Evaluating effects of recent changes in NHS resource allocation policy on inequalities in amenable mortality in England 2007-2014: time-series analysis

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Abstract

Objective
To evaluate the impact of changes in English National Health Service (NHS) resource allocation policy on spatial inequalities in mortality amenable to healthcare.

Design
Time series study.

Setting
324 lower-tier local authorities in England, stratified by level of deprivation.

Exposure variable
Funding allocations to local NHS commissioners between 2007 and 2014, mapped to lower-tier local authorities.

Outcome measure
Directly age-standardised under 75-year mortality rates for conditions amenable to healthcare for men and women, adjusted for local trends in household income, unemployment and overall time trend.

Results
More deprived areas generally received proportionally more funding between 2007-2014, though the reorganisation of commissioning in 2012 appears to stall this. Funding increases to the most deprived 20% local authorities accounted for a statistically significant reduction in the gap between deprived and affluent local authorities of 13 deaths amenable to healthcare per 100,000 population (95% confidence interval 2.5 to 25.9) among men. Funding changes also were associated with a reduction in inequalities in female deaths amenable to healthcare of 7.0 per 100,000, though this finding did not reach the 5% significance level (p=0.09).

Conclusion
Current NHS resource allocation policy in England appears to be contributing to a convergence in health outcomes between affluent and deprived areas. However, careful surveillance is needed to
evaluate whether diminished allocations to more deprived areas in recent years and reduced NHS investment as a whole is impacting adversely on inequalities between groups.

<table>
<thead>
<tr>
<th>What is already known on this subject?</th>
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<tr>
<td>▪ Rates of mortality in England due to conditions potentially amenable to healthcare vary significantly between socioeconomic groups with more deprived areas displaying far higher rates</td>
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<tr>
<td>▪ Previous analyses of policies aiming to address have shown apportioning greater levels of healthcare funds to more deprived areas to be one effective approach of tackling such inequalities between more deprived and affluent areas</td>
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<table>
<thead>
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<th>What this study adds?</th>
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<td>▪ Despite lower funding since 2010, an financial recession in 2008 and a reorganisation of the NHS in England in 2013, inequalities in amenable mortality continued to fall between 2007 and 2014 for men and women</td>
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<tr>
<td>▪ Data from more recent years however suggests successive gains are slowing and may more worryingly be in reverse</td>
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<tr>
<td>▪ Our model demonstrates differential NHS investment in more deprived areas to remain to be a cost-effective and potent way of addressing health inequalities alongside wider more upstream strategies</td>
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Introduction

Since 2010 the National Health Service (NHS) in England and other public services have faced significant funding pressures, in an effort to reduce government deficits following the global economic crisis. Following record and unprecedented investment from prior to 2010, health services received between 2010 and 2016 an average of 1.3% additional funding, against rises in demand of over 3% per year. Given rising pressures on the health service, many have questioned whether the system can cope with such budgetary pressures, given such unparalleled scarcity of spending.

Public services cross-sectorally have faced similar or more stringent budget cuts, which appear under current evidence to be negatively impacting population health. One study evaluating suicides following the financial crisis in England found that areas that experienced the highest rises in unemployment saw greater numbers of suicides, with unemployment also correlated with council budget cuts. Another study concluded budgetary reductions to income-support for low-income pensioners since 2011 to be associated with rises in old-age all-cause mortality in local areas. Inequalities in mental health problems also widened between 2009 and 2013, mirroring trends in unemployment and wages. One study estimated spending constraints on healthcare between 2010 and 2014 to be associated with around 45,000 excess deaths, predominantly among those aged over 60 or those in care homes; while the precise determinants of such deaths is challenging to elucidate, recent data released by the Office for National Statistics, corroborated by Public Health England, the Kings Fund, the Institute of Health Equity and actuaries producing industry analyses, has demonstrated a significant deceleration in the long-term trend of successive annual reductions in mortality rates in England and Wales, from around the early 2010s.

