wood et al., 2023).

4.4 Linear Regression Modelling Analysis

Table 4.5 Final models for illness and poor health, 2011-21

	illness		poor health	
	2011	2021	2011	2021
Constant	9.56***	19.91***	5.23***	-3.50***
Economically active	-0.12***	-0.22***	0.08***	0.11***
Low-quality work	0.08***	0.19***	0.26***	0.13***
No qualifications	0.26***	0.12***	0.17***	-
Private renting	-0.01***	-0.04***	-0.01***	-0.03***
Owner occupied	-	-	-0.12***	-
Lone persons	0.15***	0.19***	0.07***	0.10***
Over 65	0.29***	-	-	-0.04***
Bangladeshi	-	-	-	0.02***
Chinese	-0.24***	-0.04***	-0.24***	-0.10***
Indian	-	-	-	-0.01***
Pakistani	-0.04***	-0.19***	-0.04***	-
African	-0.05***	-0.10***	-	-
Caribbean	0.10***	-	-0.05***	0.02***
Mixed	-0.07***	0.22***	0.10***	-
Other	-	-0.13***	-0.07***	0.03***
R^2	87.08	79.30	80.25	74.16
AIC	137,305.80	101,124.00	147,510.00	105,421.40
Skew	0.12	0.42	0.05	0.43
Mean(VIF)	3.20	2.23	2.68	1.90

**p-value<0.05, **p-value<0.01, ***p-value<0.001*

Table 4.5 presents the final OLS regression models for illness and poor health in 2011 and 2021. The coefficients represent the estimated impact of each variable on SRH, and their significance is indicated by p-values (p-value<0.001), demonstrating their strong predictive power for SRH. These variables encompass the SDH, social and community networks, and constitutional factors visualised in the Rainbow Model.

At the SDH level, economic activity exhibits a negative coefficient with illness for 2011 (-0.12) and 2021 (-0.22), underlying the protective effects of employment on health (THF, 2022). Conversely, economic activity is positively correlated with poor health, indicating that not all employment leads to better health (Tinson, 2020). The association strengthens from 2011 to 2021, aligning with the rise in zero-hours contract work contributing to poorer mental health through feelings of powerlessness and stress (Wilson and McDaid, 2022).

Low-quality work is positively associated with illness, with the coefficient increasing from 0.08 to 0.19, highlighting its role as a risk factor for illness. The doubling in coefficient strength may

reflect the double cost of low-quality work during the pandemic and the inability to work from home, which increased the risk of both infection while working and income loss when jobs were terminated or hours reduced (OECD, 2022). The impact of low-quality work on poor health, however, does not follow the same pattern and declines from 0.26 to 0.13, aligning with declining low-quality work prevalence from 2011 (25.39%) to 2021 (23.61%).

Lacking qualifications is positively associated with illness in both years, aligning with expectations of direct impacts on lower income and indirect impacts on unhealthy behaviours (Zajacova, 2018). The coefficient falls from 0.26 to 0.12, indicating a slightly weaker impact in 2021. There is a positive coefficient for poor health in 2011 (0.17), but none in 2021 since the association was not contributing to poor health model. This is surprising, given the compelling evidence of the link between education and health, and the Spearman's correlation being one of the strongest in 2021 (The Lancet, 2020).

Private renting is negatively associated with illness in both years, but the effect is relatively small. Poor health echoes this pattern, with weak but negative coefficients in both years. The weak relationship between private renting and SRH is surprising as the inadequate supply of social rented accommodation has driven lower income individuals to seek private renting, which tends to be more expensive, less secure, and has 23% of houses not meeting the Decent Home Standard, compared to 10% in social rented accommodation (Tinson and Clair, 2020; Cromarty and Barton, 2022).

At the social and community layer, lone persons show a moderate positive coefficient with illness that increases from 2011 (0.15) to 2021 (0.19). This trend is mirrored, albeit weaker, in poor health. Worsening SRH may reflect the lockdown increasing social isolation and reducing social support networks, thus exacerbating loneliness and in turn damaging health (Czaja et al., 2021; GLA, 2022). However, the results also reflect a change in household composition, with more people living alone than a decade ago (Sharfman and Cobb, 2022).

