Local government funding and stalling life expectancy in England: a longitudinal ecological study

Alexandros Alexiou, PhD[1], Katie Fahy, MMath[1], Kate Mason, PhD[1], Davara Bennett, MSc[1], Heather Brown, PhD[2], Prof Clare Bambra, PhD[2], Prof David Taylor-Robinson, PhD[1], Prof Benjamin Barr, PhD[1]

[1] University of Liverpool, Department of Public Health Policy and Systems. Waterhouse Building, Liverpool, L69 3GF, United Kingdom.

[2] Newcastle University, Population Health Sciences Institute. Sir James Spence Building, Royal Victoria Infirmary, Newcastle upon Tyne, NE1 4LP, United Kingdom.

Abstract

Background. Since 2010 there have been large reductions in funding for local government services in England, due to cuts in central government funding. This has potentially led to reduced provision of health-promoting public services. We investigated whether those areas that experienced a greater decline in central government funding also experienced more adverse trends in life expectancy and premature mortality.

Methods. In this longitudinal ecological study we linked data on central government funding to 147 upper tier local authorities in England between 2013 and 2017 with outcomes on life expectancy at birth, at age 65, and premature (under 75 years of age) all-cause mortality for males and females. Using multivariable fixed effects panel regression models, we estimated whether changes in the level of funding from the Revenue Support Grant and Business Rates were associated with changes in these outcomes. We included a set of alternative model specifications to test the robustness of our findings.

Findings. Between 2013 and 2017, central government funding to local government decreased by 33% or £168 per person. Each £100 reduction per person in funding was associated with an average decrease in life expectancy at birth of 1·3 months (95% CI: 0·7 to 1·8 months) for males and 1·2 months (95% CI: 0·7 to 1·7 months) for females; and for life expectancy at 65, a decrease of 0·8 months (95% CI: 0·3 to 1·3 months) for males and 1·09 (95% CI: 0·7 to 1·5 months) for females. As funding reductions were greater in more deprived areas, the effect on life expectancy was greater in those areas. We estimated that cuts in funding increased the gap in life expectancy between the most and least deprived quintiles by 3% for men and 4% for women. Overall reductions in funding during this period were associated with an additional 9,600 deaths under 75 years old in England in total (95% CI: 3,800 to 15,400), an increase by 1.25%.

Interpretation. Our findings indicate that recent cuts in funding for local government may in part explain recent adverse trends in life expectancy. Since more deprived areas saw greater reductions in

funding, our analysis suggests that inequalities have widened. In the wake of the recent pandemic, strategies to address these adverse trends in life expectancy and reduce health inequalities could prioritise re-investment in funding for local government services, particularly within the most deprived areas of England.

Funding. National Institute for Health Research (NIHR) School for Public Health Research, NIHR Applied Research Collaboration North East and North Cumbria, NIHR Applied Research Collaboration North West Coast and Medical Research Council.

Research in context

Evidence before this study

We searched PubMed and Google Scholar from inception to March 19, 2021 for articles assessing the impact of local government spending on life expectancy or mortality using the terms ("local government") OR ("local services") AND ("expenditure" OR "spending" OR "austerity") AND ("life expectancy" OR "mortality"). The majority of relevant studies relate to the US and UK context, with a growing number of studies in the UK pointing to the association between declining life expectancy and reduced funding for public services following the imposition of austerity measures in 2010. These observational studies have largely focused on health service, public health and social care spending and have been based on relatively simple analyses of national trends, providing weak causal evidence. To our knowledge, there have been no previous studies in the UK investigating the impact of reduced local government funding on life expectancy and premature mortality.

Added value of this study

We investigated whether areas that experienced a greater decline in allocated funding between 2013-2017, also experienced greater declines in life expectancy. During this period, we estimated that each £100 reduction in funding per person was associated with an average decrease in life expectancy at birth of 1·3 months (95% CI: 0·7 to 1·8 months) for males and 1·2 months (95% CI: 0·7 to 1·7 months) for females. In total, reductions in funding during this period were associated with an additional 9,600 deaths under 75 years old in England (95% CI: 3,800 to 15,400). As reductions in funding were greater in more deprived areas, this widened inequalities. We estimate that cuts in funding may have increased the gap in life expectancy between the most and least deprived areas by 3% for men and 4% for women.

Implications of the available evidence

Reductions in funding for local government in England, along with recent policy changes on how funding is distributed among areas may have adversely affected life expectancy. Local government in England, as in many countries provides a wide range of services that have an impact on health, including housing, social care, cultural, planning and environmental services. Our study suggests that reduced funding for local services that disproportionally affected deprived areas may have had a significant impact on health. Increasing investment whilst prioritising deprived areas could reduce health inequalities.