Compared with recent years, the preceding period saw a rather different political programme and improvement in population health as a result. From 2003, the English government embarked on a comprehensive programme to tackle health inequalities, aiming to narrow the gap between the most deprived and other areas in infant mortality and life expectancy by 10%. Initial analyses
suggested the strategy to have been ineffective,\textsuperscript{16,17} however subsequent evaluations with further data eventually concluded it to have achieved its aims.\textsuperscript{18}

Evaluating the impact of healthcare on inequalities in health between socioeconomic groups is challenging, particularly since the major drivers of such disparities are predominantly socioeconomic or environmental in origin.\textsuperscript{19} One approach is to focus specifically on deaths that ought to have been avoided were timely and quality health care to have been available and delivered, otherwise termed ‘amenable mortality’.\textsuperscript{20,21} One study using focusing on amenable mortality found differential funding increases to more deprived areas between 2001 and 2011 to have significantly contributed to a narrowing in inequalities between deprived and affluent areas,\textsuperscript{22} possibly owing to the particular way in which funds were targeted towards encouraging primary care access, supply and quality.\textsuperscript{23}

Since 2013, deprived areas in England have received far less proportionally than in previous years.\textsuperscript{24} Furthermore, reduced investment in the NHS as a whole has delayed progress in redistributing funding to areas that have been historically underfunded under the ‘pace of change’ policy.\textsuperscript{25} Given the significant changes in fiscal and health policy since 2010 and emerging indications from other studies that such reforms are having a damaging effect on population health, we sought to repeat a previous analysis, examining 2001-2011 data and conducted by one of our authors, this time exploring the impact of healthcare funding policy on inequalities in amenable mortality in England between 2007 and 2014, exploring whether changes in overall funding and the distribution of those funds are already having an impact on the gap in rates of amenable mortality, using secondary NHS data.

\textbf{Methods}

\textbf{Setting and data sources}

We undertook a time series analysis using panel data from secondary data sources in England. To do this, we studied data from between 2007 and 2014 on 324 lower-tier local authorities in England, based on 2009 boundaries. The City of London and Isles of Scilly were excluded due to their small population size. Given the study involved publicly available anonymised secondary data, no ethical approval was necessary.

For annual data for the outcome variable, we extracted directly age-standardised under 75-year mortality rates for males and females for conditions amenable to healthcare for each local authority between 2007 and 2014 from the NHS Digital Indicator Portal.\textsuperscript{26} Amenable mortality has been used frequently to assess health system performance and includes any cause of mortality that is judged to constitute a failure to deliver quality or timely healthcare interventions (see supplementary appendix 1).\textsuperscript{20,21} The Indicator Portal also provided outcome variable data for rates of mortality from causes amenable to healthcare excluding ischaemic heart disease and from causes considered not to be amenable to healthcare which we used to perform robustness analysis of our regression model.

Our main exposure variable was funding allocations to local NHS commissioners across England between 2007 and 2014 which we collected from the Department of Health (see supplementary appendix 2 for full detail). To create consistency over time and ensure exposure and outcome data came from consistent analytical units, we mapped funding allocations from NHS commissioners to local authorities using population counts at Lower-layer Super Output Area (LSOA) level, a statistical geography with population of 1000-3000, and the development of a lookup between different commissioners and geographical levels, using existing lookups (see supplementary appendix 2). Allocations were adjusted for inflation using published Gross Domestic Product (GDP) deflators for
2015/16 and thereafter converted to per capita allocations for local authorities using census populations from 2011.\textsuperscript{27}

Previous analyses of NHS funding and inequalities in amenable mortality found household income and local trend in unemployment to exert a significant effect;\textsuperscript{22} as such, we incorporated annual gross disposable household income and unemployment benefit claimant rates for each local authority in our analysis, available from the Office of National Statistics (ONS).\textsuperscript{28,29}

**Statistical methods**

We first explored descriptive trends among local authorities in NHS allocations and in rates of amenable and non-amenable mortality, by quintile of deprivation, using the income component of the 2000 Index of Multiple Deprivation (IMD) score to classify local authorities.\textsuperscript{30} We used this deprivation ranking classification both to provide an accurate baseline for the period of analysis and to allow meaningful comparison to the previous analysis undertaken examining data from 2000-2014.\textsuperscript{22} For local authorities that merged since 2000, population-weighted average IMD scores were produced using ONS population estimates for these areas.\textsuperscript{31} We chose to present absolute and relative changes among the 20% most deprived and 20% least deprived local authorities, based on accepted practice of assessing both indices of change in health inequalities\textsuperscript{32,33} and to maximise comparability with the previous study conducted in 2014.\textsuperscript{22}

