The Effects of Austerity on Mortality: Evidence from the United Kingdom

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Abstract

This paper studies the impact of austerity measures introduced by the UK government after 2010 on life expectancy and mortality. We combine administrative data sources to create a panel dataset spanning from 2002 to 2019. Using a difference-in-differences strategy we estimate the effect of cuts to welfare benefits and health expenditure changes on life expectancy and mortality rates. We find that these austerity measures reduced life expectancy by 2 to 4 months by 2019. Women were impacted nearly twice as much as men. The primary driver of this trend is cuts to welfare benefits, with healthcare spending changes having a larger effect per pound. The findings suggest that austerity policies caused a three-year setback in life expectancy progress between 2010 and 2019. This is equivalent to 45000 excess deaths.

Keywords: Public economics, Austerity, Public health, Welfare programs
JEL Codes: H5, I18, I38

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1 Introduction

Between 2010 and 2020, many rich economies saw only a modest increase in life expectancy. This has followed decades of rapid rise in life expectancy. In the United Kingdom, male life expectancy at birth increased at a rate of 3.7 months per year between 1999 and 2010. Female life expectancy increased at a rate of 2.7 months per year during the same time. It increased almost 3 times slower between 2010 and 2018. This is shown in the left panel of Figure 1.

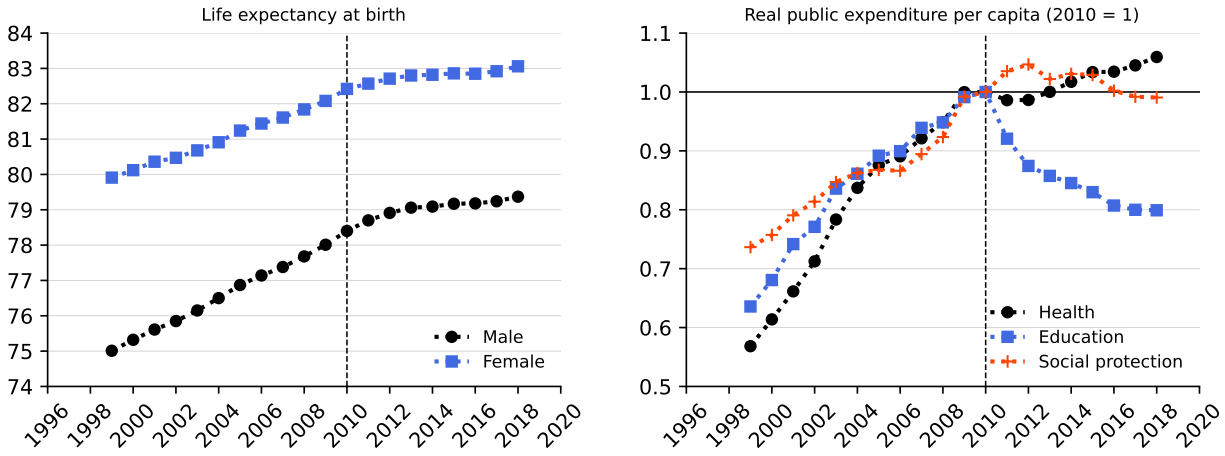

Figure 1: The evolution of life expectancy and public expenditure in the United Kingdom, 1999–2018.

Notes: Left) Male and female life expectancy at birth in the United Kingdom (source: Office for National Statistics (2021)); Right) UK-government real public expenditure per capita on health, education and social protection (normalized to 1 at 2010) (source: His Majesty's Treasury (2023)).

Following the global financial crisis, and after the 2010 general election, the British government adopted an austerity program, a contractionary fiscal policy. Between 1999 and 2010, real public expenditure per capita on health, education and social protection increased by 35 percent to 75 percent. However, between 2010 and 2018 expenditures decreased (in the case of education and social protection) or flatlined (in health). This is shown in the right panel of Figure 1. The similarity between the trends of life expectancy and public expenditures in health and social protection raises the hypothesis that austerity measures have caused increased mortality and contributed to the slow improvement in life expectancy.

This paper provides evidence that the austerity-induced cuts in welfare spending and changes in healthcare spending are important drivers of the slowdown in life expectancy after 2010. These cuts resulted in a decrease of 2.5 to 5 months in life expectancy by 2019, with women experiencing an impact twice as large as that on men. Between 2010 and 2019, austerity

measures caused a three-year setback in life expectancy progress, which is equivalent to 45000 excess deaths.

We proceed as follows. First, we build a comprehensive dataset that combines administrative data on life expectancy and mortality with data on public spending at the local-authority district level. We present a set of observations that highlight how life expectancy changed in the United Kingdom from 2002 to 2019.[1] This is before austerity measures began in 2010 and after they were fully implemented.

We show that while most districts in the United Kingdom saw a rise in life expectancy between 2002 and 2019, certain areas saw a marked increase while others saw it stagnating. This led to a growing gap in life expectancy between districts, yet only after 2010.

What led to the widening gap in life expectancy between districts after 2010? We show that the implementation of austerity measures after 2010, particularly reforms in welfare and healthcare occurring between 2010 and 2015, substantially increased mortality rates and slowed life expectancy growth.

Starting in 2010, the Conservative-led government initiated a substantial fiscal contraction. The per capita reduction in aggregate real government spending on welfare and social protection amounted to approximately 16 percent. At the district level, there was a 23.4 percent decline in real per-person welfare spending from 2010 to 2015. The magnitude of these reductions exhibited considerable heterogeneity across districts, spanning from 46.3 percent to 6.2 percent (equivalent to a 5 to 0.5 percent reduction relative to the district-average pay) (Innes and Tetlow, 2015; Fetzer, 2019). Large regional disparities were also evident in real changes in public spending on healthcare between 2010 and 2015. These varied between an £18 increase per adult per year in Greater London, and a £119 decrease per adult per year in the North East.

As described, we show that life expectancy increased slowly or decreased in areas with significant exposure to the cuts in welfare benefits after their implementation. Between 2002 and 2010, *i.e.*, before austerity measures were implemented, the average gap in life expectancy between the more austerity-exposed areas to the less exposed areas was stable at about 1.6 years at birth. Between 2010 and 2019, the gap had persistently grown to 1.9 years, a 19 percent increase, or 3.6 months in life expectancy at birth.[2]

The results provide a basis for assessing the comparative significance of fiscal measures in

[1] The paper stops at 2019 to avoid the strong effects of the COVID-19 pandemic on life expectancy and the complex policy responses to it.

[2] In this calculation, more-exposed (less-exposed) areas are defined as areas with impact higher (lower) than the median exposure to the austerity measures (see Section 2).

relation to mortality outcomes. Notably, the aggregate decline in life expectancy resulting from reductions in welfare benefits was found to be 3–5 times larger than that attributable to changes in healthcare spending. Yet, when considering the per-pound effect, healthcare spending had a 2–4 times larger effect compared with the welfare benefit cuts.

The findings also suggest that the mortality impact of austerity measures may represent a conservative estimate. Our analysis reveals no direct discernible effects on mortality from cuts in public expenditure on education, police, infrastructure, and other services by 2019. However, it is essential to recognize the potential latent effect they might have. Specifically, reductions in education spending and changes in nutrition and lifestyle induced by austerity may have significant mortality implications over an extended horizon, which could span several decades.

Moreover, the adverse effects of reductions in welfare and healthcare expenditures on life expectancy intensify progressively from 2011 to 2019. This implies that the impact of austerity measures on mortality extends beyond the period of 2011–2019. It has a lasting effect that warrants continued attention. This influence could also be relevant for current public health crises, such as the recent COVID-19 pandemic. An analysis of how austerity measures affected COVID-19 mortality exceeds the scope of this paper. Furthermore, Fetzer (2019) showed that austerity contributed to Brexit, which in turn, may have had negative health impacts, potentially exacerbating the negative impact of austerity on life expectancy.