Introduction

Life expectancy in the England has stalled. Although similar trends have been observed in many high-income countries since 2011, the situation in England is among the worst.[1] These adverse trends in life expectancy have disproportionately affected the most deprived areas, reversing improvements in inequalities accrued over the previous decade.[2]

The reasons for this plateauing remain unclear; it is unlikely that the population has reached its natural biological limits, as life expectancy in other countries are higher and rising.[3] Most reviews have pointed to multiple factors,[4,5] including the timing of the smoking epidemic[1] or cold weather and higher levels of influenza.[5]These factors however do not explain the change in trend from 2011[4] or its persistence over multiple years. A growing number of studies have associated stalling life expectancy with reduced funding for public services following the introduction of austerity measures in England in 2010.[6–9] These studies have largely focused on health and social care expenditure and have been based on relatively simple analyses comparing national trends in spending and national trends in mortality, providing weak causal evidence. Studies of the relationship between mortality and public expenditure, also struggle with distinguishing between the effects of expenditure on health outcomes and reverse-causality; whereby increased expenditure is driven by increases in needs that are determinants of increased mortality.[10,11]

It is, however, plausible that reductions in public spending may have contributed to declining life expectancy.[12] The measures introduced by the UK government to reduce public spending following the 2008 financial crisis disproportionately affected local government, with local authorities (LAs) facing cuts in central government funding of nearly 50% between 2010 and 2017.[13] Local government services in England cover a wide range of services including housing, social care, public health, cultural, planning and environmental services. There is consistent evidence that these services can have an impact on health and therefore reducing funding for these services could adversely affect health.[14–16] This reduction in fiscal support has disproportionately affected poorer areas, where the need for services is typically greater.[17]

In addition to the overall cuts, the introduction of the Business Rates retention scheme in 2013 changed how funds are distributed between local governments in England.[18] Prior to 2013, all funds raised through Business Rates – the local taxation on business properties - were centrally pooled and redistributed to local government according to regularly updated assessments of need. In 2013, a new policy allowed councils to retain 50% of their business rates as a local share, before the rest is redistributed to LAs through the Revenue Support Grant (RSG), a grant provided by central government to support local governments' general expenditure on any service. This grant is also

allocated based on an assessment of need, however, the assessment was fixed at the 2013 level and has not been updated since[18] (see Appendix 1, p.1 for a comprehensive policy review). Authorities with increased Business Rates, for example through economic growth, have benefited from the additional income generated locally. Changes in funding from these sources since 2013 are therefore unlikely to be directly affected by changes in local needs for services and therefore analysis of the association between funding changes and health outcomes will be less affected by reverse-causality, as highlighted above.

RSG and Business Rates income make up a significant part of local government funding (approximately 25%, or £26 Billion in 2013), and changes in this funding is likely to have had an impact on service provision that could influence life expectancy. We, therefore, investigated whether local authority areas that experienced greater reductions in the RSG and Business Rates income, henceforth referred to as central government funding, between 2013 and 2017 experienced more adverse trends in life expectancy and premature mortality.

Methods

Study design

We carried out a longitudinal ecological study for 147 of the 152 upper tier LAs in England, between 2013 and 2017, using fixed effects regression. We excluded the City of London and the Isles of Scilly because of their small populations. We also excluded Dorset, Bournemouth and Poole as recent boundary changes meant that consistent data for these LAs were not available.

Data sources and measures

Our primary outcome variable was male and female life expectancy at birth between 2013 and 2017 by LA in England. Our secondary outcome variables were male and female life expectancy at 65 years of age, and premature (under 75 years of age) age-standardised mortality rate (ASMR) from all causes. All measures were provided by Public Health England (PHE) and are calculated over three-year intervals to account for annual fluctuations in mortality in relatively small populations In our analyses of annual trends, we took the middle calendar year as the reference year.

The main exposure variable was the annual per capita allocation of central government funding, defined here as the sum of the RSG and the retained Business Rates income to LAs, between 2013 and 2017, obtained from the Revenue Outturn Summary tables, published annually by the UK Department for Communities and Local Government. The funding calculation methodology is detailed in the

Appendix (p.5). All values were adjusted for inflation to 2017 prices using the gross domestic product deflator.[19] Per capita values were calculated using Office for National Statistics (ONS) mid-year population estimates.