Thereafter, a fixed effects linear regression model was developed using the PLM package in R (version 3.4.1)\textsuperscript{34,35} to estimate the effect of changes in NHS allocation on rates of amenable mortality, controlling for confounding by trends in gross disposable household income and unemployment rates. We incorporated fixed effects for individual (local authority) and annual trends to model unobserved heterogeneity and confounding.\textsuperscript{36} Variation in the impact of allocation on amenable mortality was explored using an interaction term between NHS allocation and quintile of deprivation, to understand the differential impact of funding on overall population inequalities. Finally, we fitted robust standard errors from Driscoll and Kraay to reflect the inevitable clustering and serial auto-correlation present in our data.\textsuperscript{37} Models were estimated separately for male and female amenable mortality (see supplementary appendix 3 for model formulae).

**Robustness tests**

We conducted several robustness tests to explore the strength of our findings. Firstly, we performed standard regression diagnostics, testing for non-linearity between the exposure and outcome variables, for normality of residuals and for homoscedasticity (see supplementary appendix 4). Second, we tested the specificity of our findings by modelling the relationship between funding allocations and potential years of life lost (PYLL) due to mortality from amenable causes, mortality rates from causes amenable to healthcare excluding ischaemic heart disease and mortality from causes considered not amenable to healthcare (see supplementary appendix 5). We posited that any association identified between changes in NHS funding and rates of amenable mortality would be similarly identified with other variables involving indices of mortality amenable to healthcare (amenable mortality excluding IHD and PYLL from amenable causes), but not for the mortality not amenable to healthcare variable.

**Results**

**Descriptive analysis**

NHS funding allocation per head increased in real terms in each local authority quintile annually until 2012 (see Figure 1). Between 2012 and 2013, the two most deprived quintiles’ allocations reduced,
while the remaining three least deprived quintiles’ allocations rose. Funding increased per head between 2007 and 2014 by £499 in the most deprived quintile, a 37% increase, whereas the least quintile received £471 per head more funding, a 45% increase.

Figure 1 – Trend in population-weighted average NHS allocation per person to and inequalities in funding between most deprived and least deprived areas in England, 2007 to 2014.

Rates of amenable mortality among men and women both fell between 2007 and 2014, with the greatest fall in more deprived areas (figures 2 and 3). Amenable mortality rates fell among men in the most deprived local authorities from 210 (95% CI 186-241) to 166 (144-190) per 100,000, a relative decline of 21.0% (20.96-21.4%), while in the least deprived areas it fell from 125 (94-156) to 102 (74-126) per 100,000, an 18.0% (17.93-18.07%) relative decline. Amenable mortality rates fell among women in the most deprived local authorities from 133 (113-155) to 105 (89-126) per 100,000, a 21.0% (20.95-21.05%) relative decline, while in the least deprived areas it fell from 91 (65-116) to 72 (51-93) per 100,000, a 21.0% (20.92-21.08%) decline. Inequalities in male amenable mortality between the most deprived and least deprived areas between 2007 and 2014 narrowed in absolute terms by 21 deaths per 100,000 and in relative terms fell from 67% to 62%. In contrast, though inequalities in female amenable mortality fell marginally by 9 deaths per 100,000 during the period, in relative terms inequalities rose from 45% to 46%. Levels of inequality for men or women for mortality not amenable to healthcare changed little between 2007 and 2014 (see supplementary appendix 6). Trends in both amenable and non-amenable mortality appear since around 2009/10 to have changed, with reductions in amenable mortality among the most deprived areas plateauing, and rates of non-amenable mortality appearing in these areas to begin increasing.
Figure 2 – Trends in population-weighted average mortality amenable to healthcare for men in most deprived and least deprived areas and inequalities between areas in England, 2007 to 2014. AS=age standardised

Figure 3 – Trend in population-weighted average mortality amenable to healthcare for women in most deprived and least deprived areas and inequalities between areas in England, 2017 to 2014. AS=age standardised.

Statistical analysis

Our regression analysis shows that increases in funding allocations to the most deprived local authorities were associated with reductions in mortality amenable to healthcare for men, but not for women (see table 1 below). Increases in funding of £500 per person in NHS allocations were associated with a reduction in amenable mortality among men of 13 deaths per 100,000 population (95% confidence interval -1.5 to -25; p=0.03). This finding was in spite of significant socioeconomic changes in these areas following the financial crisis in 2007/08 and subsequent recession. There was
no significant association between funding allocations in the most deprived local authorities and mortality amenable to healthcare for women, though it did approach significance (p=0.09).