The constitutional factors demonstrate interesting relationships with SRH. Over 65 has a substantial effect on illness in 2011 (0.29), however, it is omitted in as it did not contribute to the model according to the AIC. In poor health, Over 65 is omitted in 2011, but included in the 2021 model with a weak negative correlation, suggesting elderly populations have less poor health, aligning with the Spearman's rank correlations. In theory, ageing is bad for population health, however, recent analysis demonstrates improvements in the general health of elderly populations since 2011 (Storey, 2023). Furthermore, research suggests that although illness is increasing, people are ageing more healthily and have less social care needs, as they are more able to live independent lives (Raymond et al., 2021).

For the ethnic-related variables, noteworthy patterns emerge. In 2011, all ethnic groups, except for the Caribbean group (0.10), exhibit negative coefficients, implying a potential role in reducing neighbourhood illness. Notably, Chinese groups display the strongest coefficient in 2011, driven by greater proportions of high income, higher education, and professional occupations compared

to other ethnic groups (Raleigh, 2023). However, Chinese coefficients were the weakest in 2021, and there were notable increases in coefficient strength in Pakistani (-0.19), African (-0.10), and Mixed ethnic groups (0.22). During the pandemic, Pakistani and Mixed ethnicities were reported to have higher risks of COVID-19 infection and mortality (PHE, 2020). This is reflected in the Mixed group transforming from a weak negative coefficient to a strong positive one, indicating it is a stronger driver of illness. This abrupt change in Mixed groups may be driven by a change from the highest level of employment to highest level of unemployment among ethnic groups (ONS, 2014; Raleigh, 2023).

The relationship between ethnic variables and poor health demonstrates a shift over time. In, 2011, Chinese (-0.24), Pakistani (-0.04), Caribbean (-0.05), and Other groups (-0.07) exhibit negative coefficients, indicating potential protective effects, while the Mixed group (0.10) displays positive coefficients. However, in 2021, Pakistani and Mixed variables are omitted, while Bangladeshi (0.02) and Indian groups (-0.01) return. Additionally, the Chinese coefficient becomes weaker (-0.10) while the Caribbean (0.02) and Other groups (0.03) transition to positive correlations. The observed shifts in ethnic-related correlations may reflect volatility due to smaller sample sizes that fluctuate over time (ONS, 2014). However, they may also reflect the intricate dynamics at play within ethnic minority populations, warranting further investigation into the underlying factors driving these variations in SRH.

While some of the predictor coefficients are weak on their own, together they can explain between 74.16% to 87.08% of neighbourhood variation in SRH as per the R^2 values. While the R^2 values are weaker in 2021 than 2011, the AIC values are lower, indicating the models provide a better trade-off between model complexity and explanatory power. The skew values are all within the threshold for normality of residuals (-0.5 to 0.5) so no transformations are needed. The Mean(VIF) values are all relatively low, indicating that multicollinearity among predictor variables is not biasing the results (Belsley et al., 2004).

Table 4.6 Final models for illness and poor health change between 2011-21

	illness change	poor health change
Constant	8.38***	2.43***
Economically active	-	-0.02***
Professionals	-0.06***	-0.03***
No qualifications	-0.14***	-0.05***
Lone persons	0.01***	-0.00***
Over 65	-0.19***	0.00***
Bangladesh	-0.07***	-
Chinese	-0.14***	-
Pakistani	-0.09***	-
African	-	-0.04***
Caribbean	-0.27***	-
Other	-	-0.05***
R^2	39.43	10.44
AIC	144,478.20	99,012.42
Skew	-0.06	-0.04
Mean(VIF)	2.07	2.44
**p-value<0.05, **p-value<0.01, ***p-value<0.001*		

Table 4.6 presents the regression models for illness and poor health changes between 2011 and 2021. Again, all variables are statistically significant (p-value<0.001), indicating their strong predictive power.