Moreover, the impact of austerity was such that it increased disparities in life expectancy. The areas that were most reliant on welfare benefits, and therefore more exposed to the cuts, are also relatively poorer than the less-exposed areas. Their baseline life expectancy before 2010 was already lower than that of the areas least-exposed to cuts. Therefore, in addition to direct impact on mortality, austerity measures have increased inequality in health outcomes.

We also study the causes of increased mortality brought by austerity measures, and find that changes in healthcare spending, and in particular welfare cuts, caused an increase in drug-poisoning deaths. These account for about 1000 "preventable deaths" in the absence of austerity, which represents about 3 percent of all drug-poisoning deaths in the relevant period in England and Wales.

This paper is related to several strands in the literature. First, it highlights the substantial contribution of austerity measures, and in particular cuts in welfare benefits and healthcare spending, to the slowdown of life expectancy growth in the United Kingdom. This adds to previous work on the topic. For example, in a recent paper, which served as the basis for a debate on the topic in the House of Lords (Scott, 2023), Walsh et al. (2022) found that "approximately 335000 more deaths occurred between 2012 and 2019 than was expected

based on previous trends, with the excess greater among men." Yet, this estimate is based on an extrapolation from trends preceding the onset of austerity measures. It may overestimate the actual contribution of austerity measures to mortality, and takes into account overall changes in longevity that occurred at the time, and in particular the slower improvements in cardiovascular disease (CVD) mortality (Mehta, Abrams and Myrskylä, 2020; Cheema et al., 2022).[3]

This literature has been growing over the past decade. Rajmil and Fernández de Sanmamed (2019), for example, found that countries with moderate austerity measures experienced an additional mortality rate of 40.2 deaths per 100000 people annually compared to nations with low austerity by 2015. Toffolutti and Suhrcke (2019) revealed that after adjusting for the impact of recession, austerity programs are linked to a 0.7 percent rise in death rates. van der Wel et al. (2018) found that austerity measures were associated with increasing disparities in individuals' perceptions of their health, and that this association grew stronger over time. Moreover, a study by Loopstra et al. (2016) attempted to differentiate the impacts of cuts in pension credits and social care among the older population. They showed that a reduction of 1 percent in spending on pension credit resulted in a 0.65 percent increase in death rates among individuals aged 85 and older. Additional similar papers include Dorling (2019); Alexiou et al. (2021); Crawford, Stoye and Zaranko (2021); McCartney et al. (2022).

There are two main gaps in this literature that the current paper is aiming to fill. First, the quality of identification. This paper pushes forward the empirical design used in this literature so far. It addresses the direct impact of austerity measures on mortality and life expectancy more accurately than before. It does this by offering a quasi-experimental design. Second, the current paper discusses the impact of different austerity measures. This enables comparison between them without the need to bundle them together. It also offers a longer time frame than most previous papers on the topic, by using data going from 2002 to 2019.

Other studies have delved into more specific mortalities resulting from austerity measures. For example, Friebel, Yoo and Maynou (2022) explored the relationship between opioid abuse and austerity. They found that an increase in total local expenditure on public services leads to a significant decrease in opioid-related hospital admissions. Their results emphasized the link between unemployment and opioid-related deaths, noting that a 10 percent increase in unemployment significantly raises opioid-related deaths. Also, they found that higher total local expenditure mitigates this negative effect. These results are in line with ours, which highlight the significance of drug-poisoning deaths as a result of austerity measures.

[3]In Appendix A we address this issue and show that the excess deaths identified as caused by austerity measures are unlikely to be more accurately identified as CVD-related excess deaths.

Another strand of literature has been dedicated to exploring other effects of austerity. Fetzer, Sen and Souza (2023) showed that austerity-related cuts in housing benefits increased homelessness by 6.4 percent and rough sleeping by 41.3 percent. In a seminal earlier paper, Fetzer (2019) studied the relationship between austerity-induced cuts in welfare payments and support for Brexit. He showed that the "EU referendum could have resulted in a Remain victory had it not been for austerity." We build upon and expand the methodology used in these papers, contributing to this strand of literature.

The paper also contributes to the literature on the impact of public spending, particularly in terms of the Marginal Value of Public Funds (MVPF) (Hendren and Sprung-Keyser, 2020, 2022). MVPF is a unified method of assessing the impact of policy changes on social welfare. It is expected that a reduction or slower growth in public spending on healthcare and social protection will lead to a decrease in the rate at which life expectancy is increasing. Clearly, access to better healthcare and the ability to afford a healthier lifestyle would influence mortality. However, from the perspective of optimizing welfare gains from government spending, it is possible that the marginal welfare gain from an additional pound spent on healthcare is lower than if invested differently. Therefore, in addition to establishing a clear link between austerity measures and their effects on life expectancy and mortality, this research aims to translate the findings into the MVPF framework. This will allow comparing the results to other public policies. To the best of our knowledge, the only existing paper in which the MVPF framework is directly used in the context of UK austerity is Facchetti (2021), who found that austerity-induced closures of police stations in London "produced considerable distributional and efficiency losses, and generated costs that substantially outweigh the benefits in terms of lower public expenditure for the criminal justice system."

The paper contributes to the discourse surrounding the overall slowdown of life expectancy growth. In the United States, for example, "Deaths of Despair" (Case and Deaton, 2020, 2021) – from suicide, drug overdose, and alcoholism – have been identified as major contributing factors. However, their role in the overall slowdown of life expectancy growth is thought to be lower than that of the "stagnating decline in cardiovascular disease mortality" (Mehta, Abrams and Myrskylä, 2020). Our results show that a rise in deaths of despair has also occurred in Britain, and that a significant part of this increase could be attributed to austerity measures.

Finally, the paper also adds to recent work on the mortality and welfare outcomes of the Great Recession (Finkelstein et al., 2024), which largely coincides with the period considered in our context. Importantly, Finkelstein et al. (2024) find that the recession led to reduced mortality in the United States, primarily due to lower air pollution. These results, consistent

with the seminal paper by Ruhm (2000), suggest that the increased mortality and reduction in life expectancy we observe are unlikely to be attributed to the recession preceding the implementation of austerity measures.[4]

The rest of the paper is organized as follows. Section 2 discusses the context and the necessary institutional background, and describes the data. Section 3 describes the empirical strategy and presents the main results. Section 4 studies the specific role of drug-related deaths in the rise in mortality due to austerity measures. We conclude in Section 5.

2 Context and data

2.1 Mortality and life expectancy in the United Kingdom

The key motivation for the paper is a better understanding of the evolution of life expectancy and mortality in the United Kingdom. Figure 1 above showed a clear slowdown in life expectancy improvement after 2010. This slowdown can also be observed when considering the crude mortality rate, as presented in Figure 2. The crude mortality rate decreased quickly in the United Kingdom between 2002 and 2011, and has since gone up from about 8.75 deaths per 1000 a year to 9 deaths per 1000 a year in 2019.