A potential confounder in this analysis is the trend in overall economic growth in each LA, as this could increase income through retained Business Rates and contribute to increased life expectancy.[20] To control for these trends in our analysis we obtained data on unemployment rate, denoted as a percentage of the economically active population aged 16 and over, and the average annual Gross Disposable Household Income (GDHI) estimates for each LA, supplied by the UK Office for National Statistics (ONS). In additional analyses we allocated LAs to five equal groups based on their average income deprivation domain scores of the 2015 Index of Multiple Deprivation (IMD).[21]

Analysis

We first graphically explored the unadjusted association between changes in average life expectancy at birth and changes in central government funding to each LA, by sex. We then used a set of linear fixed effects regression models to estimate the association between change in central government funding and change in each of our health outcomes, within each LA, after adjusting for unemployment rate and average GDHI. The fixed effects approach removes unobserved confounders that vary between LAs but are constant over time.[22] We also included an annual trend term to adjust for the national long-term trend in health outcomes.

In all models we used robust clustered standard errors to reflect the fact that populations were not sampled independently and to ensure that standard errors were robust to serial correlation in the data. We estimated the models separately using male and female health outcomes (see Appendix, p.6 for model formulae).

We used the predicted marginal effects from these models to estimate trends in life expectancy at birth that would be expected across all of England and in LAs in the most and least deprived quintiles, if funding for local government had remained at the 2013 level, and graphically comparing expected and observed trends. Finally, we used the predicted marginal effects to estimate the additional number of premature deaths during this period compared to the estimated if funding had been maintained at the 2013 level. We used the R 4.0.2 programming language for the statistical analysis.

Robustness tests

We carried out a number of tests to assess the robustness of our findings including tests for normality, linearity, collinearity, heteroscedasticity (Appendix, p.7). To investigate whether results are sensitive to our model specification we estimated several alternative models, including: controlling for annual

fixed effects to account for annual shocks such as severe flu seasons, log transforming exposure and outcomes to account for potential diminishing returns from investment on life expectancy; and including population as an offset in order to account for potential spurious relationships due to mathematically coupling,[23] as both the outcomes (life expectancy, mortality) and exposure (funds per capita) are derived using population estimates. As the recent adverse trends in life expectancy could be related to other factors that have disproportionately affected deprived areas, we estimated a model allowing for differing annual trends by quintile of deprivation. Additionally, we estimated a model accounting differing annual trends by region to account for differential regional trends in access to healthcare. Since there have been very different trends in life expectancy within London in recent years, we estimated a model excluding London LAs, to examine whether our results were influenced by other factors inherent to the region. We also tested for potential confounding effects of internal migration and ethnicity. To explore whether our results are sensitive to our use of three-year moving averages for life expectancy, we calculate models using single-year data.

Finally, it is possible that trends in life expectancy after 2013 are associated with pre-existing trends, originating after the 2010 austerity measures. For this purpose, we conducted supplementary difference-in-differences analysis to test whether there was a change in life expectancy after the 2013 changes in funding. We identify the third of local authorities with the largest cuts in central government funding between 2013-2017, and compare the change in the life expectancy trends in this group to the rest of the LAs in England who received less severe cuts. Information on additional data sources used and detailed alternative model results can be found in the Appendix (p.13).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or the writing of the report. All authors had full access to all data in the study. The corresponding author had final responsibility for the decision to submit for publication.

Results

Central government funds to LAs, from the RSG and Business Rates streams, decreased by 33% in real terms between 2013 and 2017, from £514 to £346 per person on average. Average male life expectancy at birth increased by only 0.4% from 79.3 years in 2013 to 79.6 in 2017, whilst female life expectancy increased by only 0.1%, from 83.1 to 83.2. Figure 1 shows the unadjusted association between change in life expectancy and change in central government funding for each LA between

2013 and 2017. This indicates that LAs that experienced a greater reduction in central government funding over this period tended to experience slower growth in life expectancy, or indeed a decline, for both men (ρ= 0·308, p < 0·001) and women (ρ= 0·315, p < 0·001). Figure 1 also shows that declines in funding and more adverse trends in life expectancy have tended to be greater in the more deprived LAs.

Figure 1. Association between change in central government funds to each LA area and change in life expectancy at birth for men and women between 2013 and 2017.