Economically active shows a weak negative coefficient with poor health change, further demonstrating the protective effects of employment on health. However, this variable is not included in illness change, which is unexcepted, given its strong Spearman's rank correlations for illness change.

Professionals have negative coefficients in both SRH change models, indicating that neighbourhoods with higher percentages of professionals experienced a decrease in SRH between 2011-21. This is in line with literature that highlights the positive health outcomes associated with higher socioeconomic status (Marmot et al., 1991; Marmot, 2010; Marmot et al., 2020). However, it goes against the Spearman's rank association.

No qualifications have negative coefficients in both models, contradicting the commonly observed association between lower education levels and poorer health outcomes (Zajacova, 2018), suggesting a unique trend in this context. The coefficient is stronger with illness, which contradicts the notion that lower educational attainment leads to unhealthy behaviours and ultimately worse health (ibid). However, it aligns with research that suggests education has a large impact on mental health but little effect on physical or more general health (Meriouma, 2021).

Lone persons show a positive coefficient for illness change (0.01), but a negative coefficient (-0.00) for poor health. While interpretations could be made, both coefficients are small and weak, implying other factors play a more substantial role in driving SRH change.

Over 65, on the other hand, exhibits a strong negative coefficient (-0.19) with illness change, indicating ageing populations have experienced lower illness rates over the decade, aligning with some research (Raymond et al., 2021; ONS, 2023). In contrast, the coefficient is positive in poor health and weak (0.00), suggesting age is not an influential factor, as highlighted in the correlation analysis.

The presence of specific ethnic groups has varying impacts on illness and poor health changes between 2011-21. In the illness change model, some ethnic groups, such as Chinese, Pakistani, and African, have negative coefficients, implying a decrease in illness over the decade in neighbourhoods with higher proportions of these groups. In contrast, the presence of Caribbean groups is associated with a substantial increase in illness (-0.27). Caribbean groups were the most at-risk ethnic group for COVID-19 infection and were 1.9 times more likely to die than White British groups (PHE, 2020). In the poor health change model, only African and Other groups have negative coefficients, suggesting a decrease in poor health over time in neighbourhoods with more individuals from these groups. When considering intersectionality theory and evidence in the literature review, the omission of ethnic variables from the poor model suggest that other factors contribute to poor health and the ethnic variation in SRH is likely a reflection of intersecting factors such as deprivation, discrimination, and geography (CRED, 2021).

The R^2 values indicate that these models explain a substantial proportion of variation in illness change (39.43%) and a lower proportion of poor health change (10.44%). The AIC values are relatively high compared to **Table 4.5**, indicating a worse trade-off between predictive power and model complexity. The skew values are close to zero, indicating a normal distribution of residuals. The Mean(VIF) is relatively low, suggesting that multicollinearity among predictor variables is not biasing the results (Belsley et al., 2004).

These results confirm the notion that the determinants of health are complex. With most of the variables in **Table 4.6**, there are varying outcomes that do not necessarily match the strength or direction compared to **Table 4.4** and **Table 4.5**. The different findings, sometimes even with the same variables, highlight the less predictable and more varying nature of SRH change data, as visualised in **Figure 4.3** and in the weaker R^2 values. Therefore, future research, considering a longer time frame, is needed to properly explain the changes in relationships and uncover the causal determinants of health.

4.5 Inequality Measures

Table 4.7 SII and RII results for illness and poor health between 2011-21

Variables	illness				poor health			
	2011		2021		2011		2021	
	SII	RII	SII	RII	SII	RII	SII	RII
Economically active	-0.45	-8.19	-0.35	-4.79	-0.21	-3.77	-0.14	-1.96
Low-quality work	0.34	1.51	0.35	1.58	0.17	0.76	0.18	0.82
No qualifications	0.47	2.06	0.42	1.87	0.23	0.99	0.25	1.11
Lone persons	0.25	1.55	0.29	1.89	0.13	0.84	0.13	0.87
Over 65	0.42	1.72	0.19	0.74	0.06	0.23	0.03	0.11

Table 4.7 presents the SII and RII results for illness and poor health between 2011 and 2021. The variables included are consistently the most important determinants of SRH throughout the dissertation and reflect different layers in the Rainbow model. The table suggests that inequalities are wider in illness than poor health because illness is a broader and more inclusive measure encompassing various health outcomes.