Table 1: Changes in amenable mortality for men and women for every £500 additional per person investment in NHS services, by local authority quintile of deprivation

<table>
<thead>
<tr>
<th>Local authority deprivation quintile</th>
<th>Change in amenable mortality rate per 100,000 population for every £500 per head additional NHS funding allocation (95% CI)</th>
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<tbody>
<tr>
<td></td>
<td>Males</td>
</tr>
<tr>
<td>First quintile (20% least deprived)</td>
<td>7.5 (-6.5, 21.0)</td>
</tr>
<tr>
<td>Second quintile</td>
<td>2.0 (-11.5, 15.0)</td>
</tr>
<tr>
<td>Third quintile</td>
<td>1.5 (-10.5, 13.5)</td>
</tr>
<tr>
<td>Fourth quintile</td>
<td>-2.5 (-15.0, 10.5)</td>
</tr>
<tr>
<td>Fifth quintile (20% most deprived)</td>
<td>-13.0 (-1.5, -25.0)</td>
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95% confidence intervals (CI) based on robust standard errors. Model based on equation 1 in supplementary appendix 3. Model adjusted for local authority, annual trend, local unemployment rates and gross household income per head for each local authority.

Further analysis of these figures suggests NHS resource allocation policy during this period accounted for a reduction in inequalities in absolute terms in mortality amenable to healthcare between the most deprived and least deprived areas of 13 deaths per 100,000 population (1.5 to 25) for men (see supplementary appendix 7 for calculations). The overall level of absolute inequality among men in mortality amenable to healthcare fell between 2007 and 2014 by 21 deaths per 100,000, suggesting that over half of this reduction could be explained by differential funding allocations to local areas. Unlike previous research, trends in unemployment rates and household income were not significantly associated with changes in amenable mortality rates, though their inclusion did adjust coefficient estimates, and given their importance in previous research it was felt they should be included.

Robustness tests

Diagnostics checks demonstrated our model conformed to conventional regression assumptions. The relationships between NHS allocation and mortality amenable to healthcare among the 20% most deprived local authorities was shown to be approximately linear (see supplementary appendix 3). Further checks for normality of residuals and homogeneity of variance of the error terms confirmed our linear regression model to be fitted appropriately.

Specificity testing of our model revealed mixed findings. A similar association was found between NHS allocation and mortality measured in potential years of life lost to causes amenable to healthcare as for under 75 mortality rates, with a significant association among men, but not among women (see supplementary appendix 5). However, no significant association was found between funding and amenable mortality excluding ischaemic heart disease for either men or women, while funding appeared to have a significant association with mortality among men from causes not amenable to healthcare, with increasing funding leading to greater reductions in mortality rates, an association that grew in effect size among more disadvantaged quintiles.
Discussion

Following a change in government in 2010, the financial crisis of 2008-2009 and a diminished policy focus on narrowing inequalities, our study has shown that inequalities in male and female mortality from causes amenable to healthcare continued to fall in absolute terms between 2007 and 2014. The reduction in inequality among men during this period appears to be explained statistically by differential funding to more deprived areas under the NHS resource allocation policy. In comparison, while our model did not find an association between funding increases to more deprived areas and reductions in inequalities in female amenable mortality that reached statistical significance at the 5% level, this may have been due to a lack of power owing to the lower numbers of death occurring or the short period under analysis. Of perhaps greatest concern however, amenable mortality rates in the most deprived areas since 2009/10 appear to be worsening, a trend which should it continue may erode past gains.

Comparison with other studies

Our findings corroborate previous research which has shown changes in health policy can impact on inequalities in mortality amenable to healthcare. Inequalities in amenable mortality fell in both absolute and relative terms between the most deprived and least deprived areas between 2007 and 2014 for males, and in absolute terms for females. One study by Asaria et al found relative inequalities to rise for both genders while absolute inequalities fell, though these authors aggregated individual mortality at an LSOA level, not local authority level, while no attempt was made to adjust for socioeconomic confounders.

Our analysis also appears to suggest a more conservative relationship between funding and reductions in amenable mortality than in previous studies in England. Reductions in amenable mortality may have become more refractory to funding increases over time. Alternatively, previous analyses took place during record investment in the NHS and a policy focus on tackling health inequalities; diminished funding and focus since 2010 in addition to the national reconfiguration of the health service may have distracted from this agenda.

