

Inequalities in life expectancy

Changes over time and
implications for policy

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Background to this report

- Our health as individuals, and as communities, is influenced by many factors – our family background, our lifestyles, the health and other services we receive and the wider physical, social and economic environment in which we are raised, live and work.
- *Fair society, healthy lives*, more widely known as ‘The Marmot Review’ after its author Professor Sir Michael Marmot, has been highly influential in debate on health inequalities policy since its 2010 publication, especially among local authorities and health and wellbeing boards. One of the iconic charts in the review, referred to below as ‘the Marmot curve’, shows how life expectancy and disability-free life expectancy are systematically and consistently related to differences in income deprivation across thousands of small areas in England.
- In this report we draw on and test some of the insights of the Marmot curve. We revisit, update and explore the implications of ‘peering behind’ the curve and extend the analysis beyond the curve for policy, practice and research. In doing so, we review previous research on explanations for health inequalities and bring together a unique collation of data on 6,700 areas of England to explore how life expectancy is changing over time and why.

In particular,

- we update the curve from the 1999–2003 data that underpins it to a new analysis based on 2006–10 data
- we include income deprivation in a wider regression analysis using the 2006–10 data, which includes other wider determinants of health, lifestyles and indicators of services to understand the contribution of all these factors to life expectancy – this is the first time we are aware of that this has been done with data at this level of analysis
- we further analyse those areas with persistently low or high life expectancy over both periods (1999–2003 and 2006–10), and attempt to identify factors behind this with our wider dataset from 2006–10.



Key findings

- The social gradient in life expectancy improved between 1999–2003 and 2006–10. In short, income-related inequalities in life expectancy improved. Marmot’s goal – ‘to shift the gradient’ – happened.
- Some factors are shown to be consistently important in explaining life expectancy differences between areas, in particular unemployment, deprivation among older people and gender. But there is support for a range of factors that impact on life expectancy including lifestyles.
- We identify areas that have persistently poor or good life expectancy over time. In particular, where there is higher deprivation among older people, unemployment, housing deprivation and binge drinking, these factors all increase the risks of those areas having persistently low life expectancy over time.

In the report, we set out the policy and practice implications of our findings.

- We review the policies and evaluative studies of inequalities in health over the first years of the 21st century. Our findings call for a much more thorough analysis and learning from the Labour government’s approach to health inequalities policy and a greater understanding of the impacts of the wider social and economic circumstances of that time.
- In the 2000s the NHS was clearly focused on reducing inequalities. Access to key treatments – including to treatments that the Department of Health assessed would reduce inequalities in life expectancy – improved for more deprived patients. Although the then Labour government’s specific targets on health inequalities were not met, it is likely that the actions underpinning them contributed to the Marmot curve becoming shallower.
- However, during this time there were also changes in the wider determinants of health and in our lifestyles. For instance, rates of child and pensioner poverty fell considerably and there were also large improvements in the quality of housing, particularly in the socially rented sector, and differences in unemployment rates between areas reduced in the late 1990s until the late 2000s recession.



- Having looked at a wide range of characteristics and behaviours, we believe our findings, read alongside other research, show that unemployment and older people's deprivation play a particularly important role in determining differences between areas in life expectancy.
- There consequently needs to be a much more nuanced and integrated policy response to inequalities in health than is currently the case. There are some early signs of this integrated approach, for example in the *NHS five year forward view* ([NHS England et al 2014](#)) and its emphasis on prevention, and potentially through the 'Devo Manc' deal. Beyond this, we argue for a more coherent approach to inequalities in health delivered through population health systems that more strongly integrate NHS services with other public services and approaches to public health, with the aim of reducing inequalities at their heart.
- Austerity, and, as importantly, the policy reaction to it, will have consequences for health inequalities. Our previous research showed that poorer groups were not sharing the improvements in lifestyles that wealthier groups were enjoying. In this research we show how employment, housing and older people's deprivation all help to explain health inequalities, and how some areas persistently do worse than others. This means that the NHS and wider government policy need to refocus on inequalities in health, if some of the positive findings that happened over the 2000s are not to be lost.
- Some places and parts of the country seem to do better or worse than our general analysis predicts. The impact of 'place' is complex and multidimensional, and requires further and deeper analysis. Clearly, however, how policies are translated at area and community level therefore needs to take into account the local knowledge, history and experience that no high-level analysis can provide.



1 Introduction

It is widely accepted that our health is influenced and determined by more than our genetics or our access to health care. More important influences than either of these are our lifestyle behaviours and the wider determinants of our health – the physical, social and economic conditions in which we are born, raised and live. These also help to explain systematic inequalities in health between different groups, whether defined by gender, age, socio-economic class, income, ethnicity or other characteristics. That is not to say that access to health care is not important – indeed access to the *right* health care at the *right* time, for example for hypertension and cholesterol control for those at high risk of cardiovascular disease, is probably the single quickest thing that can be done to reduce inequalities in health. But getting the delivery of health care right will not on its own solve England's inequality problem.

Recognition of these facts partly explains why local authorities were given a greater responsibility for public health in the coalition government's reforms. Michael Marmot's independent review, *Fair society, healthy lives* ([The Marmot Team 2010](#)) commissioned by the last Labour government and broadly accepted by the coalition, has been very influential in reinforcing that recognition.

Fair society, healthy lives itself ran to more than 200 pages. Behind it was a further raft of reviews and papers, but perhaps what epitomised its conclusions so influentially was what we shall refer to here as the 'Marmot curve', a figure that shows the relationship between an area's income deprivation level and its life expectancy and disability-free life expectancy. Put simply, richer areas have better health on average, at *every* level of income. *Fair society, healthy lives* used this point to argue that inequalities in health affect all communities systematically across society – it is not just a problem of poor people or places.

This paper uses the insight of the Marmot curve and review as its inspiration and departure point. We revisit the curve, update it and 'peer behind' it, drawing conclusions for further analysis, practice and policy along the way. In particular, we make use of a unique collation of data on 6,700 English areas to look in more detail



at the drivers of our life expectancy and why some areas seem to do particularly poorly or well over time.

The report is organised as follows. The next section sets out recent thinking and evidence on what determines our health, as individuals and as communities, and how this translates into inequalities in health. Informed by this, we outline our research questions in section three, followed by our data and methodology in section four. Section five sets out our main results, while the subsequent sections explore the wider discussion and implications of these.



2 What determines our health?

On one level, our health at community level is simply the aggregation of our health as individuals. But increasingly we have come to understand that where we live, how we live and the social and economic conditions around us contribute to our health, as do our own personal characteristics and choices.

What determines our health as individuals?

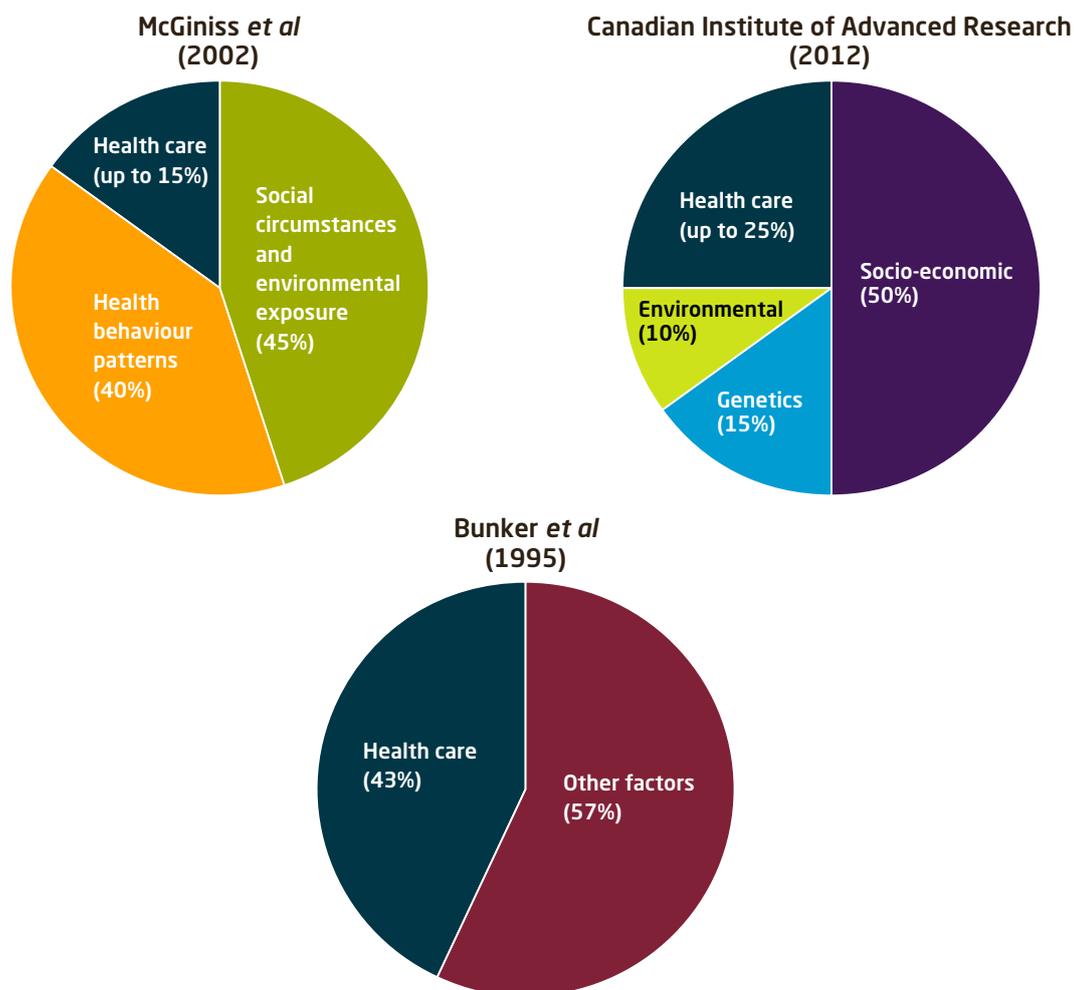
A century or more of study has established that many factors affect how long and how well we live. As early as 1845 Engels reported on the impact of housing on mortality (Engels 1845). In the same period, the Poor Law Commissioners presented evidence on the ‘pestilential places the industrious poor are obliged to take their abode’ and gave figures on the ‘final results of that suffering’ (Goldblatt and Whitehead 2000).

Yet there is no gold standard estimate of how far our health is determined by each of these factors. Most studies, despite differences in theory, data and methodology, agree that the contribution of health care, although important, is responsible for less than half of our health. The biggest contributor is the wide bundle of factors wrapped up in the phrase ‘the wider determinants of health’, those factors that are not health care, behaviours or genetics.

Figure 1 gives details of three of these studies, although there are others. Interpreting and translating these studies, from North America and in the context of a different welfare system, is not straightforward. That is why we need more studies of this kind in the United Kingdom, and within our separate nations. These studies are also usually backward-looking – about what has happened, rather than what could happen. This is particularly true for the potential ‘compensatory effect’ of health care. Most evidence, rightly in our view, suggests the wider determinants are the prime causes of health, but health care could have more impact on our health than it does presently. This compensatory effect could be delivered through systematic

and scaled-up intervention, even given the wider determinants have generated high levels of risk of, or actual, poor health. The Bunker *et al* (1995) study results presented in Figure 1 show a large impact for health care, because its methodology showed what is possible, if all health care that was effective was implemented. This is important, because often studies can be used as an excuse for why it is ‘too difficult’ to tackle population health or inequalities through the health care system (see Bentley 2008 for more on this).

Figure 1 Estimates of the relative contribution of factors to our health



Source: The King's Fund 2013



Beyond these relatively few meta-level studies, there are hundreds if not thousands of research papers looking at the contribution of specific factors. Much of this work looks at the relative contribution of lifestyle factors to health, usually defined as risk of disease or mortality. For example, the latest Global Burdens of Disease study for the United Kingdom shows that the leading causes of life-years lived with disability are tobacco, high blood pressure and a high body mass index, accounting for around 30 per cent of all disability-adjusted life years lost (DALYs) (Murray *et al* 2013). Since many of these lifestyle factors are associated with income, social class, education or deprivation and in fact cluster together in the population (Buck and Frosini 2012), many, including Marmot, see these as only the proxy causes – these wider factors are the ‘causes of the causes’ and therefore should be the focus for stronger policy action. Much of this literature was reviewed for the work behind *Fair society, healthy lives*, which also assesses other factors in our wider environment that impact on health, such as stress in the workplace, early life experience, educational attainment, transport systems and housing.

What determines our health as communities?

There is a growing recognition that where we live, and who we live with, affects our health over and above our own individual circumstances. We know that social relationships, norms and networks – and the absence of them – have an impact on the development of and recovery from health problems such as heart disease (Kim *et al* 2014). They also affect whether we take up and maintain unhealthy behaviours such as smoking (Folland 2008). Our *Improving the public’s health* publication (Buck and Gregory 2013) reviewed related work, including the corrosive effect of the lack of community and networks on the health of older people – a bigger risk factor for health for this group than either moderate tobacco smoking or obesity. These effects operate through various mechanisms but essentially they are all about the cues we take from others, how we respond to the social norms of those around us and the powerful effects of the social networks that we belong to. This can lead to very localised health behaviours and wider health outcomes, both good and bad.

There is also a long and rich tradition of community development and community engagement that has sought to empower local communities to take control over the factors that determine their health (South 2015). The US Institute of Medicine has argued that the capability, capacity and motivation to work together to take



action on health is both a process leading to improvements in the determinants of health and an outcome in itself (Hibbard and Gilbert 2014; Wallerstein 2002). A recent systematic review (O'Mara-Eves *et al* 2013) suggests that there is some evidence that community development approaches that improve social inequalities also improve health behaviours, and by extension inequalities in health. *Fair society, healthy lives* also reviewed and assessed the ways that community-level intervention can improve health (The Marmot Team 2010, pp 136–38).

The influence of community is likely to partly explain the evident differential experience of health at regional, city and local level. Much of this has focused on the north–south divide within England and the comparable experience of certain cities, especially Glasgow. The most recent study, *Due north* (Whitehead 2014) commissioned by Public Health England, confirms that health across the north is worse than levels of income deprivation alone would predict. Doran *et al* (2006) have found similar results at the level of local authorities and there has been an awareness for many years that at city-level, Glasgow's residents suffer poorer health than matched cities in the north of England and other parts of Europe. There is a wide literature on place effects on other measures of health, illness and disease (*see* Griffiths and Fitzpatrick 2002, chapter 13 in particular).

As we seek to understand health at smaller levels of geography, measurement issues start to become more important. Consider, for instance, effects seen at the level of middle layer super output area (MSOA) – a level of geography that the Office for National Statistics use to improve reporting of statistics of small areas; MSOAs have populations of around 7,200 people on average, although sometimes as small as 5,000. Population flows across boundaries due to commuting into and out of cities, for example, can have important effects on measured levels of residents' health. Parts of East London, for example, while generally poor and with large numbers of council tenants and economic inactivity, also have large numbers of relatively wealthy, young professional residents who cannot afford to live in more expensive parts of London, which obviously affects mortality, life expectancy and other measures of health measured at low levels of geography.