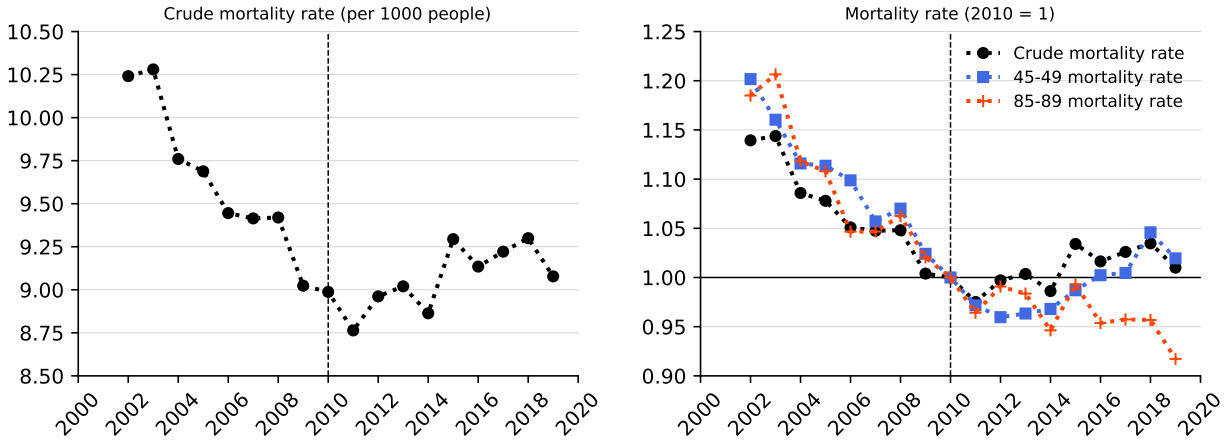

Figure 2: Crude mortality rates in the United Kingdom, 2002–2019.

Notes: Left) Crude mortality rate per 1000 people; Right) Crude mortality rates normalized to 1 at 2010 for all population (black), 45–49 year-olds (blue) and 85–89 year-olds (red).

The right panel in Figure 2 shows that different age groups experienced varying dynamics

[4]See Appendix A. The appendix shows that there is no correlation between the recession shock and the austerity shock across local authorities. Thus, even under an assumption that the recession had an effect on mortality, it would not interact with our treatment.

over the observed time period. For example, 85–89 year-olds still saw some improvement in their mortality rate between 2011 and 2019. The dynamics for 45–49 year-olds, however, follow closely the dynamics for the overall population. The differences between the evolution of mortality rates across age groups are suggestive of interventions with a differential effect. This could be related, among other factors, to welfare benefit cuts targeted at the working-age population, rather than at the elderly, as part of the austerity measures implemented between 2010 and 2015 (Beatty and Fothergill, 2014).

The trends shown in Figure 2 are not unique to the United Kingdom. Specifically, a similar trend has been observed in the United States. It has been largely attributed to slower improvements in cardiovascular disease (CVD) mortality (Mehta, Abrams and Myrskylä, 2020), although other deaths, and in particular drug-related deaths have been substantially increasing as well (Mehta, Abrams and Myrskylä, 2020; Case and Deaton, 2021).[5]

Importantly, there is a clear regional variation in life expectancy in the United Kingdom. Southern England, as well as small parts of Northern England, enjoy very high life expectancy, nearing 90 (85) years for females (males) at birth. However, other parts, particularly deprived areas in England and Scotland, suffer from poor health, with female (male) life expectancy as low as 78 (73) years at birth. The regional variation in life expectancy is presented in the left panel of Figure 3. The data are based on Office for National Statistics (2021) publications, and is in the local authority district level. There are 382 local authorities in the United Kingdom, which are the main municipal unit in the country, and are the main unit of observation used in this paper.[6]

In addition to differences in baseline life expectancy, UK districts experienced large variation in life expectancy improvement in the past decades. The right panel of Figure 3 shows the change in female life expectancy at birth between 2010 and 2019 across local authorities. They are only weakly correlated with the 2010 baseline levels ($\rho = 0.22$, $R^2 = 0.05$ for females; $\rho = 0.07$, $R^2 < 0.01$ for males).

The large regional variation, as well as the different trajectories of life expectancy over time across local authorities are useful for testing whether austerity had an effect on life expectancy and mortality. For conducting such tests it is necessary to measure the regional variation in exposure to austerity.

[5]Slower improvements in CVD mortality have also occurred in the United Kingdom between 2010 and 2019 (Cheema et al., 2022; World Health Organization, 2023), however not to the same degree as in the United States. Appendix A discusses these trends.

[6]For data availability reasons, the inclusion of Northern Ireland in the data requires treating it as a single local authority, making it the largest local authority in the dataset.

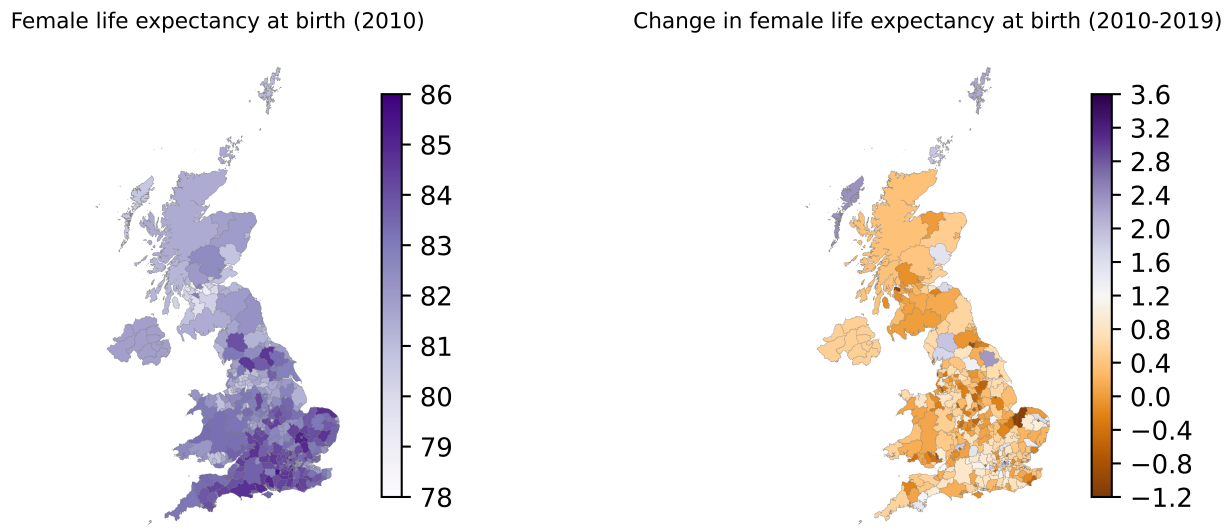

Figure 3: Geographic variation in life expectancy in the United Kingdom.

Notes: Left) Female life expectancy at birth in 2010 by local authority; Right) The change (measured in years) in female life expectancy at birth between 2010 and 2019 by local authority.

2.2 Measuring the impact of austerity

The Conservative-led coalition took power after the May 2010 general election, and in the midst of the global financial crisis. The newly-formed government instituted comprehensive austerity measures. They were aimed at drastically reducing government spending and limit public debt. Austerity entailed pervasive reductions in expenditures across all spending categories. As shown in the right panel of Figure 1, real public spending per capita substantially decreased in education and essentially remained flat in health. Healthcare expenditures were not directly cut. They leveled off as the demands on health services rose due to an aging and growing population.

The government employed a tripartite strategy to reduce expenditures. First, the 2010 budget caused an immediate impact by introducing cuts to day-to-day spending in most government departments. These cuts in local government funding subsequently strained local councils, forcing them to deliver services despite facing an increased demand due to population growth (Innes and Tetlow, 2015). Second, nominal freezes were put in place. Salaries for public-sector employees earning over £21000 from were frozen from 2011 to 2013. Then, a cap on wage growth at 1 percent was put in place from 2014 onwards. Similar freezes were instituted for most welfare benefits, leading to effective real-term cuts, as inflation averaged 1.8 percent over this time period.

The third and key part of this paper focuses on a major welfare reform initiated by the Welfare Reform Act 2012. Beatty and Fothergill (2014) detail pre-reform data on the distribution of claimants across various benefit categories and calculate the total impact of the reform on the total saving on welfare spending per working-age adult. We use these data to estimate the incidence of different welfare cuts at the local-authority level.