The association between allocation and alternative mortality measures diverged in our model from that of other studies, which have shown a more consistent relationship between allocation and inequalities in amenable mortality. Given excluding deaths from IHD in our analysis attenuated the relationship, and non-amenable mortality includes 50% of IHD deaths, it is possible that cardiovascular deaths may have been responsible for the association; debate continues on the avoidability of IHD deaths and their classification as amenable. Alternatively, some unobserved confounder may have influenced the amenable and non-amenable mortality trends observed.

Strengths and Limitations

Our analytical approach has we believe several strengths. Our longitudinal approach increased the possibility that our exposure and outcome variables are causally linked. Second, unlike other studies, we controlled for recognised socioeconomic confounders. Third, we applied a granular approach to mapping local NHS allocations to local authorities, using LSOA populations. Finally, we adjusted our findings using robust standard errors, reflecting inevitable spatial and serial autocorrelation.

However, our findings should be considered in light of some limitations. There is likely to be multicollinearity in our model between IMD and socioeconomic confounders, inflating standard errors of coefficients and biasing our results towards the null hypothesis. As shown above, changes in funding were associated with a non-equivalent variable (non-amenable mortality) and not with one of the equivalent variables (amenable mortality excluding IHD). Our study also employed a
somewhat narrow focus on amenable mortality in under-75 year olds, with a particular concentration on more deprived groups: budgetary reductions may be causing wider challenges to other social groups and services. Finally, we cannot ignore the risk that unaccounted confounding variables were responsible for the.

Implications for future research & policy

Our study’s findings make a number of compelling claims for public health and policymakers. First, despite a short period of change in government and funding policy, trends in inequalities in amenable mortality appear far less favourable than in previous years, demanding further scrutiny and surveillance. Our analysis was challenged by the reconfiguration of healthcare commissioning in England in 2013; to our knowledge, no analysis by the Department of Health has compared local allocations both before the reforms and afterwards to demonstrate equity in the transfer of commissioning. Our findings suggest the most deprived areas suffered the most from the reconfiguration, and require further research to evaluate.

Secondly, our findings again confirm that health services have a role in narrowing the gap in mortality between deprived and affluent areas: deaths from amenable causes comprise approximately on third of total deaths, making it a ripe target for improvement. Downward revisions to the deprivation weighting in funding formulae since 2013, combined with limited overall NHS investment with consequent slowing of progress towards target allocations for local areas will have limited the potential impact of this investment. With both factors looking unlikely to change, the lost opportunity of what is arguably a far less intractable source of population mortality inequalities than deaths from wider social and economic policies should we believe make policymakers and healthcare planners take stock and reconsider their efforts to exploit the NHS’ role in tackling inequalities.

Finally, though post-hoc analysis of England’s Health Inequalities Strategy has demonstrated it to have reduced the gap in life expectancy between the most deprived local authorities and the rest of England for men and women,18 it would appear since the abandonment of this policy focus that progress is being rolled back. Reductions in amenable mortality have plateaued, while rates of remaining causes of mortality in deprived areas appear to be rising. While the Health and Social Care Act40 calls on the Secretary of State, NHS England and Clinical Commissioning Groups (CCGs) to give “regard to the need to reduce inequalities”, gone is the national strategy, cross-departmental collaboration and embedding of actions to combat inequalities across services and strategies that was previously witnessed.41 Instead, a focus on balanced budgets and marginal increases or cuts to public service budgets to achieve this have become the new focus, at the expense of greater equity of outcomes. Given the impact of health inequalities to social cohesion,42 economic productivity43 and government spending44 and current forecasts in pressures on public spending in years to come, the country cannot afford not to address these factors. A fresh national strategy to tackle inequalities using the learning from previous years and renewed investment in the NHS and other services could we believe achieve this in a short space of time.

Conclusions

Compared with previous periods, 2007 to 2014 saw proportionally less healthcare funding to deprived areas while overall increases in health spending slowed. Differential investment in deprived areas contributed to a reduction in amenable mortality for men, though not for women. With diminished political focus on narrowing inequalities since 2010, careful scrutiny is needed to ensure previous gains are not being lost.
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Transparency declaration: The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and if relevant, registered) have been explained.

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