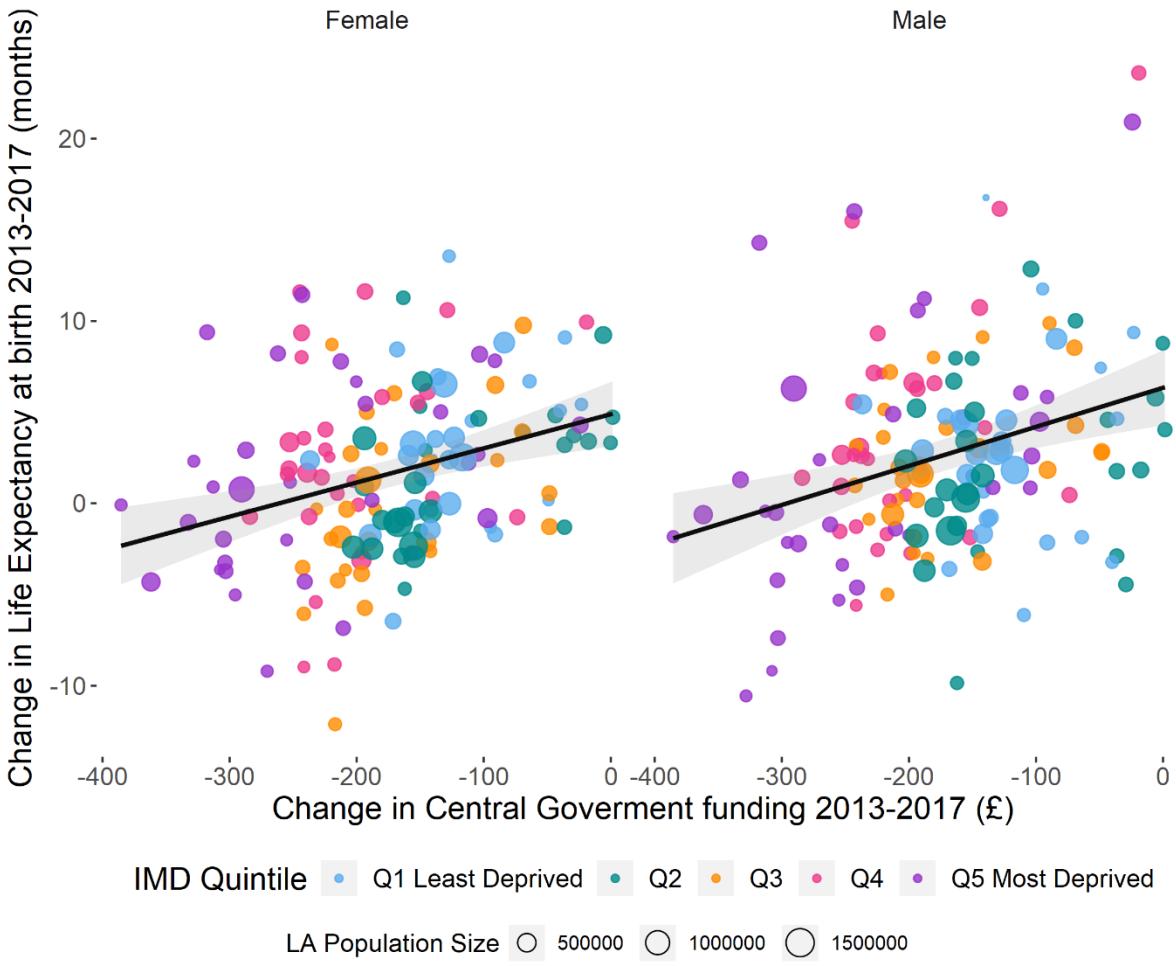


Table 1 shows the results from linear fixed effects multivariable regression models, outlining the association between trends in government funding for LAs and each of our outcomes. For males, a £100 per person reduction in central government funding to local government was associated with a reduction of approximately 1·3 months in life expectancy at birth (95% CI: 0·7 to 1·9), 0·8 months in life expectancy at age 65 (95% CI: 0·3 to 1·3), and 4 additional deaths under 75 per 100,000 population (95% CI: 1.6 to 6.3). For females, a £100 per person reduction in central government funding to local government was associated with a reduction of 1·2 months in life expectancy at birth (95% CI: 0·7 to

1·7), 1·1 month in life expectancy at age 65 (95% CI: 0·71 to 1·48), and 3 additional deaths under 75 per 100,000 population (95% CI: 1·3 to 4·6).

Table 1. Decrease in Life expectancy (months) and increase in premature mortality rate (deaths per 100,000) for each £100 per capita reduction in annual central government funds allocated to LAs.