The calculation presented by Beatty and Fothergill (2014) is based on 10 welfare-related austerity measures.[7] It relies on official statistics, combining data from the UK Treasury's estimates of expected savings, government impact assessments, and benefit claimant information. Using these data, we define exposure to the welfare reform as the real monetary loss in benefits per working-age adult per year in each local authority.

The left panel of Figure 4 shows the exposure to the welfare reform (which we consider as 'total welfare impact') as calculated by Beatty and Fothergill (2014). It displays large geographical variation. The variation is driven by the uneven distribution of benefit claimants across the United Kingdom before the reforms. The overall annual monetary loss per working-age adult ranged between £914 in Blackpool and £177 in the City of London. As a share of district-level average worker's pay, these reductions ranged across local authorities between an annual reduction of 0.5 to 5 percent.

In addition to the large reform in welfare, austerity measures led to reductions in many public services. Although expenditure on these services varies among local authorities, achieving comprehensive redistribution of 100 percent of funds at the local-authority level is impractical, primarily because spending frequently takes place at broader geographic levels, such as county or regional levels. To address this, the UK Treasury offers a detailed breakdown of spending by region (His Majesty's Treasury, 2023). There are 12 regions in the United Kingdom: 9 regions in England (North East, North West, Yorkshire and the Humber, East Midlands, West Midlands, East of England, London, South East, South West), Northern Ireland, Scotland, and Wales. Each region is divided into local authority districts, which is the main unit of observation, as discussed above.

We estimate the regional exposure to austerity in services in a comparable way to the total welfare impact. We define:

$$A_{r,s} = \frac{E_{r,s,2010}}{N_{r,2010}} - \frac{E_{r,s,2015}}{N_{r,2015}}, \tag{2.1}$$

where $E_{r,s,t}$ is the real total spending in region r on service s in year t, and $N_{r,t}$ is the working-age adult population in region r and year t. The categories of services are: general

[7] These include changes to Local Housing Allowance (LHA), underoccupation or 'bedroom tax', non-dependant deductions, household benefit cap, council tax benefit disability living allowance, incapacity benefit, child benefit, tax credits, 1 percent uprating.

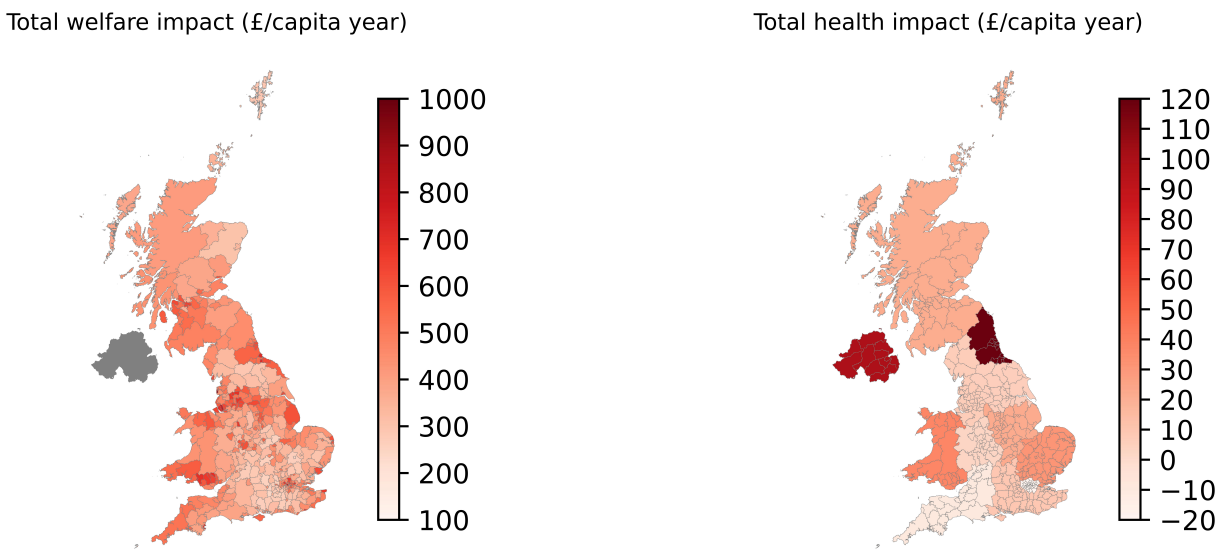

Figure 4: The distribution of austerity shocks across local authority districts in the United Kingdom.

Notes: Left) Total welfare impact – the average decline in welfare benefits per working-age adult per year by 2015 (no information available for Northern Ireland in Beatty and Fothergill (2014)); Right) Total health impact – the average decline in real healthcare spending per working-age adult per year between 2010 and 2015.

services, public order, economic affairs, housing and community, health, education, and social protection. We consider the various categories both separately and combined. Yet, the most relevant to mortality and life expectancy, in addition to the major welfare reform, is healthcare spending.

The right panel of Figure 4 shows the exposure to changes in health spending by region ($A_{r,HEALTH}$, or 'total health impact'). It shows large geographical variation in healthcare spending. In some regions, such as London, real annual spending per adult increased between 2010 and 2015. In others, such as Northern Ireland and the North East, it decreased substantially. Figure 4 also shows that the overall magnitude of the welfare reform was larger than the changes in healthcare spending. The average British person lost £473 per year in benefits by 2015, and was exposed to a real reduction of £13 in healthcare spending per year.

Importantly, there exists a weak correlation between the total welfare impact and the total health impact. At the regional level, a positive correlation between the two austerity shocks emerges, but it disappears when removing outliers, and proves to be statistically insignificant, as illustrated in Figure 5.

We define the exposure to changes in healthcare spending in an additional way. Dividing

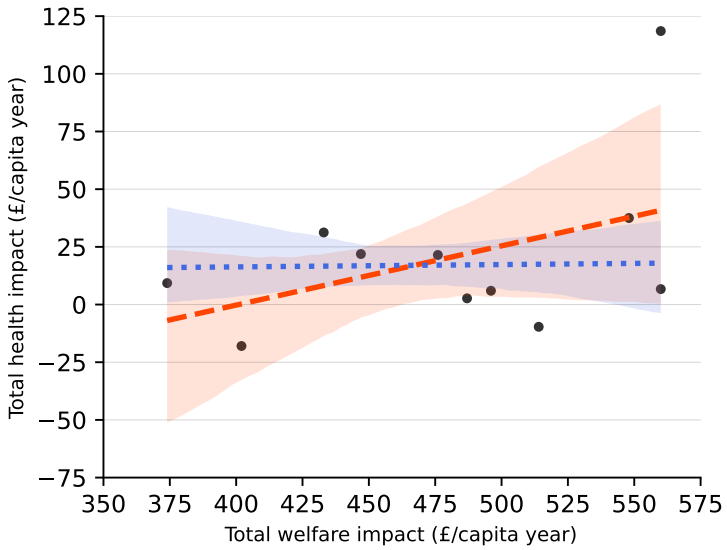

Figure 5: The association between total welfare impact and total health impact in the regional level.

Notes: The chart uses region-level averaged total welfare impact (Beatty and Fothergill, 2014) and the estimated total health impact. The chart excludes data for Northern Ireland, for which total welfare impact data are unavailable. The shaded areas represent 95 percent confidence intervals to the linear fits. The dotted linear fit excludes top and bottom outliers.

$A_{r,HEALTH}$, the total health impact, by the average annual worker's pay in local authority i ($i \in r$) for 2010, creates a relative health shock. The relative health shock ranges between -0.07 to 0.6 percent. Its advantage compared to the total health impact is that it allows for finer-grained geographical variation of the exposure to healthcare spending, as it varies between local authorities and not only between regions. This, in turn, enables considering region-year fixed effects when estimating the effect on life expectancy and mortality. Similarly, we define a relative welfare impact, by dividing the total welfare impact in a local authority by its average annual pay in 2010. These values range from 0.5 to 5 percent.