In 2011, economically active had the highest RII in illness (-8.19) and poor health (-3.77) and some of the widest absolute inequalities in SRH between neighbourhoods in England, indicating higher rates in those less economically active. In 2021, both relative and absolute gradients became less pronounced but still highlighted substantial disparity, potentially reflecting the fact that there are more people in work than ever before and spatial disparities in wages and employment rates have fallen (Green, 2020; Overman et al., 2022).

Low-quality work, on the other hand, demonstrates slight intensifications of relative inequalities in illness (1.58) and poor health (0.82) between Censuses. While the rise was only moderate in the SII, the results still indicate that low-quality work is unequally distributed across society, in terms of geography and demography, and concentrated at the lower end of the social gradient (Bell et al., 2004; Tinson, 2020).

In 2011, no qualifications had the largest absolute inequality in illness (0.47) and poor health (0.25), indicating higher rates of SRH in neighbourhoods with higher percentages of no qualifications. The relative inequality underscores this. By 2021, both SII and RII values in illness decreased, reflecting increased access to education that has led to a reduction in no qualifications (Waddington, 2023). However, slight increases in absolute and relative inequalities for poor health challenge these improvements.

Lone persons demonstrated positive SII and RII values for both SRH variables, with a slight increase over the decade. This, alongside the correlation and OLS regression analysis, highlights the serious impact of social isolation on health outcomes, specifically mental well-being, as indicated by the greater values than poor health (LGA, 2020; Czaja et al., 2021).

Over 65 had one of the largest SII (0.42) in 2011, indicating an ageing health gradient in illness. By 2021, the disparities for both SRH variables reduced significantly, suggesting the gradient has flattened, potentially reflecting healthy ageing. The disparities are relatively weak compared to the SDH and social and community networks, suggesting that the wider SDH contribute more to health than constitutional factors, as expressed continually in population health literature (Marmot, 2010; 2020).

5 Conclusion and Recommendations

This dissertation conducted a rigorous analysis of neighbourhood health inequalities in England, utilising data from the 2011 and 2021 Censuses. The research objectives encompassed an exploration of overall neighbourhood health, identification of spatial patterns, investigation into determinants of neighbourhood health, and quantification of health inequalities over time.

The dissertation revealed persistent disparities in SRH among neighbourhoods, underscoring the enduring North-South health divide. Notably, high SRH clusters were evident in post-industrial urban, mining, and coastal neighbourhoods, whilst regions with lower SRH were prevalent around the London commuter belt and the South East. Whilst spatial patterns remained stable, the SRH changes between Census periods exhibited a degree of ambiguity, marked by more pronounced clustering of illness.

The correlation analysis reveals strong links between various SDH, social and community networks, constitutional factors, and SRH. Economic activity emphasised the value of employment for health, yet low-quality work questioned this narrative. Socioeconomic status revealed a SRH gradient, where professionals exhibited lower SRH and working class higher SRH. Education significantly influenced SRH but showed evolving dynamics, with higher education exhibiting increased illness between Censuses. The adverse impacts of social housing and loneliness on SRH increased over time. Populations over 65 witnessed improved SRH between Censuses indicating healthier ageing. Ethnicity demonstrated complex patterns, challenging the notion of universally worse health outcomes among ethnic minorities compared to White groups.

In the OLS LRM analysis, the significance of economic activity, low-quality work, no qualifications, lone persons, and over 65 in predicting SRH is reaffirmed. Moreover, shifts in ethnic-related SRH underscored the diverse and varying experiences of different ethnic groups. The results highlight the value of SRH, the Rainbow model, and keeping the various ethnicities ungrouped. The final models for 2011 and 2021 explain 74.16% to 87.08% of variation in neighbourhood SRH. However, when analysing SRH change between Censuses, typical patterns differ and go against the direction demonstrated in previous correlations and coefficients. These models explained between 10.44% to 39.43% of variation in SRH change. While it is still a substantial amount, it highlights the varying nature of SRH change between Censuses, as visualised in the spatial analysis. All models exhibited statistical significance, normality of residuals and multicollinearity that did not significantly bias the results, underscoring the robustness in the findings.