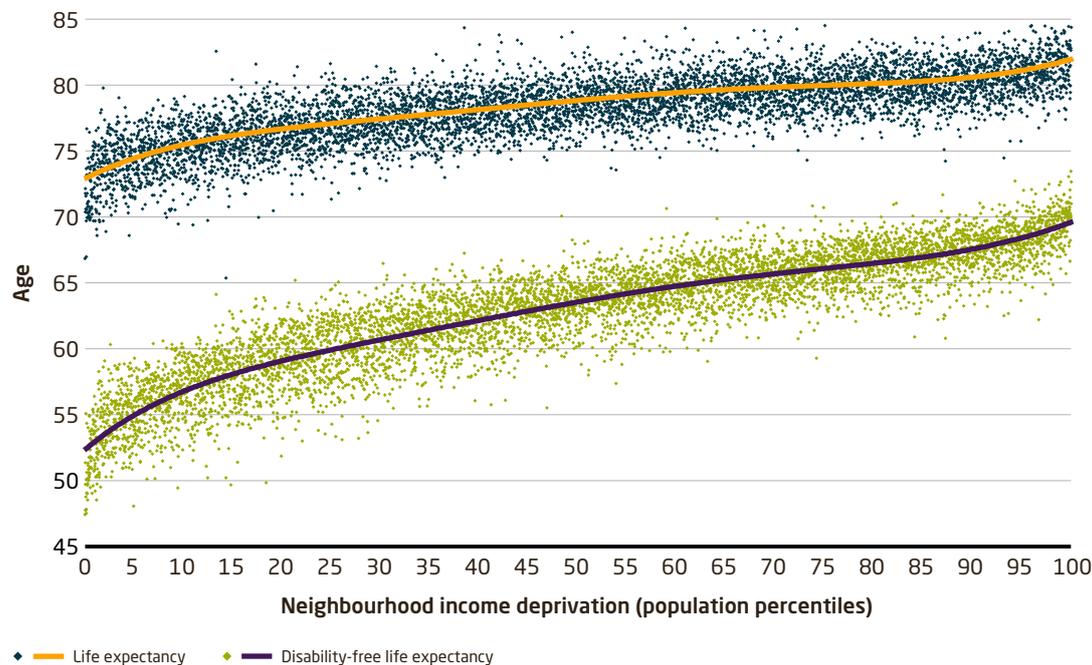


Why are inequalities in health important?

On one level inequalities in health between certain people or groups is simply the expression of how the determinants of health play out for individuals. If these differences in determinants were both randomly distributed and unavoidable or were clearly freely chosen, then health policy might not be concerned about inequalities in health per se.

In fact, it is overwhelmingly clear that much of what drives measured inequalities in health is neither random nor unavoidable, nor are they clearly chosen. The Marmot curve shows this indisputably (Figure 2), plotting life expectancy (LE) and disability-free life expectancy (DFLE) at MSOA level against the income deprivation level of the area (on the x-axis) over the period 1999–2003.

Figure 2 The 'Marmot curve'



Source: [Bernstein et al 2010](#)

Note: The original figure was first published in an independent review for government in early 2010, supported by the *Fair society, healthy lives* team.



Fair society, healthy lives draws three important messages from this figure. The first is that the average life expectancy in the poorest communities is seven years lower than in the wealthiest and disability-free life expectancy is 17 years lower. This implies a double-whammy of a shorter life, lived with a much longer period of poorer health. Second, the level of an area's health is systematically affected by income deprivation; this is the 'social gradient in health', meaning that even areas with relatively high incomes are affected by this relationship. Inequalities in health are therefore a problem for all areas, not just those that are very poor. However, the gradient, although smooth among much of its length, does steepen at the extremes indicating that particularly low or particularly high income deprivation is associated with even greater effects on health.

What drives inequalities in health?

There are myriad examples of other systematic inequalities in health, analysed by geography, class, gender, ethnicity and other factors. For example, if you happen to be female and live within the borders of NHS Guildford and Waverley in Surrey you will – on average – have 20 more years of healthy life than if you happen to be male and live within the borders of NHS Bradford ([Office for National Statistics 2014](#)).

How such inequalities in health come about, and what to do in response, is therefore one of the most pressing public health policy questions for any government. There is a long and distinguished body of academic literature on these questions, summarised initially by the Black Report ([Department of Health and Social Security 1980](#)) stretching through the Acheson Report ([Acheson 1998](#)) to *Fair society, healthy lives* itself. More recently, McCartney *et al* (2013) revisit and summarise this literature.

There are differing views on mechanisms. What are coined 'structural explanations' largely assert that it is the socio-economic circumstances of different groups, be that income, wealth or power, that ultimately cause inequalities in health. In contrast, behavioural theories see differences in lifestyles as the main cause of inequalities, with various claims for what is the 'top killer' or 'leading cause of inequality in health'. Some argue that there are cultural reasons for inequalities in health stemming from 'dependency cultures', which are inter-generational. This suggests wider problems linked to health can therefore be perpetuated through time in some groups and places, even when wider conditions become more favourable. There are also competing selection hypotheses which posit that rather than social status



defining health, poor health leads to changes in social status. Put simply, those theories suggest that the strongest, fittest and healthiest get to the top in the social hierarchy, rather than vice versa.

Added to the theories above, but often neglected in academic discourse, is the impact of the practical delivery of health and wider public services. For example, analytical work by the Department of Health showed that if a range of basic health care and preventive interventions were delivered systematically at scale, inequalities in life expectancy could be narrowed by 10 per cent between the ‘spearheads’ – those local authority areas that were the focus of the last Labour government’s health inequalities targets – and England as a whole. These interventions, including blood pressure and cholesterol control, and smoking cessation support, were set out in a Health Inequalities Intervention Tool¹ and other guidance ([Department of Health 2008](#)) on the role of the NHS in systematically reducing inequalities.

Beyond health care, the delivery of wider public services and amenities also have the potential to reduce inequalities in health. The new role of local authorities in public health provides a fresh impetus for this, given their renewed responsibility and influence over many of the wider determinants of health ([Public Health England and UCL Institute for Health Equity 2014](#); [Buck and Gregory 2013](#)).

Decisions made across the whole span of central government have a profound impact on the population’s health (Stuckler *et al* 2010) – as does the NHS through its huge economic and employment impact in every local economy, regardless of its delivery of care and prevention ([Buck and Jabbal 2014](#)). Finally, the emerging studies from neuroscience and neuropsychology on how poverty affects our cognitive abilities and reduces ‘bandwidth’ start to explain why the poorer you are, the harder it is to make what seem to be rational decisions over healthy behaviour and other decisions that affect our health ([Marteau and Hall 2013](#); Mullainathan and Shafir 2013). Clearly, wider government policy design has a role to play in these areas too.

¹ This tool was first produced by the London Health Observatory for the Department of Health. It is now hosted by Public Health England’s London Knowledge and Intelligence Team. See [London Knowledge and Intelligence Team, Public Health England \(2011\)](#).



3 Research questions and approach to analysis

The data on which the Marmot curve is based is now old. We have therefore updated the data for the years 2006–10 and assessed how the relationship between health and income deprivation has changed over time.² As we also have data for life expectancy for 1999–2003, we also assess whether some areas are persistently doing poorly over time, or indeed persistently doing well, and whether these are different from the rest in terms of their characteristics.

It is clear from our review that the debate over what determines inequalities in health, and how that is measured and assessed, is strongly contested, diverse and, by its very nature, highly political. This helps to explain why the studies in Figure 1 come to different conclusions on the relative contribution of different factors in explaining our health and, by extension, the inequalities in its distribution. The Marmot Review, of course, never claimed that area income deprivation was the single cause of inequalities in health – it was used as an indicator of the social characteristics of each local area. *Fair society, healthy lives* ranged far and wide in terms of analysing the wider determinants of health and incorporated them into a framework for action. However, it was beyond its remit to analyse the relative contributions of different factors to inequalities in health. We seek to do this here by collating a unique series of data with proxies for many of the factors discussed in section 2, and to test whether some are more strongly related to inequalities in health than others. Finally, we look at what may help to explain persistently high or low levels of health in areas over time.

Throughout, our approach to analysis is deliberately pragmatic. We explicitly do not test any particular theory in isolation but seek to understand how some of the key components from the insights of the previous section may help to answer our research questions below. We believe that no single theory can explain all the

² Although the Office for National Statistics uses and publishes the relevant updated data, it is not in the format of the Marmot curve. See [Office for National Statistics \(2015b\)](#).



complexities of inequalities in health, but many are useful in highlighting the prime causes and relationships and, by extension, the policies and practice that are chosen to tackle them. Overall, we therefore seek to ‘let the data speak’ and point to which of the components seem to be most relevant and influential on health.

In summary, our key research questions are:

- What does the updated Marmot curve now look like and how has it changed over time? What does this tell us about inequalities in health in England over the first 10 years of the 21st century?
- What factors, in addition to income deprivation, help to explain differences in life expectancy between areas? Are they as important as income, or even more important?
- Are there any common features among areas that have persistently low or high life expectancy over time, and does this differentiate them from other communities?

We go on to discuss our findings before setting out the policy and practice implications.



4 Data

The Marmot curve is iconic partly because of its use of data on thousands of small communities based on 6,700 areas in England, defined by MSOAs in 2001, as opposed to higher levels of aggregation, such as local authorities, which earlier studies had used.

Our analysis also uses MSA-level data so that we can replicate, update and explore the Marmot curve further. However, following the 2011 Census, the boundaries of some of these MSAs have changed. In order to replicate, update and allow direct comparison between time periods we have therefore had to manipulate some of the data. Our replication of the original Marmot curve in the next section therefore uses the geography of the 2011 Census in order to allow us to compare change over time. A full description of our transformations is available on request.

In order to address our research questions we collated a unique dataset at MSA level representing factors theoretically linked to life expectancy. Our selection is pragmatic, driven by both availability and representativeness, and it ranges from demographics and population structure to the wider determinants of health such as housing, education, lifestyles and proxies for the quality of and access to public services. Since ‘place’ and community effects have been found in several studies, especially at smaller levels of geography, we also included various variables on ‘place’ in our analysis.

Our set of variables (Table 1) refers only to life expectancy. Although the Office for National Statistics (ONS) released tables of disability-free life expectancy in March 2015, they did not include any updated data at MSA level.³

We believe our variable set is a balanced one, which reflects many of the leading theories of the generation of inequalities. Some of the variables are relatively novel, including some we have transformed, and others we use are not commonly seen in studies of this sort, such as Wellbeing Acorn types used as proxies for behaviour. See Annex A for full details, definitions and sources.

³ The ONS released tables of DFLE (alongside healthy life expectancy and LE) data at various levels of geography in March 2015. However, this did not include updated DFLE MSA-level data. See Office for National Statistics (2015b).



Table 1 Our data

| | Time period | | Source |
|---|-------------|---------|----------------------------------|
| Health outcomes | | | |
| Life expectancy | 1999–2003 | 2006–10 | Public Health England 2014 |
| Disability-free life expectancy (DFLE) | 1999–2003 | n.a. | Olatunde <i>et al</i> 2010 |
| Demography (all variables captured as a percentage of the area population) | | | |
| Black minority ethnic (BME) status, non-British white | | 2006–10 | 2011 Census |
| GCSE achievement (5 or more C+ grades) | | 2006–10 | Department of Education |
| Gender (male) | | 2006–10 | 2011 Census |
| Pensioners living alone | | 2006–10 | 2011 Census |
| Population | | 2006–10 | 2011 Census |
| Behaviour | | | |
| Percentage who smoke | | 2006–10 | Wellbeing Acorn data |
| Percentage who consume five or more portions of fruit and vegetables daily | | 2006–10 | Wellbeing Acorn data |
| Percentage who binge drink | | 2006–10 | Wellbeing Acorn data |
| Deprivation indices | | | |
| Income | 1999–2003 | 2006–10 | Gov.uk website |
| Housing | 1999–2003 | 2006–10 | Gov.uk website |
| Air quality | 1999–2003 | 2006–10 | Gov.uk website |
| Employment | 1999–2003 | 2006–10 | Gov.uk website |
| Older people's | 1999–2003 | 2006–10 | Gov.uk website |
| Children's | 1999–2003 | 2006–10 | Gov.uk website |
| Access to services (binary variables) | | | |
| Area within 1.6 miles of a GP surgery | | 2006–10 | Gov.uk website |
| Area within 1.4 miles of 'other' services | | 2006–10 | Gov.uk website |
| Geography (binary variables) | | | |
| Area within a major city? | 1999–2003 | 2006–10 | ONS (derived by The King's Fund) |
| Area within a major city's travel to work area? | 1999–2003 | 2006–10 | ONS (derived by The King's Fund) |

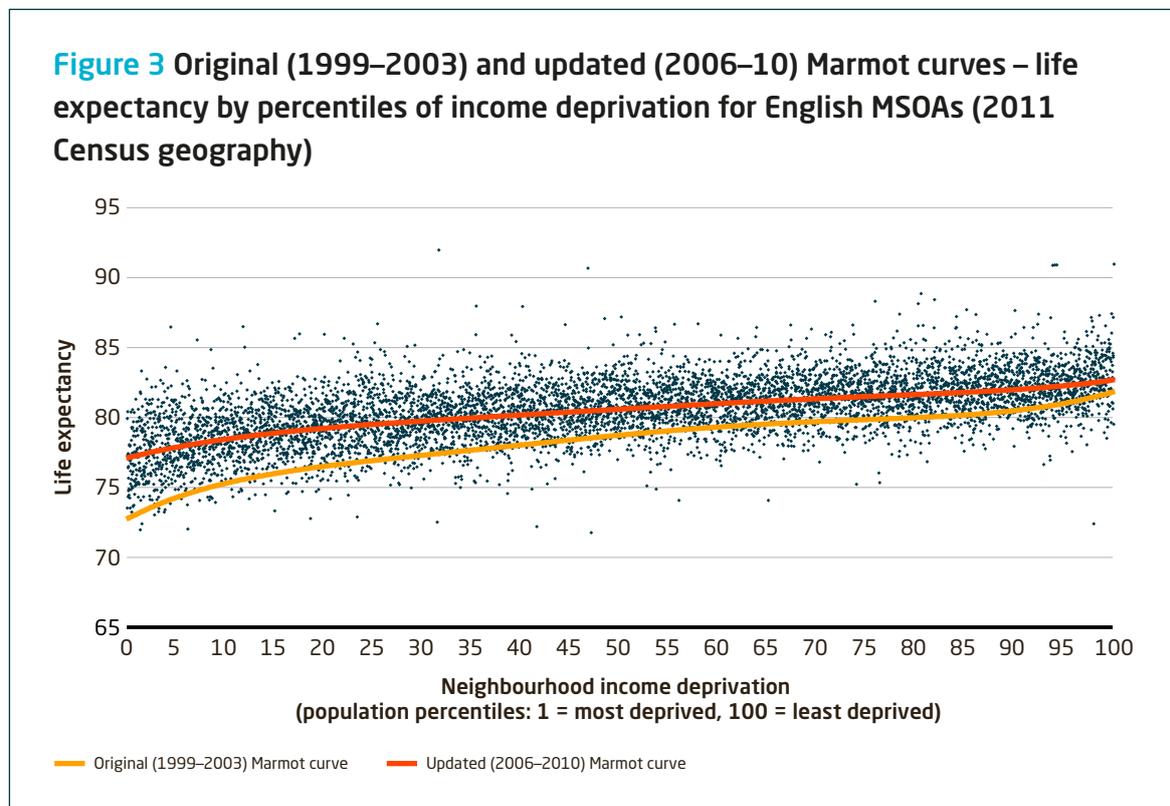


5 Findings

Here we set out our main findings based on the three research themes posed above. Each is based on a specific methodology, the basics of which are also outlined in this section. A detailed methodology is presented in Annex D.