Exposure to police budget spending changes can also be estimated. This can be done in a finer geographical resolution than the regional. The local authority districts are divided into 44 police force areas, for which the annual spending by the UK government is detailed in the Police Grant Reports by the Home Office (UK Home Office, 2023). Each local authority is fully contained within a police force area, which in turn is fully contained within a region. This makes the police grant data compatible with the data described so far.

In addition to the information on life expectancy, and exposure to austerity measures, we use data on unemployment, average worker's pay, population, in- and out-migration and drug poisoning mortality rates by local authority. These are available from multiple datasets

published by the Office on National Statistics (Office for National Statistics, 2023). We compile all the information described into a large panel dataset, which comprises of all local authority districts in the United Kingdom, covering the years 2002 to 2019. This now allows for addressing various questions related to the impact of austerity on life expectancy and mortality. Descriptive statistics of key variables in the dataset are presented in Appendix B.

3 Results

3.1 Empirical strategy

Following the construction of the dataset, the next step is designing an appropriate empirical strategy. The key idea is using the large geographical variation in the exposure to various austerity measures, as well as the variation in life expectancy and mortality. Since austerity measures were mostly implemented in between 2010 and 2015, and our dataset comprises of the years 2002–2019, we can use a difference-in-differences design.

We make use of two main specifications. The first is a dynamic "event-study" design, which takes the following form:[8]

$$y_{i,r,t} = \alpha_i + \theta_{r,t} + \sum_{t \neq 2010} \delta_t \times Year_t \times Austerity_{i,j} + \mathbf{x}_{i,t}\beta + \epsilon_{i,r,t}\,, \tag{3.1}$$

where $y_{i,r,t}$ denotes the life expectancy (or mortality rate). $Austerity_{i,j}$ quantifies the exposure of unit i to austerity measure j – this would be the total wealth impact, total health impact, or another definition for the exposure to austerity. The fixed effect α_i absorbs any time-invariant differences in the outcome variable across local authorities. Region-by-year fixed effects $\theta_{r,t}$ capture nonlinear time trends specific to each of the regions across the United Kingdom. $\mathbf{x}_{i,t}$ are control variables. Standard errors are clustered at the local-authority level. The main coefficients of interest are the interaction terms (δ_t) between austerity measure j and a set of year dummies. This allows us to estimate the treatment effect dynamically, as well as testing for pre trends.

In the case of the total health impact the treatment is by region. Thus, we replace r in Equation (3.1) from being a region to being either England if the local authority is in England, or other, if the local authority is in Scotland, Wales or Northern Ireland. We discuss the sensitivity to these differences in Appendix A.

[8] This assumes that all units, *i.e.*, local authorities, are treated at the same time. This follows from Fetzer (2019).

The second specification is a pooled difference-in-differences design that takes the following form:

$$y_{i,r,t} = \alpha_i + \theta_{r,t} + \delta \times \mathbf{1}_{t>2010}(t) \times Austerity_{i,j} + \mathbf{x}_{i,t}\beta + \epsilon_{i,r,t}\,. \tag{3.2}$$

The main coefficient of interest is δ, which captures changes in the outcome variable $y_{i,r,t}$ following the exposure of unit i to austerity measure j. With the pooled difference-in-differences, the overall effect of each austerity measure on mortality and life expectancy can be estimated.

This design, including both specifications, follows closely Fetzer (2019), who used a similar strategy to estimate the causal effect of UK austerity measures on the support for Brexit. We expand it by using additional treatments to account for different austerity measures. Importantly, this allows a comparison of the effect different austerity measures had on life expectancy both overall, but also per pound. This will also be used to estimate the marginal value of public funds (MVPF) of the welfare and health treatments.

The empirical design assumes that the exposure of local authorities to austerity measures does not vary in a way that is correlated with unobservables. Justification for these assumptions is discussed in detail in Fetzer (2019) and Fetzer, Sen and Souza (2023). A specific potential concern is if life expectancy increased more slowly due to slow improvements in CVD mortality and if this effect is particularly observed in areas that are also more exposed to austerity measures, but not as a result of the austerity measures themselves. We address this concern in Appendix A.[9]

The impact of austerity measures on benefits, as assessed by Beatty and Fothergill (2014), exhibits a clear correlation with life expectancy across local authorities. This is also true for the total health impact, although to a lesser extent. This is depicted in Figure 6. Consequently, regions characterized by greater deprivation, where austerity measures had a more pronounced impact compared to other areas, demonstrated lower baseline life expectancy before the implementation of these measures. The non-random assignment of treatment requires rigorous testing of the difference-in-differences assumptions. Specifically, we use the tests outlined by Rambachan and Roth (2023) to verify the absence of severe violations to the parallel trends assumption (see Appendix A).

[9] Appendix A also considers the possibility that the observed effect on life expectancy results from the Brexit referendum, rather than from austerity measures.

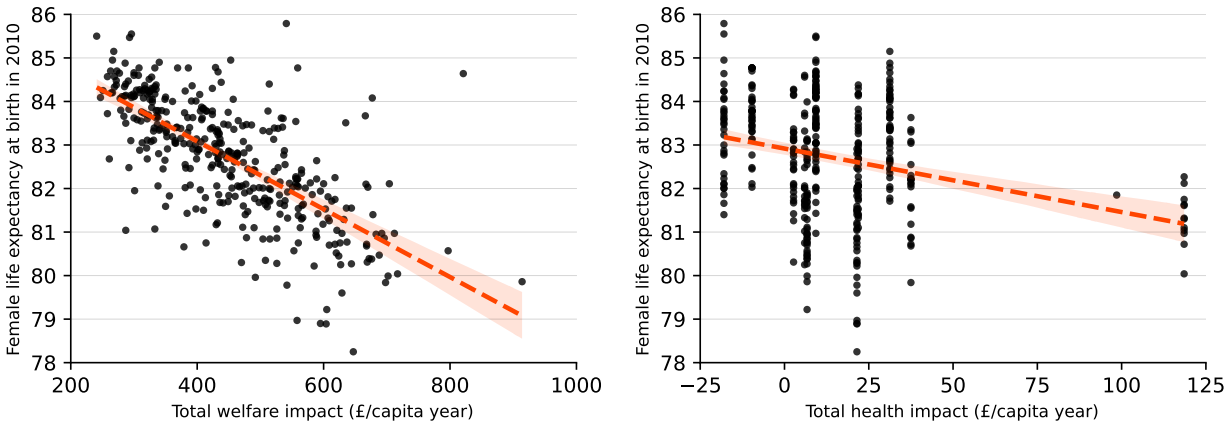

Figure 6: The association between life expectancy and exposure to austerity.

Notes: Left) The chart displays female life expectancy at birth in 2010 and total welfare impact across local authorities in the United Kingdom. The shaded areas represent 95 percent confidence intervals to the linear fit; Right) Similar to left, with total health impact. The total health impact is defined by region and not by local authority. Life expectancy is by local authority.

3.2 The welfare reform effect on life expectancy

We first consider the effect of the welfare reform.

The results from the pooled difference-in-differences analysis (Equation (3.2)) are presented in Table 1. The point estimates indicate a strong negative relationship between the austerity exposure and life expectancy. Computing the full in-sample distribution of point estimates suggests that life expectancy decreased, on average, by 2.6–3.7 months for men and 4.8–5.2 months for women between 2010 and 2019 as a result of the welfare treatment. This indicates that austerity policies caused a three-year setback in life expectancy progress between 2010 and 2019 (*c.f.*, Figure 1).

Importantly, the pooled difference-in-differences results are likely to underestimate the effect. The effects of the welfare reform on health outcomes may take time to manifest, and accumulate gradually over an extended period of time. As argued by Fetzer (2019), such results "may underestimate the effect of austerity [, since welfare] cut measures, such as freezing of benefits, or changes in inflation indexing, compound over time, while others only become fully effective at a later date."