The absolute and relative inequality measures demonstrated the persistence of health disparities in England from 2011 to 2021.

Considering these findings, a new multi-level governmental national health inequalities strategy that looks beyond planning cycles and political attention spans is essential. Health equity actions of this strategy should be evidence-based, outcomes orientated, systematically applied, scaled up and funded appropriately to need through proportionate universalism. Within this strategy, recommendations to address health inequalities should include:

1. Reforming the health and social care system by:
    a. Introducing statutory definitions of sustainability in health and care.
    b. Prioritising workforce retention through improved conditions and incentives.
    c. Ensuring hospital occupancy targets are closely monitored and met.
    d. Increasing multi-year funding towards prevention and community health building, whilst targeting left-behind neighbourhoods with multiple deprivations (according to the Index of Multiple Deprivation) and high community needs (according to the Community Needs Index).
2. Increasing funding for Research and Development in the North to address national R&D disparities.
3. Devolving power and increasing funding for regional governance (i.e., metro mayors) and restoration of cuts to Local Authorities.
4. Ensuring the Health Inequalities Dashboard is made available at the neighbourhood (LSOA) level.
5. Creating targeted employment strategies that:
    a. Abolish zero-hour contracts, address in-work poverty and ensure all jobs provide security.
    b. Improve job quality, not just quantity, by improving working environments and encouraging in-work progression.
    c. Promoting good quality jobs for local populations through local enterprise partnerships.
    d. Restoring real-terms cuts to public sector employees
6. Improving early child development, education, and skill development by:
    a. Addressing decreases in physical education levels.
    b. Restoring real-term cuts in funding per pupil.
    c. Improving skill base of local and regional labour markets.
    d. Ensuring free school meals for all.
7. Creating healthy and sustainable places to live and work by:
    a. Improving quality and affordability of private housing and increasing the stock of social housing in line with demand.
    b. Restoring austerity-induced cuts to social infrastructure by investing in public transport, active travel, and digital connectivity as well as community assets like parks, pools, and libraries.

Whilst implementing these policies would require substantial financial investments from central government, the moral and societal costs of ill health are even greater. Furthermore, the economic repercussions of lost productivity, tax revenues, and increased expenditure on health-related benefits and ill health, dwarf these upfront costs. The narrative that growth (trickle-down economics) is the sole solution to these issues is simply untrue, as proven for over four decades. Therefore, it is paramount that we build back fairer by investing in the building blocks to a healthy life and prosperous society.

The dissertation is subject to limitations that should be considered. The variables were not age-standardised and SRH may be influenced by cultural differences, social desirability, and relative deprivation making people less likely to rate their health status at the extremes of poor health. The phrasing of the illness-related question changed between Censuses from "health problems or disability" to "physical or mental health conditions or illnesses." Our definition is the same as 2011 to maintain consistency, however, this risks not capturing those with mental health conditions. The 2021 Census was recorded during a national lockdown, resulting in a significant portion of people residing outside their usual place of residence due to travel restrictions (i.e., students and remote workers).

Considering these limitations, future research should aim to:

- Establish the causal factors between the predictor and outcome variables.
- Utilise a mix of objective and subjective health and wellbeing measures with longer time frames (i.e., previous Censuses).
- Incorporate more social and community network factors.
- Investigate budgetary changes at the Local Authority level and their subsequent impact on health to assess the influence on austerity.

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Wirral%20Documents/Reg%2018%20Issues%20and%20Options%202020/Health%20and%20Social/Interim%20Health%20Impact%20Assessment%202019/HS%201.1%20Interim%20Health%20Impact%20Assessment%202019.pdf. Accessed: 17/08/23.