How has the Marmot curve changed over time?

Our first task was to redraw the original Marmot curve, with MSOAs based on 2011 boundaries. Figure 3 shows the original 1999–2003 Marmot life expectancy curves with MSOAs based on updated 2011 boundaries and income deprivation data for the original curve. The red line shows the same relationship with 2006–10 life expectancy and 2010 income deprivation figures.





There are two obvious findings from this. The first is that the curve has shifted upwards over time. This in itself is not surprising, given the overall improvements in life expectancy across England that occurred in the population between 1999–2003 and 2006–10. Second, and more significantly, the curve has not shifted equally across its length. Rather it has pivoted upward from an anchor point towards the right, and the gradient, or slope, is undoubtedly shallower. More specifically, the difference in life expectancy between the bottom 10 per cent of areas and the top 10 per cent fell from 6.9 years in 1999–2003 to 4.4 years in 2006–10. These findings signify that income inequalities in health seem to have improved overall over time (the gradient is shallower along its length) and this effect is more marked for poorer communities. We return to the significance of this and what it may tell us about health inequalities policies of the past, and for the future, in the discussion in sections 6 and 7.

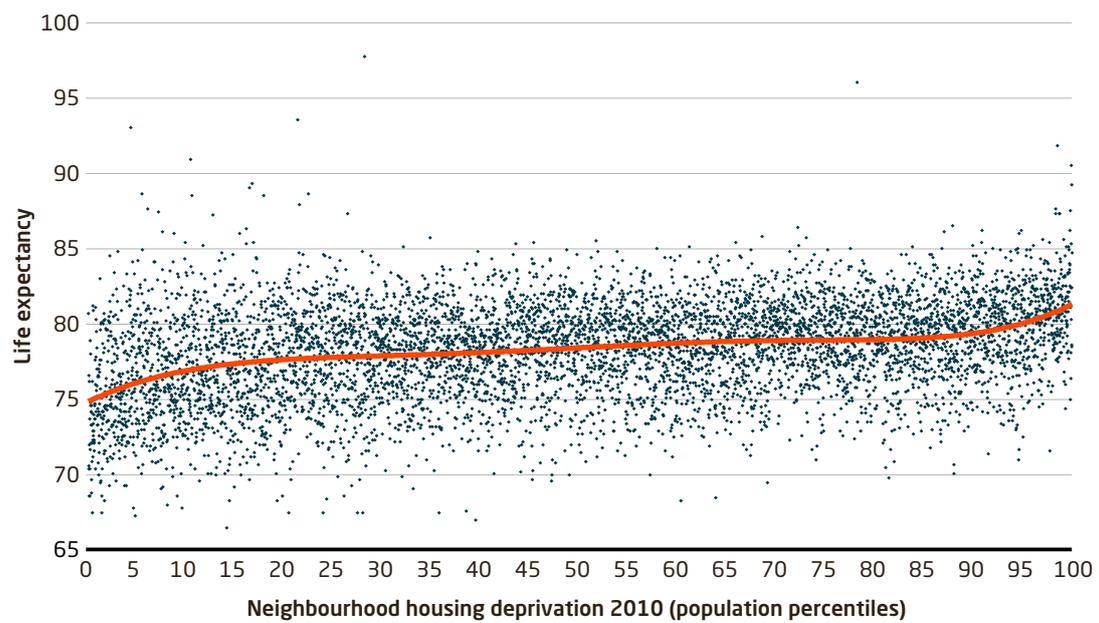
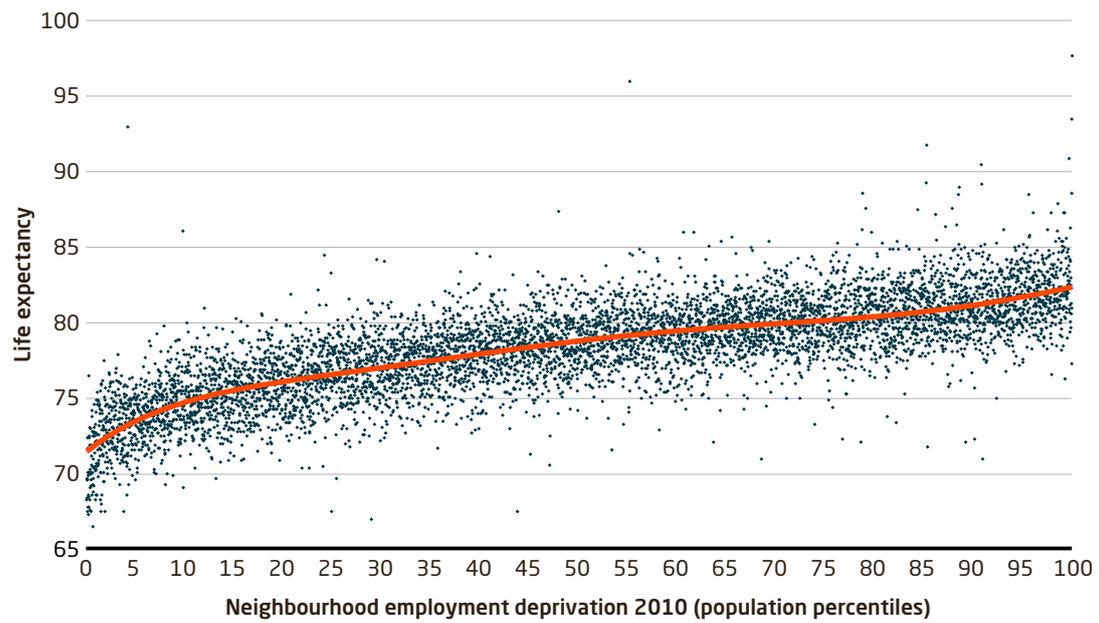
What explains the life expectancy of areas?

We can draw the Marmot curve for other variables as well as income deprivation. Figure 4 shows a range of curves for other wider determinants in 2006–10, for unemployment and housing, and for children’s and older people’s deprivation. Unsurprisingly, given our review of what explains inequalities in health, these charts exhibit the same general pattern as with income deprivation – a generally upwards sloping curve from left to right.

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Figure 4 Life expectancy by percentiles of employment deprivation, housing deprivation, older people’s deprivation and children’s deprivation for English MSOAs 2006–10

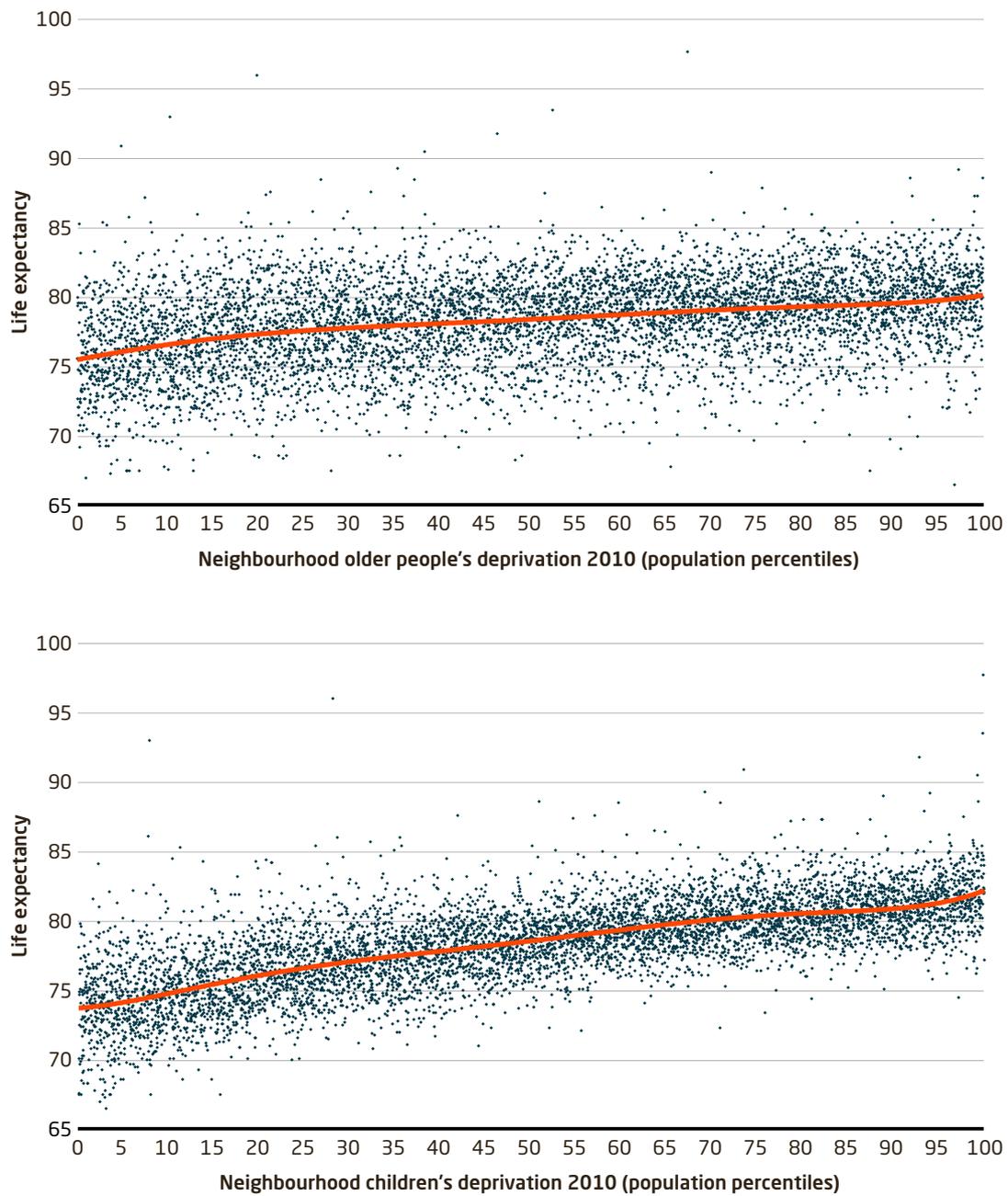


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Figure 4 Life expectancy by percentiles of employment deprivation, housing deprivation, older people’s deprivation and children’s deprivation for English MSOAs 2006–10 *continued*





We could draw similar curves for all of the variables in Table 1 (their equivalents for 1999–2003 are in Annex B). Looking at each of them separately, while informative, does not give us any sense of their *relative* contribution to inequalities in life expectancy.

So we set out to explore this aspect using multiple regression analysis and found support for the impact of wider determinants and lifestyles.

Our main results are set out in Table 2, which is our final model after removing all insignificant variables. The full details of our analysis and wider methodology can be found in Annex D and definitions of these variables in Annex A.

We have grouped our variables according to how they relate to the theories of health and inequalities generation in section 2.

For example, for every 10 per cent increase in older people suffering deprivation, life expectancy falls by six months; for a 10 per cent increase in employment deprivation (those involuntarily unemployed), life expectancy is a year lower. In contrast, for every 10 per cent more fruit and vegetable consumption, life expectancy is seven months greater whereas for every 10 per cent increase in binge drinking, life expectancy is four months lower.

We find that place effects have an important influence over and above these general relationships (*see* Annex C for a map of the baseline areas and place variables). Generally, these are consistent with previous findings. For example, being in the travel-to-work areas of London's suburbs is associated with five months' higher life expectancy and roughly double this in the central London travel-to-work area. Being in parts of the north, particularly the North West, Yorkshire and Humberside is conversely associated with lower life expectancy. This is also true for some parts of the Midlands, while in the South West place is both negatively and positively associated with life expectancy. Another striking finding is that income deprivation, the defining variable of the Marmot curve, did not make it to our final model. It did not have a statistically strong relationship with life expectancy, given the inclusion and role of the other variables in the model. We return to the interpretation and implications of this in the discussion section.



Table 2 What explains life expectancy in 2006–10 across 6,700 areas in England?

| Explanatory factors | Impact of every 10 per cent difference between areas on months of life expectancy |
|--|---|
| Constant | 85.3 (years, in absence of explanatory factors) |
| Wider determinants | |
| Older people's deprivation | -6.1 |
| Employment deprivation | -11.8 |
| Housing deprivation | -2.2 |
| Behaviours | |
| Fruit and vegetable consumption | 6.9 |
| Binge drinking | -4.0 |
| Services | |
| More than 1.1 miles from 'other services' | 2.0 |
| Demographics | |
| Male | -7.0 |
| BME status non-white British | -0.9 |
| Impact of being in geographical area on life expectancy | |
| Area variables | |
| <i>Travel-to-work areas (suburbs)</i> | |
| London | 5.3 |
| North West | -9.3 |
| <i>Travel-to-work areas (central)</i> | |
| London | 10.4 |
| North West | -9.4 |
| South West | -8.0 |
| <i>Other areas</i> | |
| North West | -4.5 |
| Yorkshire and Humber | -8.5 |
| East Midlands | -4.2 |
| West Midlands | -2.6 |
| South West | 5.1 |
| Number of observations | 6,700 |
| Adjusted R ² | 0.44 |



Why do some areas have persistently higher or lower life expectancy than others?

Given that we have data for the same areas for 1999–2003 and 2006–10, we can look at persistence over time. In particular, which and how many areas do particularly well or poorly over time, and why?

To explore this, we split the sample into those that had particularly low or high life expectancy in both 1999–2003 and in 2006–10, based on which MSOAs lay outside the lower and upper confidence intervals in each period (*see* Annex D for details). When we did this, we found that 335 MSOAs had persistently low and 158 had persistently high life expectancy. There was also a very small number of areas (seven in total) that switched from having unusually low to high life expectancy over this time and vice versa. Overall, 500 areas – 7.4 per cent of our 6,700 areas – had either persistently high or low life expectancy over time.