In the event studies depicted in Figure 7, we present results for the dynamic specification (Equation (3.1)) for life expectancy at birth among females and males. There is no evidence of systematic divergence before 2010 in a fashion that is correlated with exposure to austerity. After the onset of austerity measures, a clear reduction in life expectancy is observed. The reduction is more pronounced among females. The result indicates that every £100 of benefits

Table 1: The impact of austerity on life expectancy in the United Kingdom – welfare results

	Female at 65	Female at birth	Male at 65	Male at birth
$\mathbf{1}_{t>2010}(t) \times Welfare$	-0.012***	-0.011***	-0.008***	-0.006**
	(0.002)	(0.002)	(0.002)	(0.003)
Average effect (months)	-5.2	-4.8	-3.7	-2.6
Mean of dep. variable (years)	20.6	82.4	18.0	78.5
Local authorities	379	379	379	379
Observations	6822	6822	6822	6822

Notes: The table reports results from a panel OLS regressions with the dependent variable being life expectancy in English, Welsh and Scottish local authorities between 2002 to 2019. The regressions control for local authority fixed effects as well as region by year fixed effects throughout, as well as for unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors clustered at the local authority level, with standard errors presented in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

lost on average in a year led to a decrease in life expectancy of 0.5–2.5 months. The estimated coefficients for the year 2019 are larger compared to the pooled difference-in-differences estimates, as expected. This reflects how the welfare effect on life expectancy is indeed compounding.

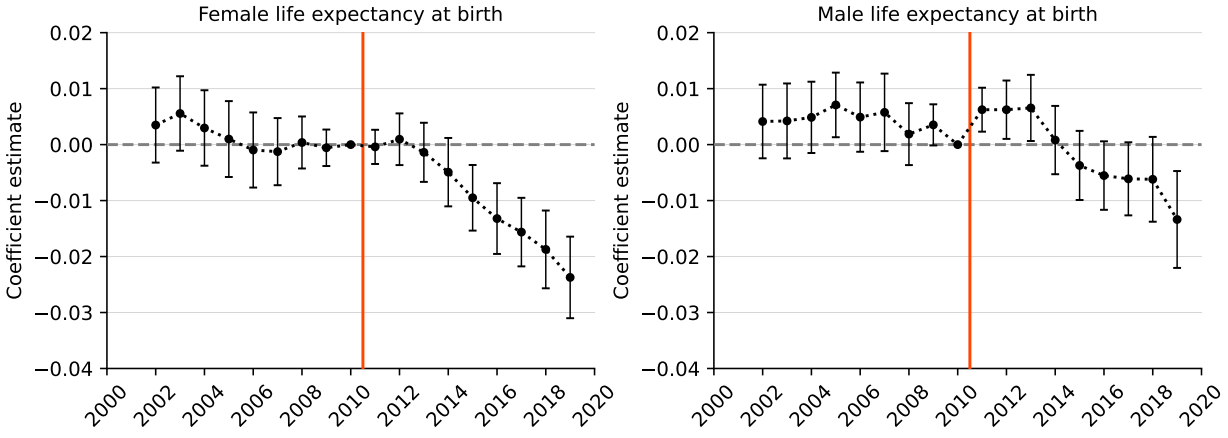

Figure 7: The effect of the welfare austerity shock on life expectancy at birth.

Notes: The dependent variable is female (left) and male (right) life expectancy at birth measured in months. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England, Scotland, and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

This lasting impact warrants continued attention, and may also be important for current

public health crises, such as the recent COVID-19 pandemic. It is plausible that the exposure of specific local authorities to the welfare reform has implications for factors linked to an increased risk of COVID-19 mortality. However, an in-depth analysis of this relationship extends beyond the scope of the present paper.

3.3 The healthcare spending effect on life expectancy

We now turn to the effect of changes in healthcare spending on life expectancy. We repeat similar estimations as done for the welfare impact while using the total health impact.

There exists a crucial distinction between the welfare and health total impacts. Notably, healthcare spending is defined at the regional level, as opposed to the local-authority level. Consequently, when considering health treatment, we replace the term $\theta_{r,t}$ in Equation (3.2) and Equation (3.1) with $\theta_{c,t}$ to account for country-year fixed effects, rather than region-year fixed effects. Appendix A presents a comparative analysis between region-aggregated and local-authority level treatments, revealing only minor differences. This provides confidence that using the region-aggregated total health impact is indeed reliable.

The results from the pooled difference-in-differences analysis (Equation (3.2)) are presented in Table 2. The point estimates indicate a strong negative relationship between the exposure to healthcare spending reductions and life expectancy (apart from life expectancy at 65 for males). The effect, measured per pound, is stronger than in the case of the welfare treatment. This result is expected, since healthcare spending has a clearer direct impact on life expectancy compared with welfare spending.

Yet, the average impact overall is smaller for the health treatment compared to the welfare treatment. Computing the full in-sample distribution of point estimates suggests that life expectancy decreased, on average, by 0.1–0.7 months between 2010 and 2019 as a result of the health treatment. The reason for this relatively small effect is that healthcare expenditures were not reduced as dramatically as welfare benefits.

In the event studies depicted in Figure 8, we present results for the dynamic specification (Equation (3.1)) for life expectancy at birth among females and males. Again, similar to the case of the welfare treatment, there is no evidence of systematic divergence before 2010 in a fashion that is correlated with exposure to the austerity measure. After the onset of austerity, a clear reduction in life expectancy is observed. The results indicate that a decline of £100 in annual healthcare spending led to a decrease in life expectancy of 5–7.5 months by 2019. This is in line with the pooled regression estimates, showing that the effect of healthcare spending on life expectancy per pound is much larger than of welfare spending.

Table 2: The impact of austerity on life expectancy in the United Kingdom – healthcare results

	Female at 65	Female at birth	Male at 65	Male at birth
$\mathbf{1}_{t>2010}(t) \times Health$	-0.021**	-0.038***	-0.009	-0.05***
	(0.008)	(0.012)	(0.009)	(0.015)
Average effect (months)	-0.3	-0.6	-0.1	-0.7
Mean of dep. variable (years)	20.6	82.4	18.0	78.5
Local authorities	380	380	380	380
Observations	6840	6840	6840	6840

Notes: The table reports results from a panel OLS regressions with the dependent variable being life expectancy in English, Northern Irish, Welsh and Scottish local authorities between 2002 to 2019. The regressions control for local authority fixed effects as well as country by year fixed effects throughout, as well as for unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors clustered at the local authority level, with standard errors presented in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

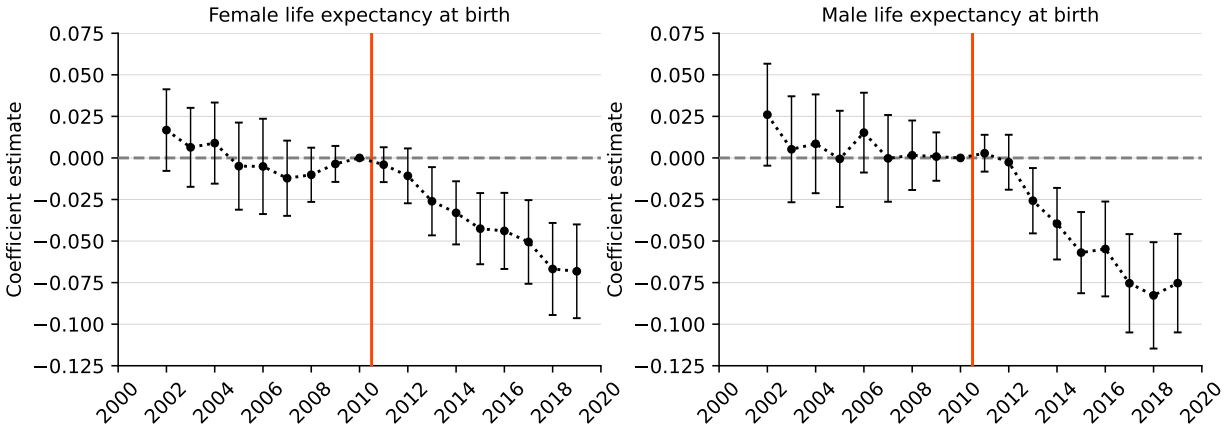

Figure 8: The effect of the healthcare austerity shock on life expectancy at birth.