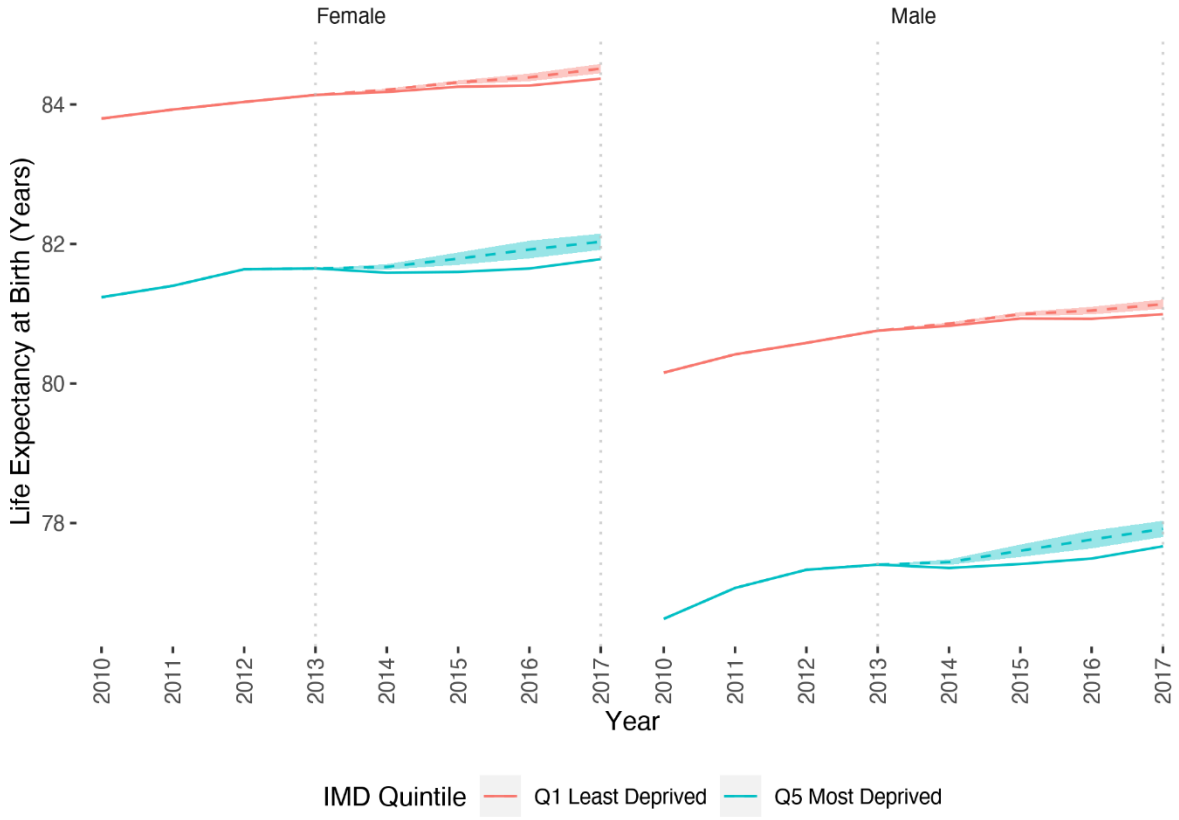
		Change in outcome for each £100 per capita reduction in Central Government Funding			
				95% C.I.	
	Outcome	Estimate	P-value	Lower	Upper
(1)	Males – Life expectancy at birth (months)	-1·28	<0·0001	-1·88	-0·69
(1)	Females – Life expectancy at birth (months)	-1·19	<0·0001	-1·73	-0·65
(2)	Males – Life expectancy at 65 (months)	-0·81	0·0021	-1·32	-0·29
(2)	Females – Life expectancy at 65 (months)	-1·09	<0·0001	-1·48	-0·71
(3)	Males - under 75 years old age-adjusted all-cause mortality rate (deaths per 100,000)	3·91	0·0012	6·27	1·55
(3)	Females - under 75 years old age-adjusted all-cause mortality rate (deaths per 100,000)	2·94	0·0005	4·61	1·27

Note: Model results based on fixed effects regression as shown in Appendix 3, p.6, equations (1)-(3), for male and female measures as noted, adjusted for trends in household income, unemployment rate, and national annual time trends. P-values and confidence intervals (95%) reported are based on robust clustered standard errors.