Figure 5 plots these areas against 2006–10 income deprivation, showing the areas with significantly low and significantly high life expectancy in both periods. The majority of areas with persistent lower life expectancy come from areas with high income deprivation and vice versa for areas with higher life expectancy – although there are some exceptions as Figure 5 shows.

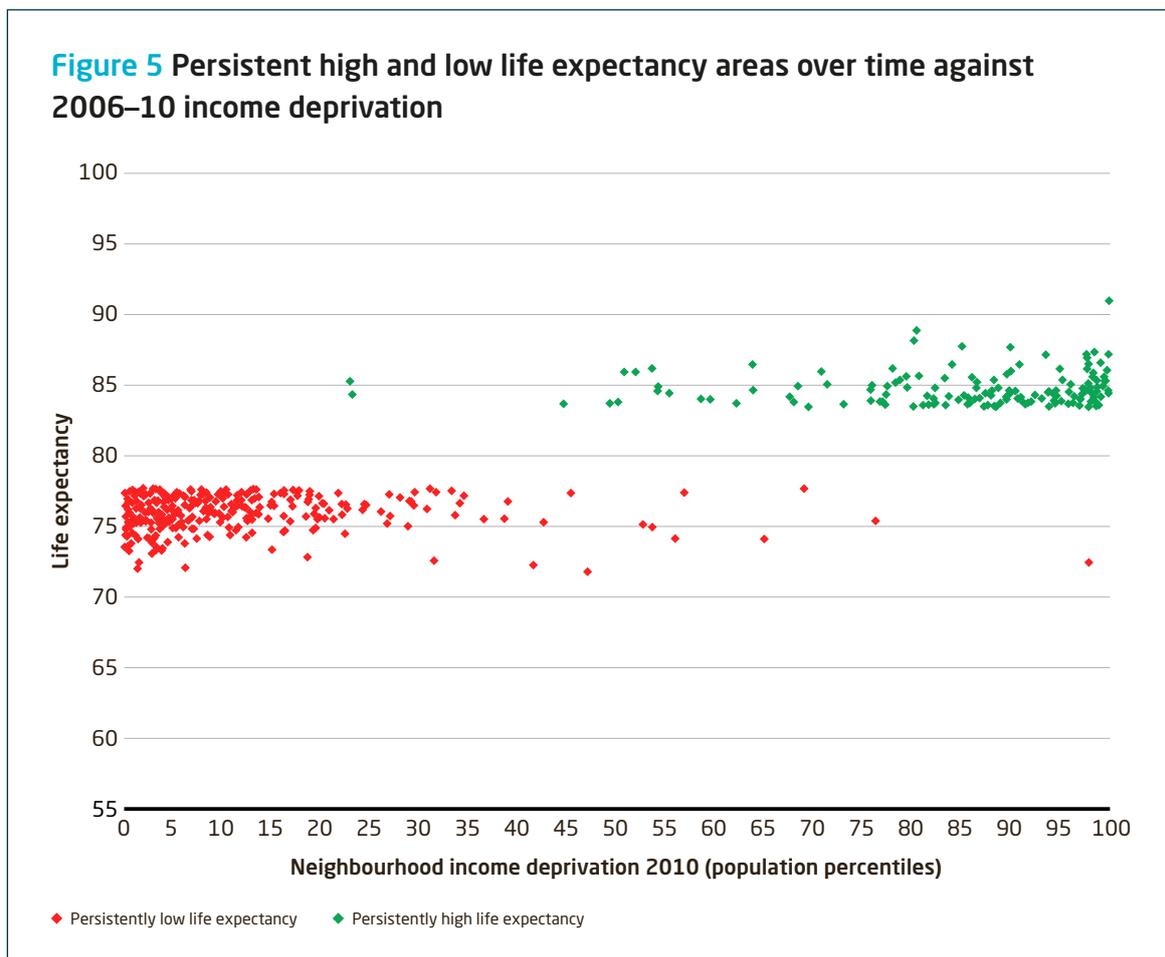
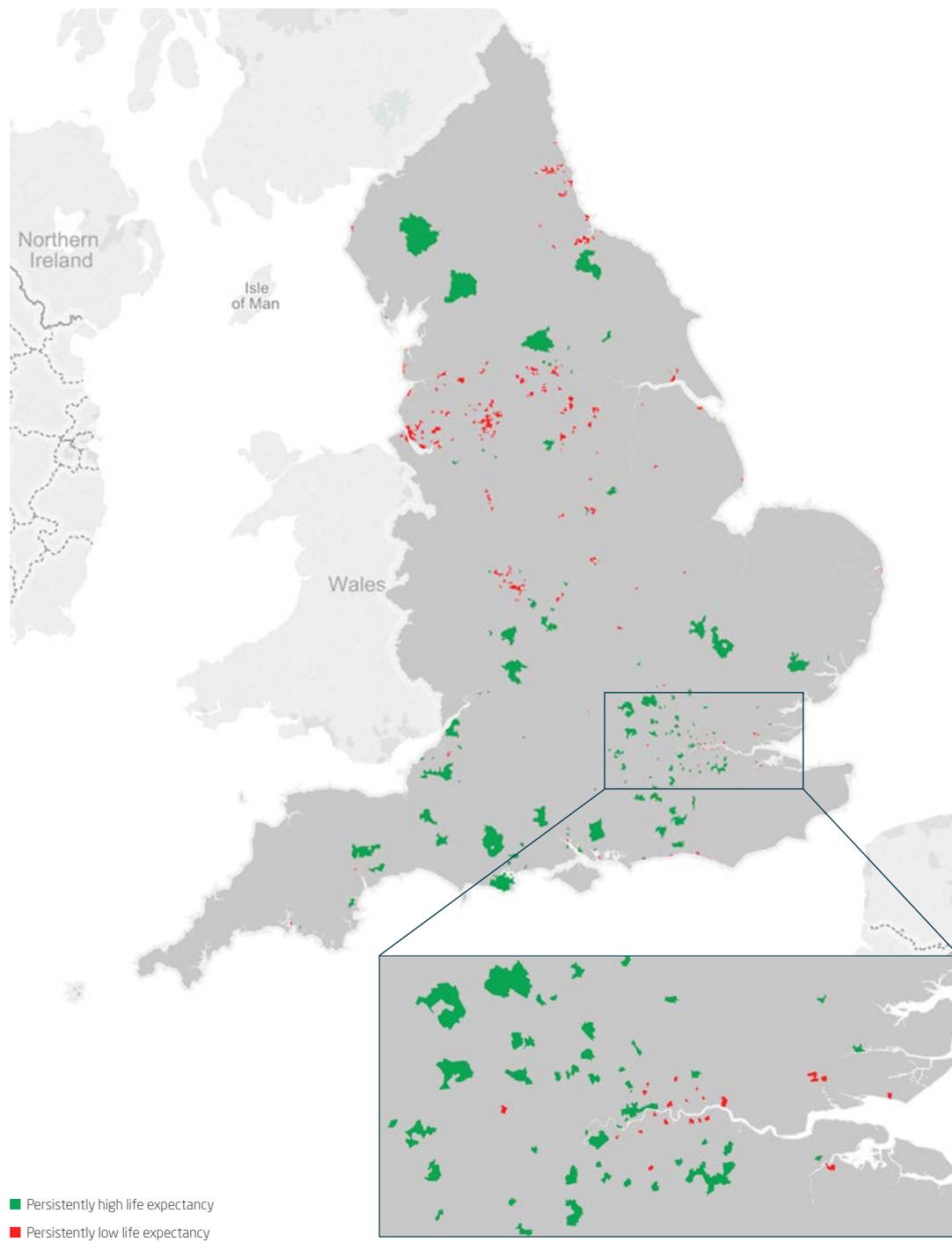


Figure 6 shows the location of these persistently high and low life expectancy areas, plotted on a map of England and with a close-up of areas in London and the surrounding area.

There is a geographical pattern to the areas that have persistently lower life expectancy. More areas in the north of England around urban centres are doing less well than anywhere else in England, with some hot spots in coastal areas, the Midlands and London. Conversely, many of the areas with persistently high life expectancy are relatively large rural patches with sparser populations, although there are also areas in city centres, particularly west London, with persistently high life expectancy.

Figure 6 Areas of persistently high and low life expectancy, England and London area, 1999–2003 and 2006–10



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To further understand the characteristics of different areas, we undertook further statistical analysis of the two groups – having persistently high life expectancy or having persistently low life expectancy. We carried out two further regressions, seeking to explain membership of these groups compared to not being in either, again using our independent variables in Table 1, and refining down.

Our results are presented in Tables 3 and 4. Full details of the methodology and how to interpret these results are in Annex D. These results are based on ‘probit’ regressions and which variables were significant in each case explaining the membership of the two groups. They look at the likelihood of an MSOA being a persistently high or low life expectancy area over time, given an absolute change (either increase or decrease) in the explanatory factors from their average or typical values.

The pertinent columns are the final three from left to right in both tables. The first of these three shows the relative risk, given a 5 percentage point absolute increase in the relevant factor, holding other things equal. The next column shows the relative risk given a 5 percentage point drop.

So, in Table 3, for example, for areas with 5 per cent higher than average smoking rates the chances of the MSOA having persistently high life expectancy is a quarter that of the average area, whereas if smoking rates are 5 per cent lower than average there is a 3.7-fold greater chance that an MSOA will have persistently high life expectancy over time. The final column shows the impact for variables that are ‘either/or’. So, being in the travel-to-work area of central London increases the relative chances of living in a persistently high life expectancy MSOA 46-fold compared to living in a baseline area.

Table 4 is read in the same way as Table 3. So, for example, a 5 per cent higher prevalence of binge drinking is associated with a two- to three-fold risk of being a persistently low life expectancy MSOA. Being in the travel-to-work area of central London reduces those chances to a tenth compared to baseline MSOAs.



Table 3 The significant factors in determining whether a community is persistently above the 'normal' range of life expectancy

| Explanatory factor | Typical value (%) (average across MSOAs) | Relative risk of being a persistently high LE MSOA after 5% increase from typical value (holding other factors constant) | Relative risk of being a persistently high LE MSOA after 5% decrease from typical value (holding other factors constant) | Relative risk of being in high LE group if living in area compared to other areas (holding other factors constant) |
|--|---|--|--|--|
| Older people's deprivation | 19.25 | x0.08 | x11 | - |
| Children's deprivation | 19.62 | x1.67 | x0.58 | - |
| Employment deprivation | 9.34 | 0 | x19 | - |
| Smoking | 19.92 | x0.25 | x3.7 | - |
| BME | 13.42 | x1.67 | x0.58 | - |
| Distance from GP >1.6 | - | - | - | x0.33 |
| Travel-to-work area (suburbs) South West | - | - | - | x20 |
| Travel-to-work area (central) London | - | - | - | x46 |
| Travel-to-work area (central) Yorks and Humber | - | - | - | x11 |
| Travel-to-work area (other) South West | - | - | - | x12 |



Table 4 The significant factors in determining whether a community is persistently below the 'normal' range of life expectancy

| Explanatory factor | Typical value (%) (average across MSOAs) | Relative risk of being a persistently low LE MSOA after 5% increase from typical value (holding other factors constant) | Relative risk of being a persistently low LE MSOA after 5% decrease from typical value (holding other factors constant) | Relative risk of being in low LE group if living in area compared to other areas (holding other factors constant) |
|--------------------------------------|--|---|---|---|
| Older people's deprivation | 19.72 | x1.45 | x0.68 | - |
| Children's deprivation | 21.18 | x0.94 | x1.07 | - |
| Employment deprivation | 10.04 | x5.03 | x0.13 | - |
| Housing deprivation | 29.34 | x1.26 | x0.774 | - |
| Smoking | 20.62 | x1.48 | x0.68 | - |
| BME | 14.26 | x1.45 | x0.68 | - |
| Binge drinking | 19.95 | x2.52 | x0.35 | - |
| Pupils 5+ GCSEs | 64.33 | x0.94 | x1.06 | - |
| Distance from GP >1.6 | - | - | - | x0.36 |
| Travel-to-work area (other) | | | | |
| North West | - | - | - | x1.55 |
| North East | - | - | - | x0.55 |
| South West | - | - | - | x0.19 |
| Travel-to-work area (suburb) | | | | |
| London | - | - | - | x0.23 |
| North West | - | - | - | x0.65 |
| North East | - | - | - | x0.45 |
| Yorks and Humber | - | - | - | x2.16 |
| Travel-to-work area (central) | | | | |
| London | - | - | - | x0.10 |
| North West | - | - | - | x1.77 |
| West Midlands | - | - | - | x0.07 |
| Yorks and Humber | - | - | - | x0.48 |



6 Discussion of findings

The Marmot curve's improvement over time

We have found that the Marmot curve improved significantly between 1999–2003 and 2006–10. The whole curve shifted upwards, reflecting improvements in life expectancy across England and the gradient between life expectancy and income deprivation also got less steep. Having a higher prevalence of income deprivation relative to other communities, while still apparent, therefore seemed to have a smaller effect on a communities' life expectancy in 2006–10 than in 1999–2003.

This took place at a time when there was a strong government commitment to reducing inequalities in health. However, this commitment did not focus on narrowing income-related health inequalities. Rather, its main focus was a managed target to focus on closing the life expectancy gap between spearhead local authority areas and England as a whole (although there was also a target on infant mortality differentials; *see* Bambra (2012) for details). The strategic approach changed over time with an initial focus on cross-government action on the wider determinants of health, including a raft of 82 cross-government objectives (*see* [Department of Health 2009](#)) and latterly a greater weight on access to secondary prevention and treatment interventions at scale through the NHS.

These later attempts were focused on the spearhead areas, chosen based on their deprivation and high levels of preventable and treatable disease. Spearheads received some specific additional funding and were both performance-managed through targets and received performance support primarily from the National Support Team for Health Inequalities. The Department of Health also developed analysis and tools to help these areas prioritise actions such as cholesterol and diabetes control focused on reaching specific groups (for more details, *see* the Health Inequalities Intervention Tool, *see* [London Knowledge and Intelligence Team, Public Health England 2011](#)). Both health inequalities targets were dropped by the incoming coalition government. The National Audit Office's assessment of the Labour government's track record was that while there had been much delay in action the government



had made a serious and concerted effort to reduce inequalities in health ([National Audit Office 2010](#)).

The last time government presented data on the authorities included in the target and compared with England was in September 2011, for the years 2008–10. Between 1999–2001 and that date, the absolute and relative life expectancy gap was virtually unchanged for men and had increased for women ([Department of Health 2011](#)).

So, to the end of the period under scrutiny, there was little sign that the spearhead approach was yielding dividends, at least in terms of life expectancy gaps between spearhead local authorities and others (Dorling 2013a). However, there were more positive signs on life expectancy *within* spearheads – not the focus of the target and at levels of analysis more similar to ours and Marmot’s review ([Buck 2011](#)). This story is told in Community Health Profiles, summary documents on the health of local authority populations that include information on how life expectancy differs by deprivation within them. For example, at the end of the period under scrutiny here, Hackney – an inner London area often associated with inequalities – saw the biggest improvement in the country for men (the gap falling by 2.9 years). Other spearhead areas also did well in narrowing inequalities within their areas over the period. Within London, spearhead areas did as well on average for males as non-spearheads and slightly better for women.