Notes: The dependent variable is female (left) and male (right) life expectancy at birth measured in months. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England, Northern Ireland, Scotland, and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

In addition to the welfare and health treatments, other treatments can be defined. Specifically, public spending on other services, including police, education and economic affairs, has also decreased following the onset of austerity. Appendix A presents the effect of additional

treatments on life expectancy, showing that it is small and not robust.

3.4 Summary of main results

The results are indicative of a strong effect of both welfare and health treatments on life expectancy. It is also possible to combine the effects, and consider the total impact of the two. In order to add the two treatments in a meaningful way, we consider the total relative impact RI_i:

$$RI_i = \frac{WelfareImpact_i}{Pay_i^{2010}} + \frac{HealthImpact_i}{Pay_i^{2010}}\,, \tag{3.3}$$

where $WelfareImpact_i$ is the total welfare impact in local authority i, $HealthImpact_i$ is the total health impact in local authority i, and Pay_i^{2010} is the average annual worker's pay in 2010 in local authority i. This allows adding together the welfare and health treatments in the local-authority level, enabling using fixed effects in the most accurate way – considering region-year and local authority fixed effects.

Figure 9 presents event-study results for the dynamic specification (Equation (3.1)) with the total relative impact. As before, there is no evidence of systematic divergence before 2010 in a fashion that is correlated with exposure to austerity. After the onset of austerity measures, a clear reduction in life expectancy is observed. A pooled difference-in-differences specification (Equation (3.2)) also results in a clear reduction of life expectancy. It estimates a reduction of 1.2–2.7 months for a one percent decline in spending per person per year between 2010 and 2019 for females or males, either at birth or at 65. Computing the full in-sample distribution of point estimates indicates that the combined treatment led to an average decline of 2.2 to 4.2 months in life expectancy from 2010 to 2019. This aligns closely with the overall effect observed using the total welfare impact. Such alignment gives confidence in the estimation using the relative treatment definition.

The various treatment effects are summarized in Figure 10. There are three key observations:

- The effect of healthcare spending reduction per pound is substantially larger than that of welfare spending reduction
- The overall effect of health spending reduction on life expectancy is generally small
- The overall effect of the total welfare impact is very close to the overall effect of the total relative impact

The overall effect of austerity measures on life expectancy at birth is thus a reduction of about 4 months for females and 2 months for males. This allows estimating the number of excess

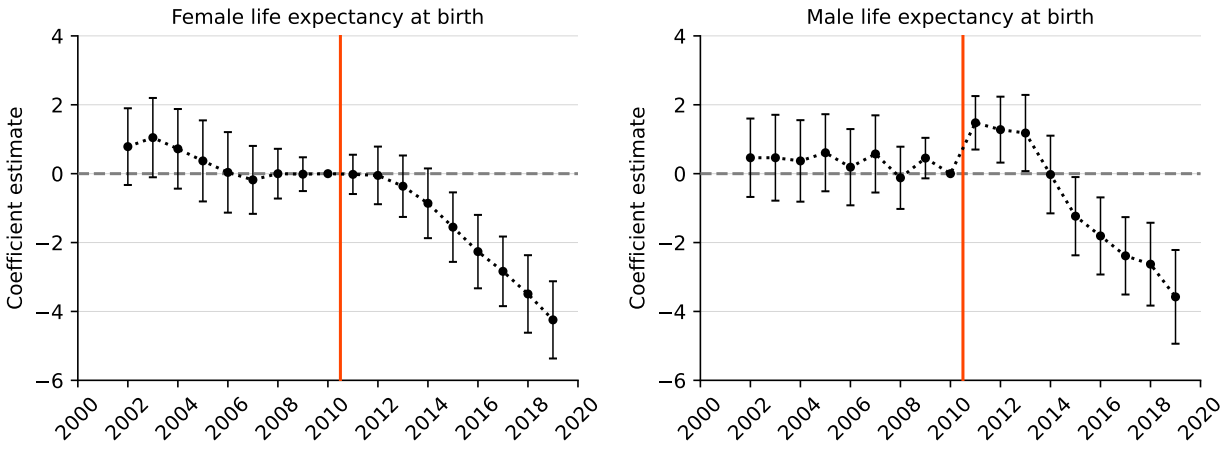

Figure 9: The effect of the combined healthcare and welfare austerity shock on life expectancy at birth.

Notes: The dependent variable is female (left) and male (right) life expectancy at birth measured in months. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England, Scotland, and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

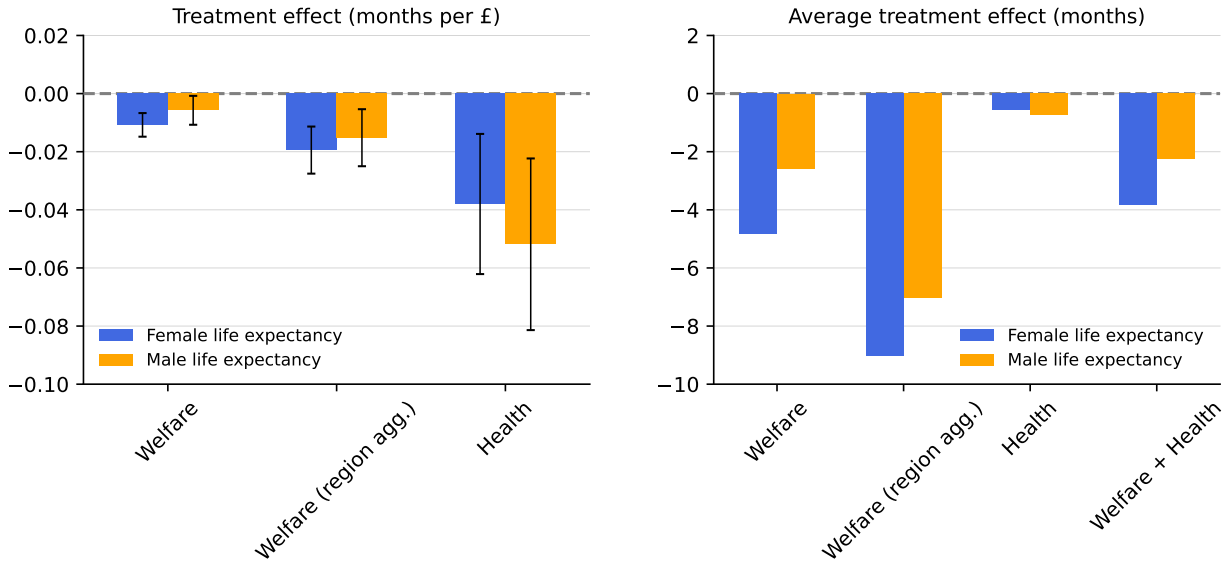

Figure 10: The effect of austerity measures on life expectancy in the United Kingdom.