Overall, in the absence of the cuts over this 5-year period, we estimate that on average in 2017, male life expectancy at birth could have been 2·2 months higher (95% CI: 1·2 to 3·2) and female life expectancy could have been 2·0 months higher (95% CI: 1·1 to 2·9) than observed. Figure 2 shows the trend in life expectancy predicted from the regression models in the most and least deprived quintiles of LAs had funding been sustained at 2013 levels, compared to the actual trend. As reductions in local government funding were greater in more deprived areas, the estimated impact is greater in those areas. Over the 5-year period, the most deprived 20% of areas experienced an average decrease in central government funding per capita of £233, compared to £135 within the 20% least deprived areas. Our model suggests that within the most deprived quintile of areas, in the absence of cuts, male and female life expectancy at birth in 2017 could have been 3·0 months higher (95% CI: 1·6 to 4·4), and 2·8 months higher (95% CI: 1·5 to 4·0) respectively. Whilst within the least deprived quintile of areas, in the absence of cuts, male life expectancy at birth in 2017 could have been 1.7 months higher

(95% CI: 0·9 to 2.5), and female life expectancy at birth in 2017 could have been 1.6 months higher (95% CI: 0.9 to 2.3). Due to these differential effects by level of deprivation we estimate that the cuts in funding may have increased the gap in life expectancy between the most and least deprived quintiles by 3% for men and 4% for women. Using the models for premature mortality we estimated that overall, the reduction in funds for local government was associated with an estimated additional 9,600 deaths under 75 years old (95% CI: 3,800 to 15,400) over this 5-year period.

Figure 2. Actual trend in life expectancy between 2010-2017 and expected trend (dashed line) in the absence of cuts to central government funding for local government between 2013 -2017. Shaded area indicates the 95% confidence intervals of the prediction.



We found that the estimations of the alternative model specifications, as outlined in the robustness tests section above, did not markedly change the findings (see Table 7 in Appendix, p.14 for comparisons). Results from the analysis using single-year life expectancy measures show no significant change in strength or direction of the association. In difference-in-difference analysis accounting for pre-existing trends in life expectancy from 2010, we find similar effects with the third of LAs with the highest level of cuts experiencing a greater reduction in life expectancy after 2013 compared to LAs receiving less severe cuts (Appendix 4, p.11).

Discussion

Our study suggests that, during a period of large reductions in central government funds for local government in England, areas that experienced the greatest loss of revenue also experienced slower improvements or a decline in life expectancy and premature mortality trends. As funding for the most deprived LAs decreased to a greater extent than in other LAs, they experienced the most adverse impact –widening health inequalities.

While this study has not directly investigated causal mechanisms, potential pathways include those affecting mortality in older or vulnerable cohorts via the social determinants of health, over shorter time-lags. Increased mortality could be attributed to decreased spending in adult social care, housing and homelessness prevention, and environmental and regulatory services. There is evidence that decreased spending on people aged 65 and above has led to increased use of Accident and Emergency services.[11] Social isolation and loneliness are now recognized as important causes of death from cardiovascular disease and stroke[24] and decreased spending on social support services may impact mortality through these pathways over short time periods. Decreased investment in housing services has been associated with the sharp rise in homelessness since 2010.[25] Homelessness is viewed as a key risk factor for drug- and alcohol-related mortality.[26,27] In addition, environmental services include a broad range of services targeted at population health, including infectious disease control, food and water safety, and housing standards, which effect conditions associated with higher mortality from cardiovascular, respiratory, and communicable diseases, among others.[28]

Stalling life expectancy in recent years has been a major public health concern, not only in the UK but also in other European countries. Mortality trends and austerity measures occurred in parallel following the global financial crisis of 2008, and austerity policies have been associated with increased health and social crisis in Europe.[29] Similar mortality trends have also been observed in the USA, with similar timings but different underlying characteristics, the latter being heavily influenced by midlife deaths related to drug and alcohol abuse.[30] There is some American evidence on the effect of local services on mortality[31,32] but the relevance of these studies in international contexts is limited because of the underlying differences in healthcare systems and local service delivery.

Several strengths of our analysis enhance its validity. We assessed the natural policy experiment of changing funding for local areas in England using high quality longitudinal data. By using fixed-effects panel regression techniques we were able to control for potentially unobserved time-invariant confounders between LAs, as well as controlling for observed differences in economic trends. Our analysis of subnational variation in policy exposure is more informative than a simple analysis of national time trends, as we can also account for time-varying unobserved confounders that have a

similar effect across the country as a whole, such as particularly cold winters. We were able to address endogeneity concerns by identifying local government funding streams, whereby the change in resources from these streams would not be influenced by changes in needs during the study period.