So looking at higher levels of geography, such as gaps between spearheads and England as a whole, can obscure improvements within those areas. Further, there is also some evidence to suggest that the actions the NHS was encouraged to take that Department of Health modelling had predicted would be beneficial to inequalities in life expectancy were indeed having some effect. Analysis for the National Audit Office’s assessment of the spearhead policy ([Hippisley-Cox 2009](#)) showed a closing of the gaps in primary care for deprived versus non-deprived practices across a wide range of conditions such as type 2 diabetes, obesity and cardiovascular disease risk over the first years of the 21st century. For statins the relationship was even reversed, with a higher proportion of deprived patients with cardiovascular disease receiving statins than affluent patients by the end of the period. The big exception to these favourable trends was smoking rates, where the relative gap increased over time and the absolute gap was reasonably stable. Other studies have shown that differences in cancer survival rates narrowed between spearhead and other areas (Ellis *et al* 2009)



and overall Quality and Outcomes Framework (QOF) achievement converged between deprived and non-deprived practices within general practice (Dixon *et al* 2011). Finally, recent research suggests that between 2001 and 2011 there was a drop in mortality amenable to health care between deprived and less deprived areas (Barr *et al* 2014). The deprivation weighting in the NHS resource allocation formula, sending more funding to more deprived areas, accounted for the large majority of this drop.

Beyond the activities of the NHS, wider trends were also developing. Our own work suggests that there was an increase in inequalities in clustering of unhealthy behaviours between social groups, with those from lower occupational and educational groups not benefiting from reductions in the number of multiple risk behaviours (ie, concurrent combinations of smoking, and lack of adherence with government guidelines on alcohol, diet and physical activity) certainly storing up inequalities in life expectancy in the future (Buck and Frosini 2012). So although they had little impact in the period under scrutiny, these trends during the first years of the 2000s are likely to be storing up problems for the future.

Wider economic and social factors were also in play. First, income inequalities seemed to have actually increased over the period, at least until 2006–07 (Cribb 2013) and then improved to leave the situation roughly where it was at the start of the period. But within this were big changes within the life course. In particular, Labour prioritised reducing child and pensioner poverty, both of which fell considerably over the course of their time in power, whereas poverty for working-age adults without children increased. As Hills (2013) summarises, ‘differences in net incomes between age groups were much lower. The smoothing of incomes that occurred across the life cycle could be seen as a striking, if unremarked, achievement.’ Another area where there were strong improvements was in the quality of housing. The proportion of homes that were designated as ‘non-decent’ fell from around 45 per cent in 1996 to less than 30 per cent in 2006. When the definition of non-decent changed and got tighter, the fall continued from around 35 per cent to around 30 per cent by 2009. Further, the fastest rate of improvement was in the socially rented sector. Finally, differences in unemployment rates between areas reduced in the late 1990s until the late 2000s recession. Barr *et al* (2012) have shown that this has had some impact on narrowing health inequalities.



In conclusion, the reasons for the Marmot curve pivoting and becoming shallower are more complex than our review here can do justice. However, there appear to have been several favourable trends that converged in the first 10 years of the 21st century that could have helped to improve and ameliorate the relationship between income inequalities and health. These range from the actions of the NHS to improvements in wider determinants, although lifestyle changes as discussed above were clearly storing up problems for the future. Much more research on these factors is required in order to fully understand the causes of and lessons from this important improvement in the relationship between income deprivation and health.

The wider influences on life expectancy

As far as we are aware, our analysis of life expectancy in a multiple regression context at the MSOA level is the first to be undertaken. In order to complete it, we brought together a unique collation of data at area level in England. There is clear evidence that the wider determinants of health and lifestyles are both important for understanding life expectancy differences between English areas. However, our service variables, including our health service variable, were not significant in the main regression, though there was an effect on persistently high or low life expectancy over time.

We also found that income deprivation per se is not a significant factor when we include other measures of deprivation. We posit that there are several related reasons for this. There remains debate on the biological mechanism between income and health (*see* Dorling (2013b) for a full discussion). But one clear mechanism is as a gateway to the material goods, services and psychological factors related to stress (such as status, our place in the social hierarchy and access to social networks) that enable us to be healthy. Income, or in relation to our analysis, more correctly at an area level lack of income deprivation, acts as a gateway to access those things that really determine our health, as well as having an impact on our health directly. Since the factors that it is associated with in terms of health effects, in particular employment and older people's deprivation, are also in our model it becomes a less powerful predictor than if it is analysed alone. This effect may be compounded because of the definition of the income variable used: 'income deprivation' is defined as the number of people (and children living with them) in an area who claim various benefits, including income-based Jobseeker's Allowance and Pension Credit.



Since our income variable will be closely related to our unemployment and older people's deprivation variables, statistically, it is harder to disentangle their specific effects. This is known as the problem of *multicollinearity*. We discuss these issues and how we approached them in more detail in Annex D.

Overall, what we did find is that our analysis is in line with the general messages from our review of the evidence. Areas with higher employment deprivation, older people's and housing deprivation have lower life expectancy, as do areas with higher binge drinking. On the other hand, fruit and vegetable consumption is associated with higher life expectancy.

Finally, 'place' is important *over and above* these general effects. However, the impact of place is complex and is clearly not straightforward to interpret. Our results do conform well to what others have generally found, that place exerts an influence on health that is independent of, or complexly interwoven with, the more general factors that effect an area's overall life expectancy. We return to what this means for policy, practice and research below.

Persistence over time

In explaining persistently low life expectancy over time the analysis revealed that employment deprivation is particularly important, increasing the chances of being in a persistently low life expectancy area five-fold for every 5 per cent absolute increase from the average value, holding other factors constant. More lifestyle factors come into play here, with smoking and binge drinking becoming important. Place also features strongly, with being in an MSOA in central London reducing the chances of being a persistently low life expectancy area 10-fold, again holding other factors constant.

Three other broad findings deserve comment. First, BME status at first sight appears contradictory in these findings, being associated with *both* persistently higher life expectancy and persistently lower life expectancy areas over time. We believe that this is likely to be caused by the catch-all nature of our BME variable, which includes all those who did not refer to themselves as 'white, British' in the 2011 Census (see Annex A). Clearly this will include very different people and communities with spatially patterned demographics and age ranges. Further



analysis is required to unpack these effects more precisely. More difficult to explain are the results for distance from a GP and children's deprivation. Being more than 1.6 miles from a GP practice is, like BME status, associated with being both more likely to be a persistently high and low MSOA over time. More counter-intuitive still is that rising deprivation among children increases the relative risk of being in a persistently high life expectancy MSOA and reduces the relative risk (albeit to a relatively minor extent) of being in a persistently low life expectancy MSOA. One possible explanation is that the link between child deprivation and life expectancy is less stable than some of our other variables because child deprivation affects life chances and quality of life, more than length of life per se.



7 Policy and practice implications

The findings on the Marmot curve raise important questions for policy and practice. We need to look again in more depth at the policy experience, and the wider societal changes, in the first years of the 21st century and their historical context ([Dorling 2013a](#)). The Labour government of the time was poised to fail its own target for reductions in inequalities in life expectancy – a target dropped by the subsequent coalition government. However, Labour did – unknowingly – preside over an improvement in the Marmot curve and in several of the areas that we find were key determinants of life expectancy at area level in those early years of this century. That analysis finds that lifestyles and the wider determinants of health – particularly unemployment and older people’s deprivation – have an important role to play in determining differences in life expectancy between areas. This is consistent with a more nuanced and integrated response, in which wider central government policies, the NHS and local government have a wider role to play than is currently reflected in the health policy narrative.

There remain big areas of NHS policy where a focus on inequalities is most notable by its absence. Integration in the health policy debate is too fixed on integration between health and social care. If we are to address inequalities in life expectancy and morbidity, there needs to be much wider integration with other public services and community assets. Behind the headlines, this is one of the core priorities of the ‘Devo Manc’ initiative ([Buck 2015a](#)). Greater Manchester is seeking to integrate a wide array of public services around families to save money but more importantly to deliver a more appropriate mix of medical and social interventions to tackle the causes and implications of inequalities and poverty, with a particular focus on tackling ingrained long-term unemployment (see [Blond and Morrin 2014](#) for more on the rationale). This approach is supported by our own analysis, given that employment deprivation comes through as the strongest overall factor in explaining life expectancy in our main model and the persistence of low life expectancy over time. This also means that integration policy needs to connect with public health policy. At the moment the public health contribution to diverting people from



integrated care pathways, to playing a part in those pathways, and to shaping the nature of the pathway, are all notable by their absence. Only once they are included can we be confident of being on our way to true population health systems with inequalities reduction at their heart ([Alderwick et al 2015](#)).

Who should do what?

Although our general practice variables did not come into our main model, there is no lack of evidence that general practice is important in reducing inequalities in health. The work of Starfield *et al* (2005) and Dorling (2013a) suggests that absolute numbers of general practitioners are important. This is data we do not have at MSOA level to plug into our model. More generally, systematic and scaled-up care in general practice can influence life expectancy. Indeed, the Department of Health itself took the lead in developing the evidence and disseminating the tools for local areas to do this in support of the last Labour government's health inequalities target. While the National Audit Office (2010) criticised the Department of Health for its actions on inequalities, this was because it failed to take earlier or strong enough action – *not* because it did not know what to do. It is therefore welcome that NHS England (2014) is seeking more from clinical commissioning groups (CCGs) and their partners in terms of quantifiable ambitions for health inequalities.

The NHS therefore needs to step up, or back, to the plate. There was a loss of momentum in policy and action on health inequalities from the Department of Health and NHS England under the coalition government ([Buck 2015b](#)). The systematic performance management, support system and expertise that underpinned the former inequalities targets were dismantled. NHS England needs to address this, to expect and demand more from the NHS in terms of action on inequalities in health.

But the NHS and its leadership need to go further if they are to maximise the contribution to reducing inequalities in health. The NHS and its extra resources during the first years of the 21st century may have helped to ameliorate the effect of income inequalities on health ([Dorling 2013a](#)). While that growth has now stopped, the NHS is still protected compared to other public services and it needs to make much better use of its economic, commissioning and procurement, and employment power in all communities. We have discussed elsewhere how this can be achieved ([Buck and Jabbal 2014](#)), setting out many case studies of good practice,



including NHS trusts proactively seeking to employ and offer apprenticeships to those from disadvantaged backgrounds and communities, and from vulnerable groups. This is an area of great potential, and one that NHS administrations have largely ignored until now, despite a push on it in the early 2000s (Coote 2002). There are some welcome signs that NHS England's leadership is starting to wake up the NHS 'sleeping giant' on the wider determinants of health – for instance, the new offer from NHS England of working with Public Health England to actively support the design of healthier towns (NHS England 2015).

We strongly support the National Audit Office's (2014) assessment that 'PHE should write a cross-Whitehall influencing strategy'. However, as we have stated before in our mid-term assessment of coalition health policy:

If the government is serious about narrowing health inequalities, it cannot rely on the NHS and public health sector alone. If government as a whole is to maximise its impact on reducing avoidable health inequalities, it needs to carry out proper, transparent appraisal and evaluation of government policy for its health inequality impacts. Ideally, this should be undertaken or independently commissioned through a strong Public Health England with an explicit remit to do so.

(Gregory et al 2013, p 48)

While some health impact assessments are conducted in Whitehall (Department of Health 2010), there is little evidence that they actually influence policy decisions. The short-lived sub-committee on public health under the last coalition government could have fulfilled this role and been the voice for public health across government. Andrew Lansley, formerly Secretary of State for Health, has recently implied that following the sub-committee's demise, this voice is now 'very difficult' to hear (Timmins 2015, pp 156–7). The decision to reduce local authorities' public health budgets by £200 million during this year (Buck 2015c) underscores the risks both to public health and action on inequalities. If decisions like this, coupled with the roll-back of social care and wider local government funding and welfare, continue to be made then inequalities in health could easily widen and much of any progress made will be lost.

Public Health England needs to urgently offer its expertise to other government departments – for free if necessary – to ensure that the impacts of wider government



actions adequately take into account impacts on inequalities in health. More broadly, a mechanism such as the sub-committee on public health needs to be brought back into the centre of government to adequately assess and hold to account wider government actions on inequalities in health, as policies are developed. If austerity is the only game in town, it needs to be managed in a way that minimises its effects on inequalities in health – that is not currently happening.

Local knowledge and action

Our map at Figure 6 has identified those areas with persistently high and low life expectancy over time and our analysis distinguished important characteristics of many of those areas. High-level national modelling and identification can only take us so far, however. Only in-depth local knowledge and analysis can really get under the skin of what is driving persistence in outcomes at local level.

One way to do this is through ‘deep dives’ undertaken by local authorities and the NHS with their partners. Fortunately, there is existing good practice to learn from. Several areas are using techniques developed by the former Health Inequalities National Support Team to deep-dive in their local communities on health inequalities. This is epitomised by the rapid external review of health inequalities in Maidstone ([Bentley 2013](#)). It used local data from community health profiles and wider data in combination with the Health Inequalities National Support Team methodology in the context of insights from *Fair society, healthy lives* to help develop a Maidstone-specific approach to reducing inequalities in health. We hope that future efforts can also learn from some of the findings of our work into such efforts.

Because the effect of place is so important and persistent, a key test of English devolution, in our view, will be its impact on inequalities in health. In theory, informed by deep dives as above, devolution could free up all the insight, resources and funding streams that flow into local areas to be better directed at the causes and consequences of inequalities in health ([Buck 2015a](#)).

At its best, localism could help to lead us to a true population health system with inequalities at its heart. That means the reduction of inequality becoming a core goal of health and social care integration locally; integration moving upstream to working-age populations; local behaviour change strategies recognising and



addressing the clustering of health behaviours; a local NHS playing its full role in the wider determinants of health as much as in treatment and prevention; and health and wellbeing boards moving from rhetoric on inequalities in health to delivery.

But this won't be straightforward or easy. In particular, more local political participation around the NHS could be a doubled-edged sword. There is a real danger that the electorate will vote on the basis of saving the iconic hospital down the road, rather than the complexity and interplay of the factors that drive inequalities in health, which are not easy to reduce to political sound bites. Avoiding this pitfall will remain one of the greatest challenges to local leadership. As we have made clear above, devolution will have a chance to reduce inequalities in health only if it happens within the context of supportive wider central government policy, swimming with the tide, not against it.



8 Next steps for research

The approach we have taken has its weaknesses. In particular, we were explicit in letting the data speak, being guided by theories but not testing them directly. Our aim was to test whether elements across the different theories seemed to be associated with life expectancy. Broadly the answer is yes they are. In undertaking our analysis, gathering and transforming data we also had to make many decisions, including choices that others may have made differently.