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7 Appendices

7.1 Appendix A – Supplementary Graphics

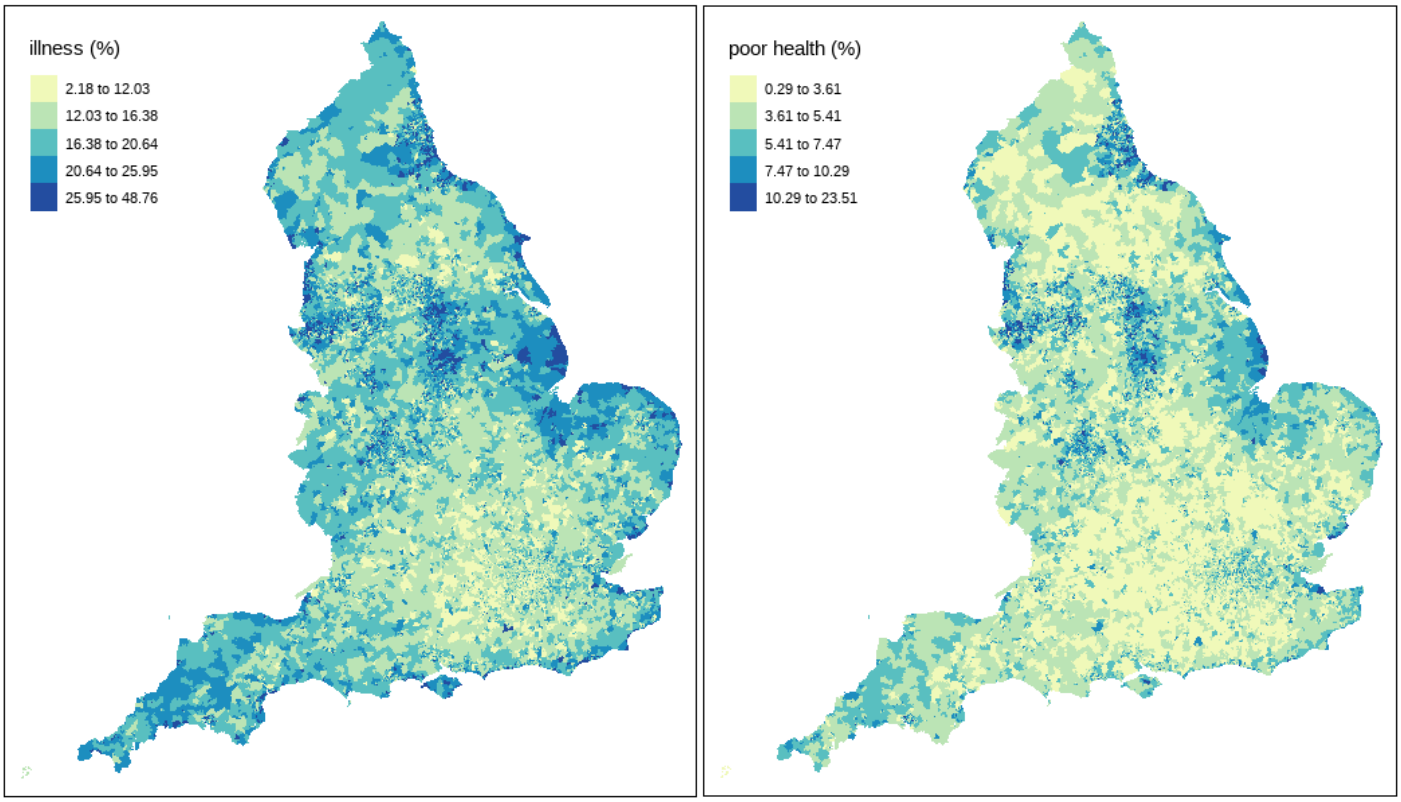

Figure 7.1 Spatial distribution of illness and poor health, 2011

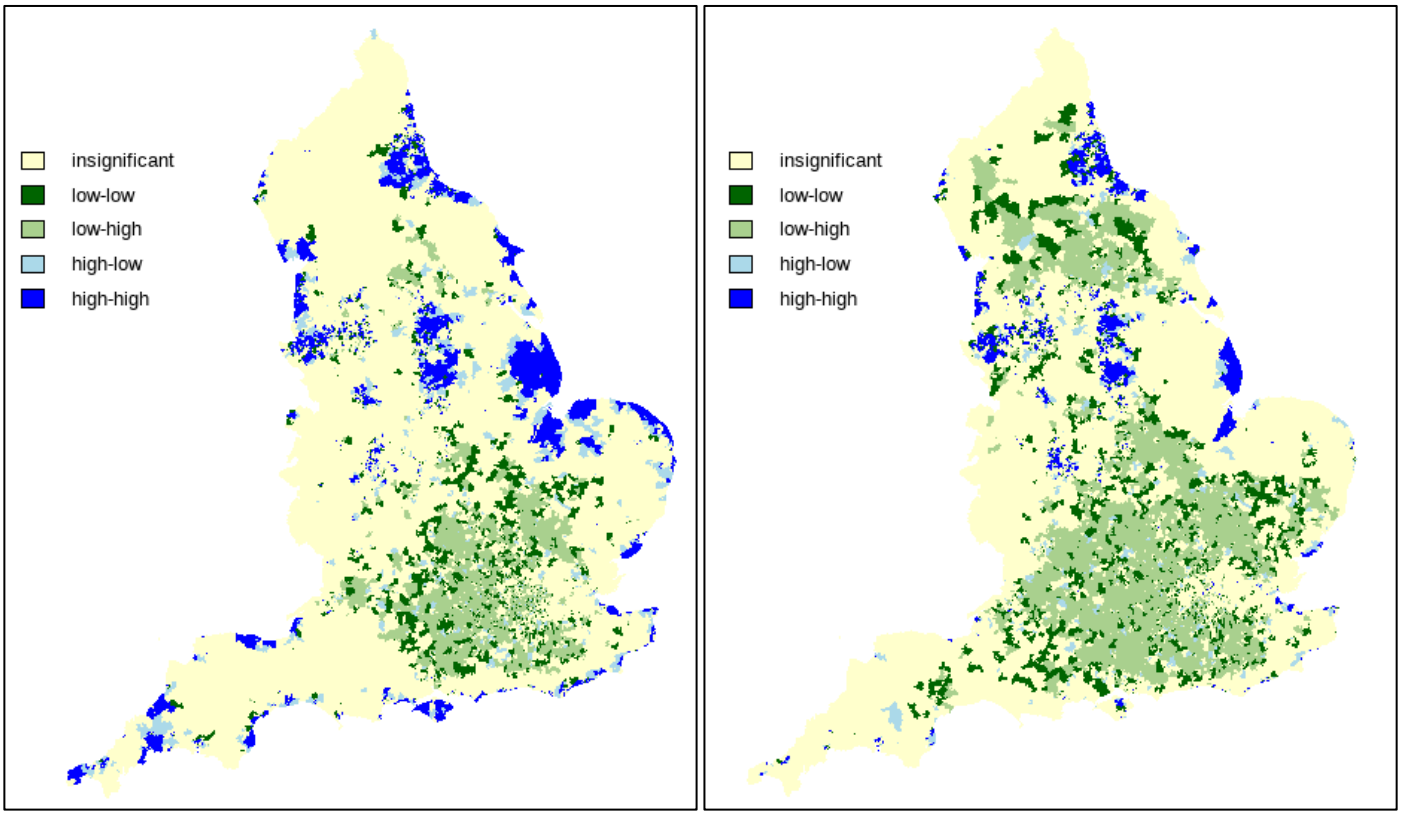

Figure 7.2 Local Moran's I for illness (left) and poor health (right), 2011

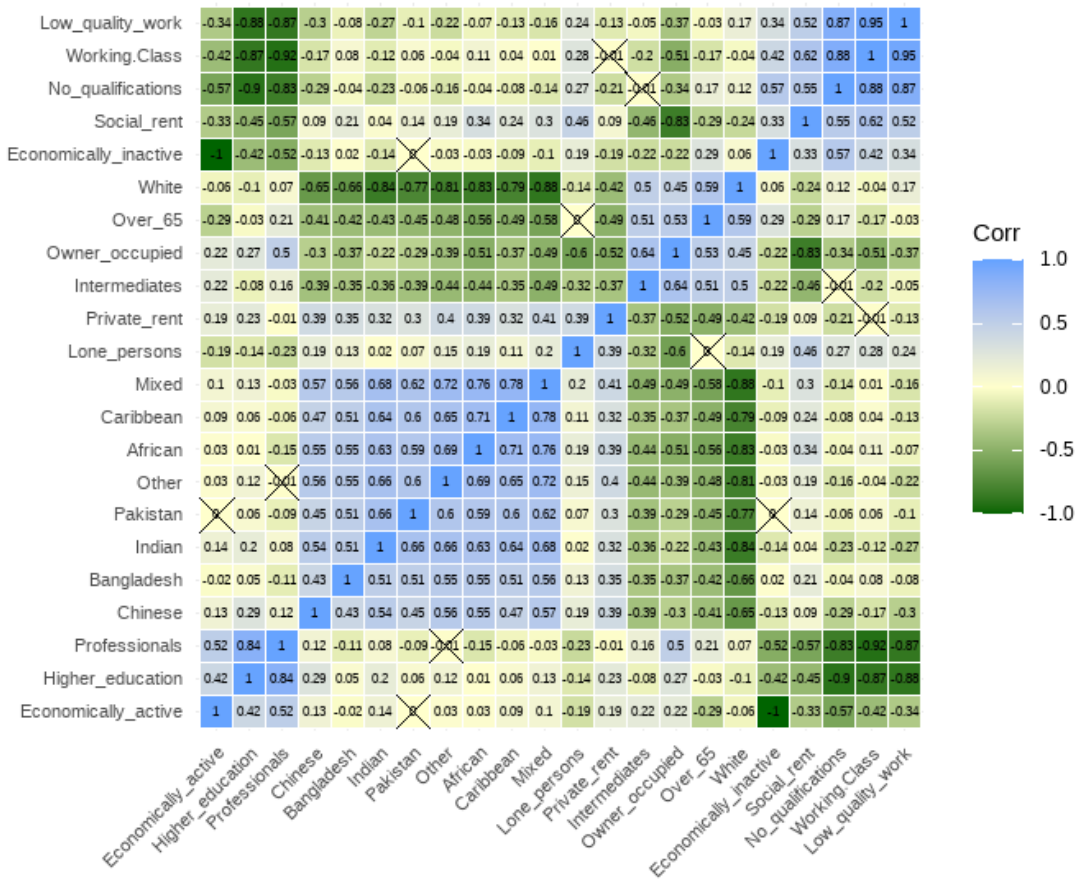

Figure 7.3 Correlation matrix for predictor variables, 2011

7.2 Appendix B – Predictor variable definitions

Table 7.1 Variable definitions

Variable Name	% of neighbourhood residents who report:
illness	long-term (over 12 months) health problem or disability that limits daily activities ‘a lot’ or ‘a little’
poor health	‘bad’ and ‘very bad’ general health
Economically active	Working-age employees
Economically inactive	Working-age unemployed
Professionals	Combines employer, higher manager, and higher professional categories
Intermediates	Intermediate occupations, Small employers, and own account workers, and Lower supervisory and technical occupations
Working class	Semi-routine and routine occupations as well as those who have never work or are long-term unemployed
Low-quality work	Semi-routine and routine occupations
Higher education	
No qualifications	Working age residents with no qualifications
Owner-occupied	Households that are owned outright, mortgaged, and shared ownership and living rent free
Private renting	Four private rented categories
Social renting	Both social rented categories
Lone persons	One-person households
Over 65	All those aged 65+
White	All White ethnic groups
Bangladeshi	Bangladeshi ethnic groups
Chinese	Chinese ethnic groups
Indian	Indian ethnic groups
Pakistani	Pakistani ethnic groups
African	African ethnic groups
Caribbean	Caribbean ethnic groups
Mixed	Mixed ethnic groups
Other	All Other Ethnicities