Some limitations remain, however. There are weaknesses inherent to ecological studies, such as the use of aggregated data and the risk of ecological fallacy. We also cannot rule out the possibility that the associations observed were due to other confounding factors for which we were not able to control. Other policies introduced or rolled out during this period may also have affected mortality, for example, welfare reforms.[33,34] However, exposure to changes to the welfare system should still broadly reflect levels of deprivation. When we controlled for differential trends across levels of deprivation our results were largely unchanged – suggesting that this was not a major concern. Despite this, there may still be unrecognised but temporally coincident causes for the observed trends in life expectancy. Alternative explanations may include, for example, migration. While we did test the influence of the net internal migration on our estimates and found no substantive difference, we could not account for differences in demographic or socio-economic composition of migrant populations.

Analyses regarding the impact of cuts before 2013 were not possible because of the change in policy in 2013. Our main results could be influenced by pre-existing trends prior to 2013, however our supplementary difference-in-difference analysis shows a clear change in trend occurring after 2013 that disproportionately affected LAs that had experienced the greatest cuts. Due to the short time series of the study, we were also not able to investigate lagged effects. Expanding the dataset when additional years of data become available would allow a more reliable exploration of lag structures. Finally, we were not able to determine whether the association between funding reductions and reduced life expectancy was due to disinvestment in specific services. Analysis of specific service budget lines is complicated by the fact that they are not independent – increased spending in one service area usually means reduced spending in another area.

Our results have important implications for current policy. They suggest that both the level and distribution of investment in local government has an impact on health and health inequalities. Policies that are likely to shift resources away from more deprived areas, for example the UK government's "Fair Funding Review"[18] and the proposed expansion of the Business Rate Retention scheme,[35] will potentially increase inequalities.

The UK government has declared that austerity is over and has committed to investing more to "level up" those places that have previously been "left behind". This has become increasingly important following the global COVID-19 pandemic which may have disproportionately affected the health and

economy of the most disadvantaged places. Fair and equitable investment in local government could potentially redress these inequalities, enabling the country to "build back better".

Contributors

AA and BB drafted the manuscript and verified the underlying data. All other authors reviewed results, provided guidance on methodology and made critical revisions to the manuscript.

Declaration of interests

All authors declare no competing interests.

Data sharing

All source data used in this study are publicly available. Compiled datasets on central government funding, including the underlying methodology, are openly available to access at the https://pldr.org/ data repository maintained by the authors, or by contacting a.alexiou@liverpool.ac.uk.

Acknowledgments

This work was supported by the National Institute for Health Research (NIHR) School for Public Health Research, the NIHR Applied Research Collaboration North East and North Cumbria, the NIHR Applied Research Collaboration North West Coast and the Medical Research Council (MR/P008577/1).

References

1 Leon DA, Jdanov DA, Shkolnikov VM. Trends in life expectancy and age-specific mortality in England and Wales, 1970-2016, in comparison with a set of 22 high-income countries: an analysis of vital statistics data. *Lancet Public Health* 2019; **4**: e575–82.

2 Barr B, Higgerson J, Whitehead M. Investigating the impact of the English health inequalities strategy: time trend analysis. *BMJ* 2017; **358**. DOI:10.1136/bmj.j3310.

3 Marmot M. Social causes of the slowdown in health improvement. *J Epidemiol Community Health* 2018; **72**: 359–60.

4 Marshall L, Finch D, Cairncross L, Bibby J. Mortality and life expectancy trends in the UK: stalling progress. London: Health Foundation.

5 Public Health England. A review of recent trends in mortality in England. London: Public Health England, 2018.

6 Hiam L, Dorling D, Harrison D, McKee M. What caused the spike in mortality in England and Wales in January 2015? *J R Soc Med* 2017; **110**: 131–7.

7 Hiam L, Dorling D, Harrison D, McKee M. Why has mortality in England and Wales been increasing? An iterative demographic analysis. *J R Soc Med* 2017; **110**: 153–62.

8 Watkins J, Wulaningsih W, Zhou CD, *et al.* Effects of health and social care spending constraints on mortality in England: a time trend analysis. *BMJ Open* 2017; **7**: e017722.

9 Loopstra R, McKee M, Katikireddi SV, Taylor-Robinson D, Barr B, Stuckler D. Austerity and old-age mortality in England: a longitudinal cross-local area analysis, 2007-2013. *J R Soc Med* 2016; **109**: 109–16.

10 Martin S, Lomas J, Claxton K. Is an ounce of prevention worth a pound of cure? A cross-sectional study of the impact of English public health grant on mortality and morbidity. *BMJ Open* 2020; **10**: e036411.

11 Crawford R, Stoye G, Zaranko B. The impact of cuts to social care spending on the use of Accident and Emergency departments in England. The IFS, 2018 DOI:10.1920/wp.ifs.2018.W1815.