Of course our dataset is limited. Our health care and wider public service variables are, for instance, very narrow and unlikely to pick up their full impact; this is true especially for the contribution of general practice. Our analysis also does not allow any assessment or measurement of community assets, or community resilience within areas – both factors that research suggests are important in explaining health inequalities.

Fair society, healthy lives itself, *Due north* (Whitehead 2014) and Doran *et al* (2006) have all shown that health outcomes from certain parts of the country are different, over and above any general relationships with income and other forms of deprivation. We find that these place effects also survive the inclusion of more variables, analysis at MSOA level and our extension to looking at persistency of high and low life expectancy over time. What explains this is open to much debate. Much time and effort has been expended, for example, on attempting to explain the poorer health outcomes than predicted for Glasgow's residents, 'the Glasgow effect' (Dodds 2014).

Our modelling has clearly not taken into account the full complexity of these effects. Different levels of place (MSOA, suburb, city, local authority and region) may interact with each other and with our other variables. Our MSOAs are therefore 'nested' within a broader geographical context of sub-region and region. We have not directly modelled this in our analysis; multi-level modelling may be a better way to do this in future (*see* Gellman and Hill 2006). In our view, some of the explanation must lie in the complex mix of populations and population churn (Dennett and Stillwell 2008) in MSOAs in areas near larger cities and centres of population, with large numbers of residents but also commuters, with different



characteristics linked to health. While important in itself, analytical modelling is unlikely ever to satisfactorily explain these effects alone. Such modelling needs to be combined with local analysis, knowledge and qualitative insight. This requires ‘deep dives’ into local data and communities themselves, as we argue above.

As with most studies of this sort – including the original Marmot curve – our analysis takes place at points in time and uses contemporaneous data. We know, of course, that life expectancy is driven by cumulative experience over time, not simply what is going on now. We also know that definitions of deprivation and other variables change over time, such as benefit rules. We therefore do not claim that our analysis is either the first or last word on this important subject. Ideally, studies that follow and improve on ours will also be able to take into account time-lagged variables.

Our view is that Public Health England is in an ideal position to move forward on many of these fronts, with its combination of greater expertise on public health data and its relationship with directors of public health and their teams who have detailed local knowledge of specific communities. This deeper performance assessment is an area that the National Audit Office (2014) also clearly expects more of from Public Health England, as it matures as a public health system leader. One good sign, would be a commitment to repeating and improving our analysis with the updated data on disability-free life expectancy at MSOA level when the Office for National Statistics makes it available in late 2015.



9 Conclusion

There are many theories about what explains inequalities in health. Many of the analytical studies that have been undertaken focus on specific factors, or classes of factors. Far fewer look at the contribution of a broad array of factors. Where they do, across time, country and method, they tend to find that wider determinants and lifestyles are more important than health care services or genetics.

Our contribution has been to update the life expectancy element of the iconic Marmot curve, a powerful and influential illustration of England's inequalities in health in the late 1990s and early 2000s. We have shown that the Marmot curve for life expectancy shifted up (reflecting life expectancy improvement for the population as a whole) and got shallower (reflecting a narrowing of inequalities in relation to income deprivation) between 1999–2003 and 2006–10. The relationship between income and life expectancy, while still present, therefore diminished. This occurred at a time when there was specific policy focus on inequalities in health, both through the NHS and in the wider determinants of health. As the new government begins work, it should be mindful of this experience when framing policies on inequalities in health, and in understanding the impact of wider government policy on inequalities in health.

We also looked beyond the Marmot curve, studying the wider family of curves for other determinants such as housing and unemployment. Drawing together a unique collation of data, representing more than 6,700 areas and guided by our review of theory and previous research, we tested which factors were most associated with differences in life expectancy between these areas. This work showed that income itself may not be as important as those things that areas with higher incomes tend to have, be that better quality services, better lifestyles, or better housing and other wider determinants of health.

We also know that some of our areas have persistently high or low life expectancy over time. We identified which these areas were and analysed what influences membership of these groups. Again, although we do have some power in identifying membership of these groups, 'place' comes up as important. High-level modelling is



only one part of the story in understanding persistence. Local knowledge, analysis, qualitative work and intelligence will need to be used in combination to uncover these factors. We give examples of where this is already happening.

Finally, the fact that the Marmot curve is shallower is good news for inequalities in health. It offers a new perspective on the health and wider policies, and economic environment that were operating in the late 1990s through the first 10 years of the 21st century.

Despite this good news there is no room to be complacent. The wider economic and policy environment has changed significantly since 2010. We also know that there was an increase in inequalities in the clustering of unhealthy lifestyle behaviours in England in the 2000s, even as the Marmot curve was getting shallower, generating inequalities in health in the future.

The persistence of low life expectancy in some areas means that the state, centrally and locally, has not tackled inequalities in health adequately. Inequalities in health are not self-correcting, and the role of wider determinants, lifestyles and services need to be addressed together rather than in isolation from – or in opposition to – each other.



Annex A: Data

We created a dataset that sought to cover many possible influences on health and health inequality. Our intention was not to confirm or deny any particular theory, but rather to explore the relative contribution of a wide range of factors.

Most data used in this report is publicly available. However, we used information on lifestyle variables provided by CACI Ltd from their Wellbeing Acorn dataset.

Collated variables

We collated the following variables at middle super output area (MSOA) level.

- Health
 - ‘Life expectancy’ is the average age that people could have expected to live to during the period in question in each area, as estimated by the Office for National Statistics (ONS).
 - ‘DFLE’ (disability-free life expectancy) is the average number of years a person could expect to be able to live without a serious health problem. This data was unavailable for 2006–10 at the time of analysis.
- Lifestyles
 - Percentage of adults who smoke.
 - Percentage of adults who consume five or more portions of fruit and vegetables a day (‘fruit and veg’).
 - Percentage of adults who ‘binge drink’ (defined as males who have consumed eight or more units and females who have consumed six or more units of alcohol on the heaviest drinking day in the last week).
- Demographic and other variables
 - ‘BME status’ is the percentage of people in an area who answered anything other than ‘white/British’ in the 2011 Census.
 - ‘GCSE achievement’ is the percentage of pupils in an area who achieved five or more A* to C grades, including in Maths and English in the 2011 Census.



- ‘Gender (male)’ is the percentage of people in an area who categorised their gender as male in the 2011 Census.
- ‘Pensioners living alone’ is the percentage of people over the age of 65 living alone.

Derived variables

We derived some of our variables.

- Deprivation. Our deprivation variables were derived from the base indices of the index of multiple deprivation. For full definitions, see the *2010 Indices of multiple deprivation* (hereafter 2010 Indices).
 - ‘Income deprivation’ is the total percentage of people in an area who fulfil one of the following criteria: adults and children in families claiming Income Support, income-based Jobseeker’s Allowance or Pension Credit; adults and children in Child Tax Credit families (who are not claiming Income Support, income-based Jobseeker’s Allowance or Pension Credit) whose equivalised income (excluding housing benefits) is below 60 per cent of the median before housing costs or asylum seekers in England in receipt of subsistence support, accommodation support, or both.
 - ‘Older people’s deprivation’ is the percentage of people living in households that claim Pension Credit.
 - ‘Children’s deprivation’ is the percentage of people aged 0 to 15 years living in income-deprived households.
 - ‘Employment deprivation’ is the percentage of people who are defined as involuntarily unemployed in an area, based on the number taking part in employment schemes or claiming unemployment-related benefits.
 - ‘Housing deprivation’ is based on the ‘indoors living environment’ sub-domain of the 2010 Indices. This is a modelled estimate of the proportion of houses in an area deemed to be unfit under the 1985 Housing Act, combined with the proportion of houses in an area without central heating.
- Quality and access to services
 - ‘GP quality’ is based on the results from the GP Patient Survey. We have taken the ‘overall satisfaction’ score for each clinical commissioning group (CCG) and assigned the value for that CCG to each MSOA.



- ‘Access to GP’ is based on the access to services sub-domain of the 2010 Indices. Where residents in an MSOA are on average within the national average distance from a GP surgery (calculated as 1.6 miles), that MSOA takes a value of 1.
- ‘Access to other services’ – where the population of an area is on average within the national average distance (1.1 miles) from ‘other’ services (post offices, primary schools and food shops), that MSOA takes a value of 1.
- Places. We generated a series of geographical binary variables based on the 2007 travel-to-work (TTW) areas and 2011 Census regions, as defined by ONS. Each MSOA is placed into its respective region, then assigned to one of three categories:
 - an urban ‘centre’ (where the MSOA is within the local authority of a major city, as defined by membership in the core cities group)
 - a ‘suburban’ area (where the MSOA is within the TTW area of a major city, but outside that city’s local authority)
 - an area designated as ‘other’ (regional areas outside urban centres and travel-to-work areas as defined above).
- ‘Air quality’ is a modelled estimate of the concentration of the four pollutants nitrogen dioxide, benzene, sulphur dioxide and particulates in each MSOA, taken from the ‘outdoor environment’ sub-domain of the 2010 Indices.
- Finally, we deflated appropriate variables by population size from the 2011 Census for use in our regression analysis.

The full dataset of variables, with links to where the base data can be accessed is presented in Table A1.



Table A1 Our data

| | Time period | | Source |
|--|-------------|---------|--|
| Health outcomes | | | |
| Life expectancy | 1999–2003 | 2006–10 | Public Health England 2014 |
| Disability-free life expectancy (DFLE) | 1999–2003 | | Olatunde <i>et al</i> 2010 |
| Demography (all variables captured as a % of the area population) | | | |
| BME status non-British, white | | 2006–10 | Office for National Statistics (no date) |
| GCSE achievement (5 or more C+ grades) | | 2006–10 | Office for National Statistics (no date) |
| Gender (male) | | 2006–10 | Office for National Statistics (no date) |
| Pensioners living alone | | 2006–10 | Department for Communities and Local Government 2010a |
| Population | | 2006–10 | Office for National Statistics (no date) |
| Behaviour | | | |
| % who smoke | | 2006–10 | Wellbeing Acorn data (CACI 2013) |
| % who consume 5 or more portions of fruit and vegetables | | 2006–10 | Wellbeing Acorn data (CACI 2013) |
| % who binge drink | | 2006–10 | Public Health England 2014 |
| Deprivation indices | | | |
| Income | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |
| Housing | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |
| Air quality | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |
| Employment | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |
| Older people | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |
| Children | 1999–2003 | 2006–10 | Department for Communities and Local Government 2010a, b |

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Table A1 Our data *continued*

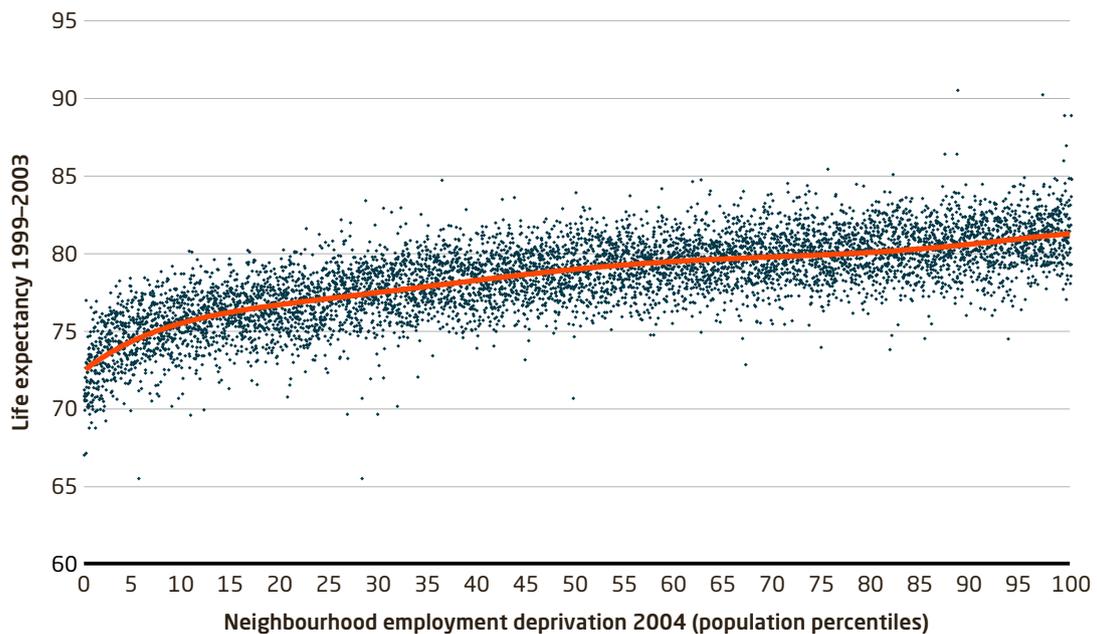
| | Time period | Source |
|--|-------------|--|
| Access to services (binary variables) | | |
| Area within 1.6 miles of a GP surgery | 2006–10 | Department for Communities and Local Government 2010a, b |
| Area within 1.1 miles of 'other' services | 2006–10 | Department for Communities and Local Government 2010a, b |
| Geography (binary variables) | | |
| Area within a major urban centre | 1999–2003 | 2006–10 Office for National Statistics 2015b |
| Area within a major city's travel-to-work area, but outside the centre | 1999–2003 | 2006–10 Office for National Statistics 2015b |
| Area outside a major city's travel-to-work area | 1999–2003 | 2006–10 Office for National Statistics 2015b |



Annex B: Family of Marmot curves 1999–2003

The ‘family’ of Marmot curves in 2006–10 in the main text have their analogues in 1999–2003. These are presented below. They are based on the Index of multiple deprivation 2004 ([Department for Communities and Local Government 2010b](#)).