12 Marmot M. Health equity in England: the Marmot review 10 years on. *BMJ* 2020; : m693.

13 National Audit Office. Financial sustainability of local authorities 2018. London: NAO, 2018 https://www.nao.org.uk/report/financial-sustainability-of-local-authorities-2018/ (accessed July 6, 2020).

14 Marmot M. Fair Society, Healthy Lives: The Marmot Review. The Marmot Review, 2010.

15 Gibson M, Petticrew M, Bambra C, Sowden AJ, Wright KE, Whitehead M. Housing and health inequalities: a synthesis of systematic reviews of interventions aimed at different pathways linking housing and health. *Health Place* 2011; **17**: 175–84.

16 Bambra C, Gibson M, Sowden A, Wright K, Whitehead M, Petticrew M. Tackling the wider social determinants of health and health inequalities: evidence from systematic reviews. *J Epidemiol Community Health* 2010; **64**: 284–91.

17 Taylor-Robinson D, Gosling R, Harrison D, Khan M, Barr B. Austerity measures hit the sickest hardest. *BMJ* 2013; **347**: f4208.

18 Sandford M. Reviewing and reforming local government finance. House of Commons Library, Briefing Paper 07538. 2020 https://commonslibrary.parliament.uk/research-briefings/cbp-7538/ (accessed July 6, 2020).

19 Stoye G. UK health spending. The Institute for Fiscal Studies, 2017.

20 Barr B, Taylor-Robinson D, Whitehead M. Impact on health inequalities of rising prosperity in England 1998-2007, and implications for performance incentives: longitudinal ecological study. *BMJ* 2012; **345**. DOI:10.1136/bmj.e7831.

21 Ministry of Housing, Communities & Local Government. English indices of deprivation 2015. 2015; published online Sept 30. https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015 (accessed July 6, 2020).

22 Rabe-Hesketh S, Skrondal A. Multilevel and Longitudinal Modeling Using Stata, Second Edition, 2nd edn. Stata Press, 2008 https://www.stata.com/bookstore/mlmus2.html (accessed July 6, 2020).

23 Archie JP. Mathematic coupling of data: a common source of error. *Ann Surg* 1981; **193**: 296–303.

24 Valtorta NK, Kanaan M, Gilbody S, Ronzi S, Hanratty B. Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. *Heart Br Card Soc* 2016; **102**: 1009–16.

25 Loopstra R, Reeves A, Barr B, Taylor-Robinson D, McKee M, Stuckler D. The impact of economic downturns and budget cuts on homelessness claim rates across 323 local authorities in England, 2004–12. *J Public Health* 2016; **38**: 417–25.

26 Morrison DS. Homelessness as an independent risk factor for mortality: results from a retrospective cohort study. *Int J Epidemiol* 2009; **38**: 877–83.

27 Ivers J-H, Zgaga L, O'Donoghue-Hynes B, Heary A, Gallwey B, Barry J. Five-year standardised mortality ratios in a cohort of homeless people in Dublin. *BMJ Open* 2019; **9**: e023010.

28 Krieger J, Higgins DL. Housing and Health: Time Again for Public Health Action. *Am J Public Health* 2002; **92**: 758–68.

29 Karanikolos M, Mladovsky P, Cylus J, *et al.* Financial crisis, austerity, and health in Europe. *Lancet Lond Engl* 2013; **381**: 1323–31.

30 Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci* 2015; **112**: 15078–83.

31 Leider JP, Alfonso N, Resnick B, Brady E, McCullough JM, Bishai D. Assessing The Value Of 40 Years Of Local Public Expenditures On Health. *Health Aff Proj Hope* 2018; **37**: 560–9.

32 Goldstein ND, Palumbo AJ, Bellamy SL, Purtle J, Locke R. State and Local Government Expenditures and Infant Mortality in the United States. *Pediatrics* 2020; **146**. DOI:10.1542/peds.2020-1134.

33 Barr B, Taylor-Robinson D, Stuckler D, Loopstra R, Reeves A, Whitehead M. 'First, do no harm': are disability assessments associated with adverse trends in mental health? A longitudinal ecological study. *J Epidemiol Community Health* 2016; **70**: 339–45.

34 Wickham S, Bentley L, Rose T, Whitehead M, Taylor-Robinson D, Barr B. Effects on mental health of a UK welfare reform, Universal Credit: a longitudinal controlled study. *Lancet Public Health* 2020; **5**: e157–64.

35 Smith NA, Phillips D, Simpson P. 100% business rate retention pilots: what can be learnt and at what cost? 2018; published online April 12. DOI:10.1920/BN.IFS.2018.BN0233.