Figure B1 Life expectancy by percentiles of employment deprivation, housing deprivation, older people’s deprivation and children’s deprivation for English MSOAs 1999–2003

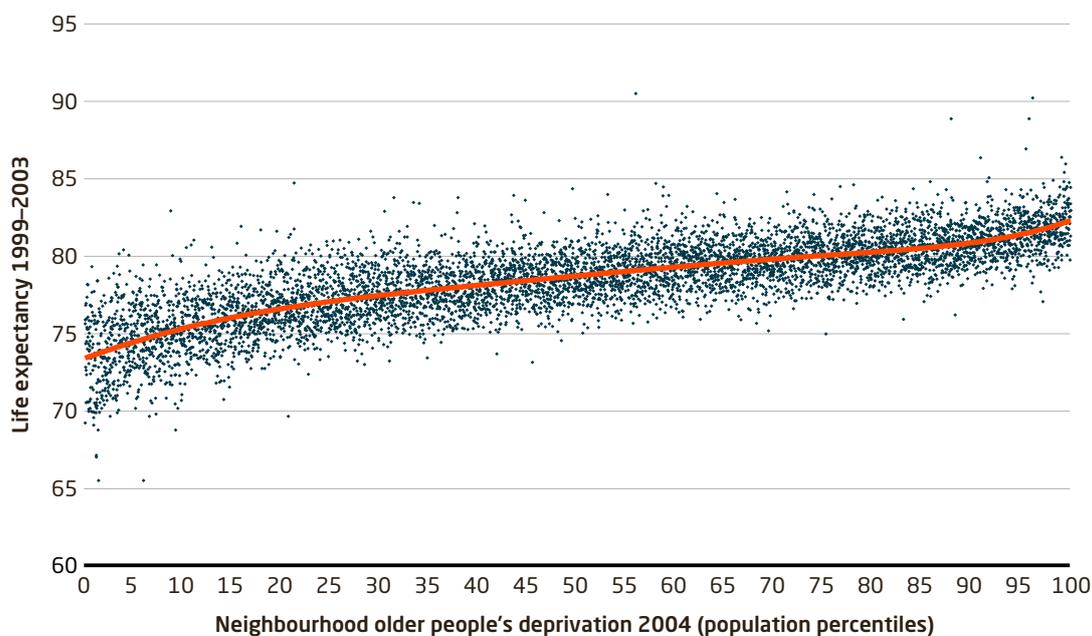
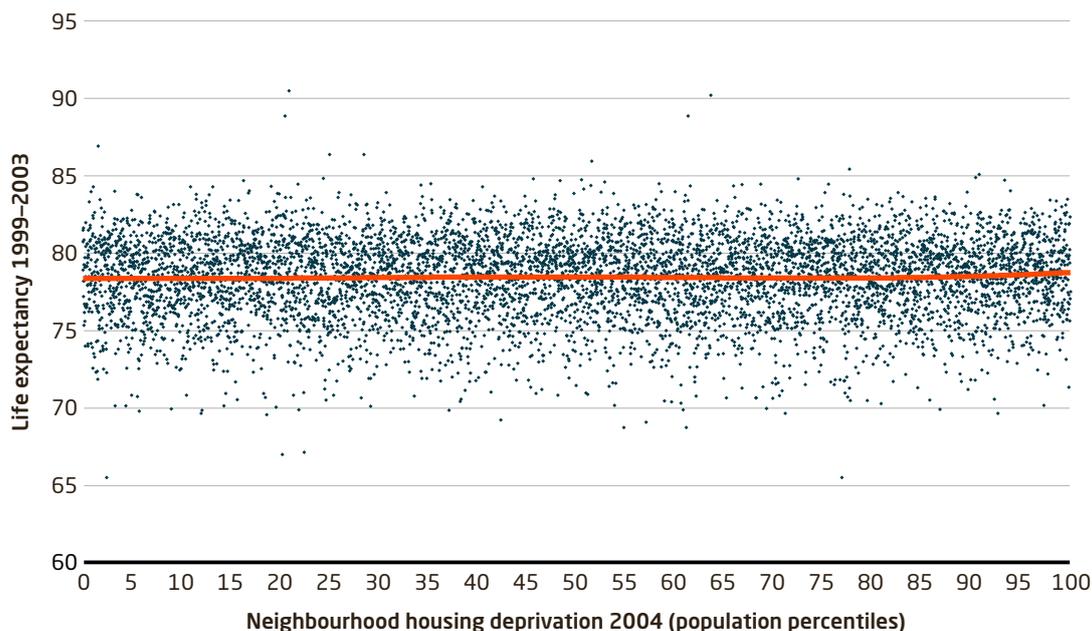


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Figure B1 Life expectancy by percentiles of employment deprivation, housing deprivation, older people’s deprivation and children’s deprivation for English MSOAs 1999–2003 *continued*

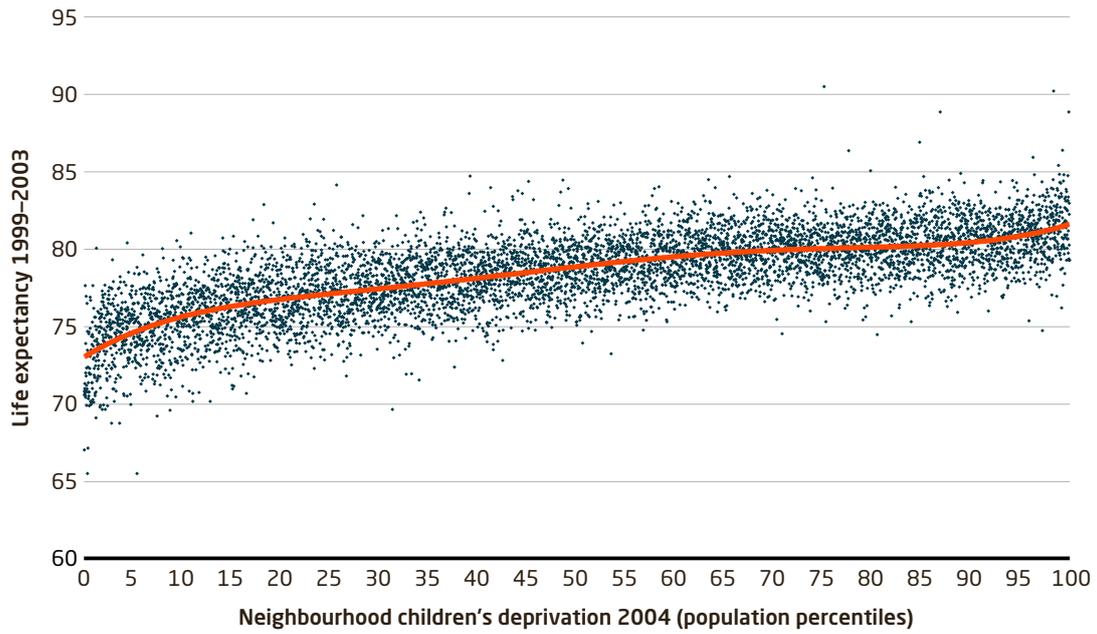


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Figure B1 Life expectancy by percentiles of employment deprivation, housing deprivation, older people's deprivation and children's deprivation for English MSOAs 1999–2003 *continued*

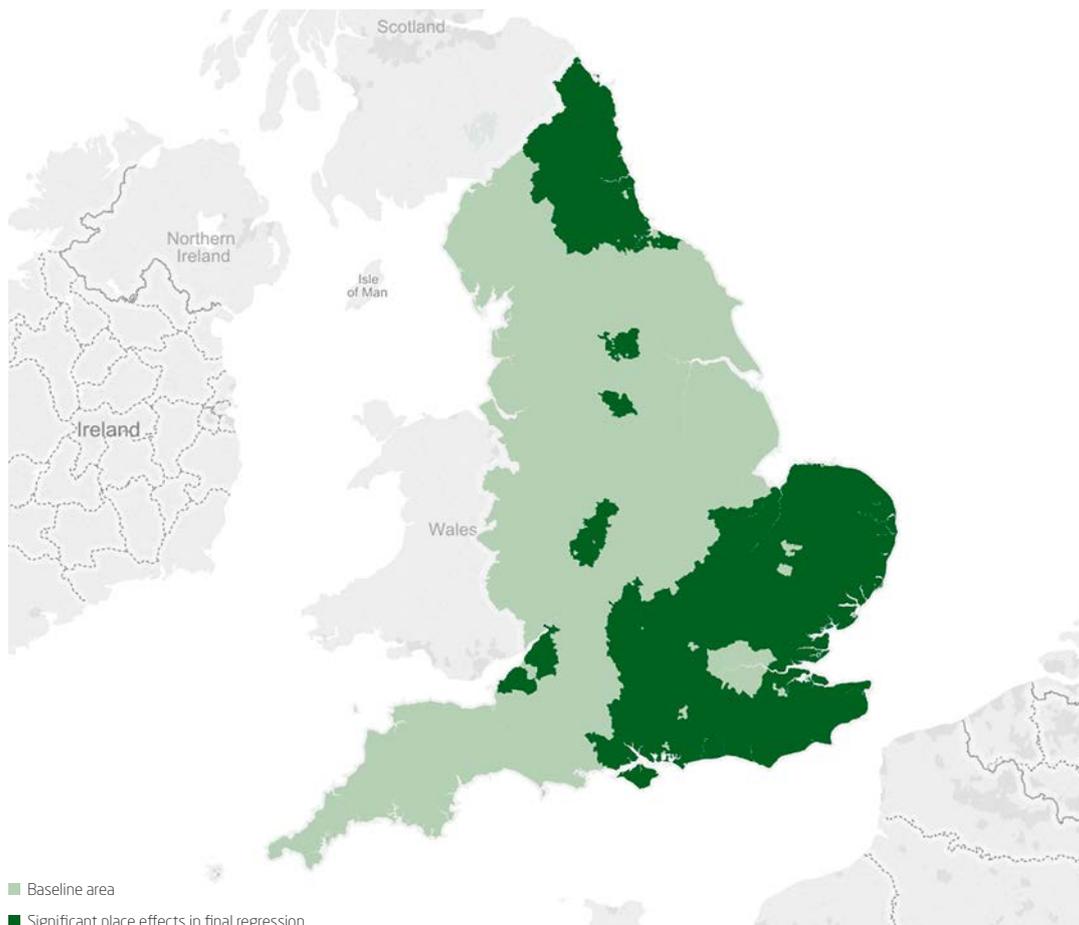




Annex C: Baseline areas

For our main analysis of persistently significantly low or high life expectancy over time we analysed the additional impact of place over and above our other explanatory variables. For that analysis, we looked at the contribution of various measures of place (*see* main text and Annex D) against the ‘average place’. The average was defined as those areas where there was no significant impact of place. These areas are outlined in the map of England below.

Figure C1 Baseline MSOAs in our main analysis



© OpenStreetMap contributors



Annex D: Methodology

We set out below the key methodological choices taken in our analysis. Clearly at several points other choices could have been made. We set out below our reasoning for the choices we made.

Redrawing the Marmot curve and change in MSOA geography

In the intervening period between the data used in *Fair society, healthy lives* and our analysis based on data in 2006–10, there have been changes to the geography of MSOAs in England following the 2011 Census. Fifty-eight MSOAs were deemed to be no longer comparable by ONS, and so had to be left out of the revised version of the Marmot curve and subsequent analysis. In addition, 60 areas from the 2001 MSOA geography were merged together in 2011. For these areas, we have taken a weighted average of each measure (whether it was life expectancy or a deprivation score) based on the 2001 population from that area (according to the 2001 Census). For areas that were split from one into multiple others between 2001 and 2011, we have made the assumption that the previous 2001 score can be applied to each of the 2011 MSOA areas.

To then create our updated Marmot curve, we converted the income deprivation scores into percentiles of rank, and plotted the results against life expectancy for each of the two time periods.

The same technique applies to each of the other deprivation against life expectancy graphs that were included in the report, this time swapping income for older people's deprivation, children's deprivation, employment deprivation or housing deprivation.

Multiple regression analysis

We were unable to obtain data for all of the areas still within our dataset, as some information was unavailable for all areas. This meant that the total number of areas included in the regression was reduced by approximately a further 35 MSOAs, bringing the total included in the model to 6,700 MSOAs.



We chose to use a linear regression on the 2006–10 life expectancy data that we collected to establish the association between our variables and the life expectancy in each of the MSOAs included in our sample. We do not claim to test any particular model of health inequalities – rather, we have aimed to select a representative range of variables from the wide range of theory and explore which are most associated with differences in life expectancy.

Multicollinearity

When one independent variable in a regression is strongly associated with another, or others, it can cause inaccuracy in the size and significance of the parameter. In short, the regression calculation struggles to tell which factor is having which effect. This is known as multicollinearity.

While this problem can never be controlled for perfectly, there are standard procedures that mitigate its effects. One approach is to analyse variance inflation factors (VIFs) in the specification of models. In our approach to model selection we removed insignificant variables in step-wise turn, taking into account the VIFs as we did so. Our final model therefore had low VIFs (below 20), and we are confident that the individual coefficients and significance are therefore reasonably robust against multicollinearity.

Table D1 represents the STATA (version 13) output for our final model, as represented and simplified in Table 2 in the main text.



Table D1 STATA output of main regression results

```
. regress LE200610 IDAOPI WeightedAverageEMP Weightedaveragehousingquality per_fandv Blackand
> MinorityEthnicBME Bingedrinkingadults Otherdist11 male NWOther YHOther EMother WMother
SWother TTWsubLON TTWsubYH TTWcentLON TTWcentNW TTWcentSW [aweight = pop]
(sum of wgt is 5.1102e+07)
```

| Source | SS | df | MS | | | |
|----------|------------|------|------------|-----------------|--------|--|
| Model | 16228.7151 | 19 | 854.142901 | Number of obs = | 6700 | |
| Residual | 17770.4358 | 6680 | 2.66024488 | F(19, 6680) = | 321.08 | |
| Total | 33999.1509 | 6699 | 5.07525764 | Prob > F = | 0.0000 | |
| | | | | R-squared = | 0.4773 | |
| | | | | Adj R-squared = | 0.4758 | |
| | | | | Root MSE = | 1.631 | |

| LE200610 | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|-------------------------------|-----------|-----------|--------|-------|----------------------|-----------|
| IDAOPI | -5.117646 | .4463843 | -11.46 | 0.000 | -5.992702 | -4.24259 |
| WeightedAverageEMP | -9.86463 | .8172306 | -12.07 | 0.000 | -11.46666 | -8.262597 |
| Weightedaveragehousingquality | -1.862671 | .3063451 | -6.08 | 0.000 | -2.463205 | -1.262137 |
| per_fandv | 5.737847 | .7208887 | 7.96 | 0.000 | 4.324675 | 7.151019 |
| BlackandMinorityEthnicBME | -.7843975 | .2308078 | -3.40 | 0.001 | -1.236854 | -.3319406 |
| Bingedrinkingadults | -3.341556 | .4248275 | -7.87 | 0.000 | -4.174354 | -2.508759 |
| Otherdist11 | .1625807 | .0508121 | 3.20 | 0.001 | .0629727 | .2621887 |
| male | -5.863596 | 1.478255 | -3.97 | 0.000 | -8.761449 | -2.965744 |
| NWOther | -.3746922 | .0802703 | -4.67 | 0.000 | -.5320476 | -.2173367 |
| YHOther | -.7046532 | .0847685 | -8.31 | 0.000 | -.8708265 | -.5384799 |
| EMother | -.3492436 | .0765484 | -4.56 | 0.000 | -.4993028 | -.1991843 |
| WMother | -.2180078 | .0810878 | -2.69 | 0.007 | -.3769658 | -.0590498 |
| SWother | .4214913 | .080345 | 5.25 | 0.000 | .2639895 | .5789931 |
| TTWsubLON | .4389984 | .0796997 | 5.51 | 0.000 | .2827616 | .5952351 |
| TTWsubNW | -.776557 | .1125581 | -6.90 | 0.000 | -.9972068 | -.5559072 |
| TTWsubYH | -1.124583 | .2280866 | -4.93 | 0.000 | -1.571706 | -.677461 |
| TTWcentLON | .8699425 | .1135518 | 7.66 | 0.000 | .6473447 | 1.09254 |
| TTWcentNW | -.7829649 | .1605996 | -4.88 | 0.000 | -1.097791 | -.4681384 |
| TTWcentSW | -.6677578 | .2318245 | -2.88 | 0.004 | -1.122208 | -.2133079 |
| _cons | 85.30509 | .7127986 | 119.68 | 0.000 | 83.90778 | 86.7024 |

The relative contribution of wider determinants, lifestyles, services and other factors

Around 48 per cent of the distribution of life expectancy can be accounted for by our model (as shown by the adjusted R² in Table D1 above).

Given the theories of health inequality generation, we are interested in the relative contribution to this overall explanation of the wider determinants, lifestyles and other factors.

We are interested in the relative contribution of these ‘groups of determinants’ to life expectancy. We did this by using a semi partial adjusted R² of each variable, that is, removing each factor from the model in turn, then attributing the change in adjusted R² to the variable in question as its explanatory power.



However, this technique is also sensitive to multicollinearity. We are therefore not confident in the exact scale of the effects of the groups of variables. However, we are mildly confident in the relative scale, and more confident in the ordering of the contributions. On this basis the largest contribution is made by the deprivation and wider determinants factors, followed by the lifestyle factors (roughly half as important), and then place effects (half as important again), and finally other factors. Exact details of our results are available on request. In our view this is consistent with the overall message of the findings given in Figure 1 of the main text.

Identifying and understanding characteristics of areas with persistently low or high life expectancy over time

We attempted to identify outliers from each of the distributions of life expectancy in 1999–2003 and 2006–10, to see if and how their relationships with the variables we had collected differed from the national model seen above. We used a 90 per cent confidence interval of the distribution of life expectancy to determine what should be identified as an outlier to ensure a reasonable sample size for our further analysis.

Table D2 Cut-off points for life expectancy for defining MSOAs with significantly low or high life expectancy

| | Lower boundary | Upper boundary |
|------------------------------------|----------------|----------------|
| 90% confidence interval, 2006–10 | 77.66 | 83.42 |
| 90% confidence interval, 1999–2003 | 75.04 | 81.74 |

The above tables show the upper and lower boundaries for the confidence interval of life expectancy in each of the two time periods examined. There were 493 areas that were above or below the confidence interval in both periods. In both periods, 158 MSOAs were above the 90 per cent confidence interval, and 335 were under in both.

In order to determine what makes these areas statistically different from the rest of the MSOAs, we created probit regressions on the likelihood of being in either the high or low outlier groups in both periods. Probits assess the probability of being in a group versus not being in that group. In these regressions the coefficients



are z-scores which can then be converted into probabilities using the normal distribution. In this way, factors which are determined to be significant illustrate the sort of conditions that create unusual and embedded life expectancy over time.

Tables D3 and D4 show the STATA output for our probit regressions. But these need to be translated into meaningful output.

Table D3 STATA output for persistently high life expectancy areas over time

```
probit Outhighboth IDAOPI IDACI WeightedAverageEMP per_smoke BlackandMinorityEthnicBME
GPdist16 SWother TTWsubSW TTWcentLON TTWcentYH if Outlowboth==0 [fweight = pop], vce(clus
> ter msoa_code)
```

```
Iteration 0: log pseudolikelihood = -5501544.8
Iteration 1: log pseudolikelihood = -4295683.4
Iteration 2: log pseudolikelihood = -3657912.1
Iteration 3: log pseudolikelihood = -3588314.3
Iteration 4: log pseudolikelihood = -3587206.4
Iteration 5: log pseudolikelihood = -3587205.3
Iteration 6: log pseudolikelihood = -3587205.3
```

```
Probit regression                               Number of obs = 48503810
                                                Wald chi2(10) = 194.82
                                                Prob > chi2 = 0.0000
Log pseudolikelihood = -3587205.3              Pseudo R2 = 0.3480
```

(Std. Err. adjusted for 6365 clusters in msoa_code)

| Outhighboth | Coef. | Robust Std. Err. | z | P> z | [95% Conf. Interval] |
|---------------------------|-----------|------------------|-------|-------|----------------------|
| IDAOPI | -13.31413 | 1.866053 | -7.13 | 0.000 | -16.97153 -9.656733 |
| IDACI | 2.715047 | 1.308109 | 2.08 | 0.038 | .1512003 5.278893 |
| WeightedAverageEMP | -16.62383 | 3.707763 | -4.48 | 0.000 | -23.89091 -9.356745 |
| per_smoke | -6.961849 | 1.898388 | -3.67 | 0.000 | -10.68262 -3.241078 |
| BlackandMinorityEthnicBME | 2.641991 | .4717841 | 5.60 | 0.000 | 1.717311 3.566671 |
| GPdist16 | -.285222 | .1016812 | -2.81 | 0.005 | -.4845135 -.0859306 |
| SWother | .6759927 | .1415628 | 4.78 | 0.000 | .3985348 .9534506 |
| TTWsubSW | .8472759 | .2534522 | 3.34 | 0.001 | .3505187 1.344033 |
| TTWcentLON | 1.131931 | .2069714 | 5.47 | 0.000 | .7262744 1.537587 |
| TTWcentYH | .6497113 | .2717898 | 2.39 | 0.017 | .1170132 1.18241 |
| _cons | .9425792 | .2864845 | 3.29 | 0.001 | .3810799 1.504079 |



Table D4 STATA output for persistently low life expectancy areas over time

```

probit Outlowboth IDAOPI WeightedAverageEMP Weightedaveragehousingquality per_smoke
BlackandMinorityEthnicBME Bingedrinkingadults GPdist16 TTWsubLON TTWcentLON TTWcentWM if Out
> highboth==0 [fweight = pop], vce(cluster msoa_code)

Iteration 0: log pseudolikelihood = -10209802
Iteration 1: log pseudolikelihood = -5791978
Iteration 2: log pseudolikelihood = -5049808.2
Iteration 3: log pseudolikelihood = -4987064.5
Iteration 4: log pseudolikelihood = -4985675.2
Iteration 5: log pseudolikelihood = -4985674
Iteration 6: log pseudolikelihood = -4985674

Probit regression                               Number of obs   =   49935388
                                                Wald chi2(10)   =    634.27
                                                Prob > chi2     =    0.0000
Log pseudolikelihood = -4985674                Pseudo R2       =    0.5117

                                                (Std. Err. adjusted for 6542 clusters in msoa_code)
-----+-----+-----+-----+-----+-----+-----+-----
Outlowboth |          Coef.   Robust   z   P>|z|   [95% Conf. Interval]
-----+-----+-----+-----+-----+-----+-----+-----
            | IDAOPI         |  2.381108   .6346575   3.75  0.000   1.137202   3.625013
            | WeightedAverageEMP | 11.48986   1.190431   9.65  0.000   9.15666   13.82306
Weightedaveragehousingquality | 1.647229   .475774   3.46  0.001   .7147292   2.579729
            | per_smoke      |  2.336436   1.114676   2.10  0.036   .1517101   4.521161
            | BlackandMinorityEthnicBME | 2.464215   .3866     6.37  0.000   1.706493   3.221937
            | Bingedrinkingadults | 5.973603   .6308074   9.47  0.000   4.737243   7.209962
            | GPdist16       | -0.3577233 .1554618  -2.30  0.021  -0.6624227  -0.0530238
            | TTWsubLON      | -0.5277269 .2139227  -2.47  0.014  -0.9470077  -0.108446
            | TTWcentLON     | -0.7923471 .1852835  -4.28  0.000  -1.155496   -0.4291982
            | TTWcentWM      | -0.8241738 .2326941  -3.54  0.000  -1.280246   -0.3681017
            | _cons          | -6.868771   .3606945  -19.04  0.000  -7.57572   -6.161823
-----+-----+-----+-----+-----+-----+-----

```

When interpreting probit coefficients, we must use the marginal effects of a given change. First, we must apply mean values to each of the variables involved, then apply our desired change to the variable we wish to investigate, in order to find the true change in probability for that variable at that given level of change. Tables D5 and D6 below present a converted version of the tables above, showing the effect of a 5 per cent absolute change from each variable’s mean value for our non-binary variables, and for those, the impact of being in the relevant group versus the baseline.



Table D5 Persistently high life expectancy over time – the influence of a 5 per cent absolute increase or decrease in significant variables

| High outliers prob vs normal group | Typical value (%) (average across MSOAs) | Normal probability of being in the high LE group (if low LE areas are excluded), holding all continuous factors at average and binary variables at 0 (%) | Probability of being in the high LE group after 5% increase from typical value, holding other factors constant (%) | Probability of being in the high LE group after 5% decrease from typical value, holding other factors at average (%) |
|-------------------------------------|--|--|---|--|
| Older people's deprivation | 19.250 | 0.012 | 0.001 | 0.132 |
| Children's deprivation | 19.615 | 0.012 | 0.020 | 0.007 |
| Employment deprivation | 9.338 | 0.012 | 0.000 | 0.225 |
| % of people who smoke | 19.922 | 0.012 | 0.003 | 0.044 |
| % of people with BME status | 13.421 | 0.012 | 0.020 | 0.007 |
| Binary factors | | Normal probability of being in the high LE group (if low LE areas are excluded), holding all continuous factors at average and binary variables at 0 | Probability of being in the high LE group when falling into binary factor group, holding all other factors at average | |
| Average distance from GP >1.6 miles | | 0.012 | 0.004 | |
| Other South West | | 0.012 | 0.14 | |
| TTW (suburbs) South West | | 0.012 | 0.24 | |
| TTW (central) London | | 0.012 | 0.55 | |
| TTW (central) Yorkshire and Humber | | 0.012 | 0.13 | |



Table D6 Persistently low life expectancy over time – the influence of a 5 per cent absolute increase or decrease in significant variables

| Low outliers prob vs normal group | Typical value (%) (average across MSOAs) | Normal probability of being in the low LE group (if high LE areas are excluded), holding all continuous factors at average and binary variables at 0 (%) | Probability of being in the low LE group after 5% increase from typical value, holding other factors constant (%) | Probability of being in the low LE group after 5% decrease from typical value, holding other factors at average (%) |
|---------------------------------------|--|---|---|---|
| Older people’s deprivation | 19.713 | 0.31 | 0.451 | 0.210 |
| Children’s deprivation | 21.184 | 0.31 | 0.290 | 0.331 |
| Employment deprivation | 10.042 | 0.31 | 1.56 | 0.04 |
| Poor quality housing | 29.344 | 0.31 | 0.39 | 0.24 |
| % of people who smoke | 20.615 | 0.31 | 0.46 | 0.21 |
| % of people with BME status | 14.259 | 0.31 | 0.45 | 0.21 |
| % binge drinking | 19.946 | 0.31 | 0.78 | 0.11 |
| % of pupils obtaining 5 or more GCSEs | 64.333 | 0.31 | 0.29 | 0.33 |
| Binary factors | | Normal probability of being in the low LE group (if high LE areas are excluded), holding all continuous factors at average and binary variables at 0 | Probability of being in the low LE group when falling into binary factor group, holding all other factors at average | |
| Average distance from GP >1.6 miles | | 0.31 | 0.11 | |
| Other | | | | |
| North West | | 0.31 | 0.48 | |
| North East | | 0.31 | 0.17 | |
| South West | | 0.31 | 0.06 | |
| Travel-to-work (suburb) | | | | |
| London | | 0.31 | 0.07 | |
| North West | | 0.31 | 0.20 | |
| North East | | 0.31 | 0.14 | |
| Yorkshire and Humber | | 0.31 | 0.67 | |
| Travel-to-work (central) | | | | |
| London | | 0.31 | 0.03 | |
| North West | | 0.31 | 0.55 | |
| West Midlands | | 0.31 | 0.02 | |
| Yorkshire and Humber | | 0.31 | 0.15 | |



At first glance, the impact may appear quite small. But we are focusing on membership of exclusive groups – there are 158 and 335 MSOAs counted as having persistently high or low life expectancy respectively in our dataset of 6,700 areas. In this context some factors have a dramatic effect on the relative chances of living in a persistently high or low life expectancy area.

For example, if you lived in an area with entirely average levels of older people's and children's deprivation, employment deprivation, people who smoke and people with BME status in a baseline area, and you then moved to central London, your chances of living in an area with consistently and unusually high life expectancy will suddenly shoot up from 0.012 per cent to 0.55 per cent. In relative terms, you are therefore more than 45 times more likely to be in the high outlier group if you live in central London than anywhere in a baseline area on average (we present the information in the main text in terms of these 'relative chances', since they are easier to interpret).

Some of the most important and consistent factors throughout our analysis is the significance and importance of employment deprivation, older people's deprivation and BME status. They appear in every regression result, and employment deprivation in particular has a consistently large effect size.

BME status at first sight appears slightly contradictory in these regressions, associated with both persistently higher life expectancy areas as well as persistently lower life expectancy. In other words, there is a larger chance of there being a relatively large population of people with BME status at the top and bottom ends of the distribution of life expectancy than there is in the middle. We believe that this is likely to be caused by the catch-all nature of our BME variable which includes all those who did not refer to themselves as 'white, British' in the 2011 Census (*see* Annex A). Clearly this will include very different people and communities with spatially patterned demographics and age ranges. Further analysis is required to unpack these effects more precisely.

Possibly more difficult to explain are the results for children's deprivation and GP distance. Being further than 1.6 miles from a GP practice is, like BME status, associated with the 'middle of the pack' – being in neither the persistently high nor low outlier group.



More counter-intuitive still is that rising deprivation among children increases the relative risk of being in a persistently high life expectancy MSOA and reduces the relative risk (albeit to a relatively minor extent) of being in a persistently low life expectancy MSOA. One possible explanation is that the link between child deprivation and life expectancy is less stable than some of our other variables because child deprivation affects life chances and quality of life, more than length of life per se.



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Our health is determined by a complex mix of factors including income, housing and employment status, and lifestyle. There are significant inequalities in health, including life expectancy, between individuals and groups in society. So what creates those inequalities and what are the implications?

Inequalities in life expectancy: changes over time and implications for policy revisits and updates some of the findings of *Fair society, healthy lives* ('The Marmot Review'). In addition, it considers a wider set of data on a range of factors for 6,700 small areas in England to explore how and why life expectancy is changing over time.

Our analysis shows that:

- although higher income deprivation is associated with lower life expectancy, between the period 1999–2003 and 2006–10 this relationship weakened; in effect income-related inequalities in life expectancy improved
- other factors such as employment deprivation, housing deprivation and lifestyle issues such as binge drinking are significantly associated with inequalities in life expectancy in the more recent data
- the area in which people live remains important over and above those general factors – for example, areas in central London are 10 times less likely to have low life expectancy than baseline areas.

The authors set out the implications of their findings for health care and public health policy, looking at the effects of previous government policies and calling for a more nuanced and integrated policy response to inequalities in health in future.

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