Notes: Left) The effects of different treatments on female and male life expectancy at birth per pound of reduction in spending (per person per year) between 2010 and 2019; Right) The average effect of different treatments on female and male life expectancy at birth between 2010 and 2019. 'Welfare + Health' represents the total relative impact.

deaths caused by the austerity measures. We link crude mortality rates to life expectancy at

birth, and assume an average population of 65,085,882 in the United Kingdom between 2011 and 2019 (World Bank, 2023). Thus, a reduction of 4 months in life expectancy at birth for females and 2 months for males yields 45000 excess deaths (±11000). This is equivalent to 0.9 percent of overall deaths in the United Kingdom over the period 2011–2019.[10]

3.5 Calculation of marginal value of public funds

The results enable the calculation of the MVPF – the Marginal Value of Public Funds (Hendren and Sprung-Keyser, 2020, 2022). MVPF is a unified method of assessing the impact of policy changes on social welfare. In our setup, it can be done separately for the two treatments – the total welfare impact and total health impact. The MVPF is defined as the ratio between the effect of a policy change on the welfare of the affected population and the overall costs of the policy change to the government. In our case, both the effect and the cost are negative, and therefore, their ratio is positive, as is typically the case in MVPF calculations. Yet, if the MVPF is larger than 1 in our context it would mean that the value in life lost was higher than the saved expenditure.

First, we consider the numerator (or Aggregate Willingness to Pay). It accounts for the cost in life-years brought by each policy intervention. We make use of the 'value of life year' (VOLY) defined in the United Kingdom to guide budgetary planning (in the United States it is typically referred to as value of statistical life-year or VSLY). The HM Treasury estimates the VOLY as £60000 (Chilton et al., 2020). We also need to take into account the total life-years lost (LFL). This would be the overall effect in life expectancy reduction between 2011 and 2019 as calculated above, multiplied by the average population over this time period. Multiplying this by £60000 would provide an approximation of the overall costs to welfare due to the reduced life expectancy.

Second, we consider the denominator (or Net Cost). We apply a simplified approach and do not account for additional costs incurred by the austerity measures, such as higher incarceration rate due to austerity, prevalence of health issues that incur costs on the health system, and multiple other costs. In our case, the net cost is essentially saving, and to account for

[10] In practice, life expectancy is a weighted average of age-specific mortality rates. To simplify the calculation of excess deaths, we regressed the crude mortality rate on life expectancy at birth of both males and females. This analysis accounted for local authority fixed effects and region-year fixed effects, with the regression limited to the years 2002–2010 to prevent contamination by the austerity shocks. For small perturbations in life expectancy (and assuming that a change of 2–4 months is small within the context of 75–85 years), this linear approximation offers a precise measure of how changes in life expectancy would translate into changes in the crude mortality rate.

the overall saving we use the following formula:

$$Saving^j = \sum_{i=1}^{N} Impact_i^j \times N_i^{2015} \times 9\,, \tag{3.4}$$

where the index j refers to either treatments (welfare or healthcare) and i indexes the local authorities. The multiplication by 9 accounts for the impact per year, and we are interested in the overall savings between 2011 and 2019 (we ignore inflation between 2011 and 2019, which was only 1.8 percent per year on average over that period). N_i^{2015} is the adult population of local authority i in 2015, the middle point between 2011 and 2019.

Table 3 summarizes these calculations. It shows that as expected, both austerity measures had positive MVPF which is larger than 1. This means that the value of life lost is higher than the saved costs for the government. As expected, the healthcare treatment, while being smaller in magnitude, had a larger MVPF. This is because the marginal pound spent on improving healthcare is more effective in saving lives compared to a marginal pound spent on welfare benefits. This is already implied by the results per pound in Figure 10. The MVPF value of 23.8 is high in comparison to calculated MVPFs for various policy changes (Policy Impacts, 2023). This is not surprising, as health-related policy changes typically have high MVPFs, and in some cases, they pay for themselves in the sense that the net costs are negative and the benefits are positive.

Table 3: Calculation of marginal value of public funds

	Welfare	Healthcare
	Value (Billion £)	
Aggregate Willingness to Pay	−1170.3	−211.6
Net Cost	−269.4	−8.9
MVPF	**4.3**	**23.8**

Notes: The table reports the calculations of the marginal value of public funds (MVPF) as described above.

The MVPF for the welfare reform – 4.3 – is lower than the average value in Policy Impacts (2023). It is also lower than the MVPF calculated for another austerity-related policy change – closure of police stations in London, for which the calculated MVPF is 7.17 (Facchetti, 2021; Policy Impacts, 2023). However, we note that the calculation of net costs, as described above, is simplified. In practice, accounting for the additional costs would bring the overall saving closer to zero, and would increase the MVPF for the welfare reform.

3.6 Distributional impact

An additional important aspect of the austerity measures is distributional. Low socio-economic status areas in the United Kingdom saw larger reductions in welfare payments per adult. This is by design, as the share of welfare recipients in such areas, and the welfare share in household income in such areas, is higher than in areas with higher socio-economic status. Thus, the austerity measures discussed had clear distributional impact, where poorer local authorities became even poorer compared to richer local authorities after taxes and transfers.

Figure 11 shows that poorer local authorities saw a smaller increase in life expectancy between 2010 and 2019, or even a decrease in life expectancy compared to richer local authorities (defined by the average pay in 2010). The results therefore indicate that austerity measures were not only regressive in their impact on income after taxes and transfers, but they were also regressive in their health outcomes. While these results are only descriptive, they highlight an additional dimension for the social welfare impact of austerity.

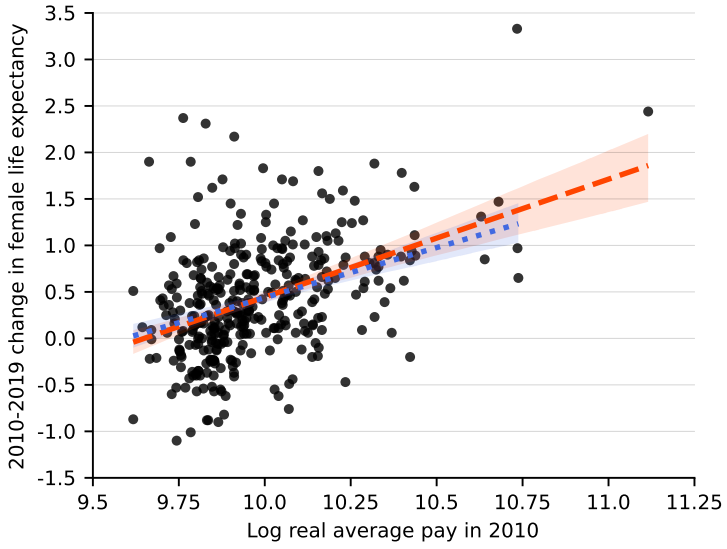

Figure 11: The association between life expectancy improvement and income in the United Kingdom, 2010–2019.

Notes: The chart shows the change (measured in years) in female life expectancy at birth from 2010 to 2019 across local authorities. It is plotted against the log real average worker's pay in 2010. The shaded areas represent 95 percent confidence intervals to the linear fits. The dotted linear fit excludes top and bottom outliers.

4 Mechanisms – the Importance of Drug-Related Deaths

So far, we quantified the way in which austerity measures affected life expectancy. However, we were not able to say much about the mechanisms underlying these effects. The impact of healthcare spending on mortality is quite direct. It results in fewer or less-qualified health professionals, fewer hospital beds, fewer ambulances, and so on. In contrast, the pathways through which cuts to welfare benefits lead to increased mortality are less direct, potentially involving lifestyle changes due to a decline in benefits, such as nutrition, homelessness, and the development of addiction.

There are multiple possible mechanisms. Here we test one of them, which is drug-related deaths. As discussed above, "Deaths of Despair" (Case and Deaton, 2020, 2021) – from suicide, drug overdose, and alcoholism – have been identified as major contributing factors to the decline in life expectancy in the United States over the past few decades. The United Kingdom has seen a rise in drug-related deaths since 2012, as illustrated in Figure 12.

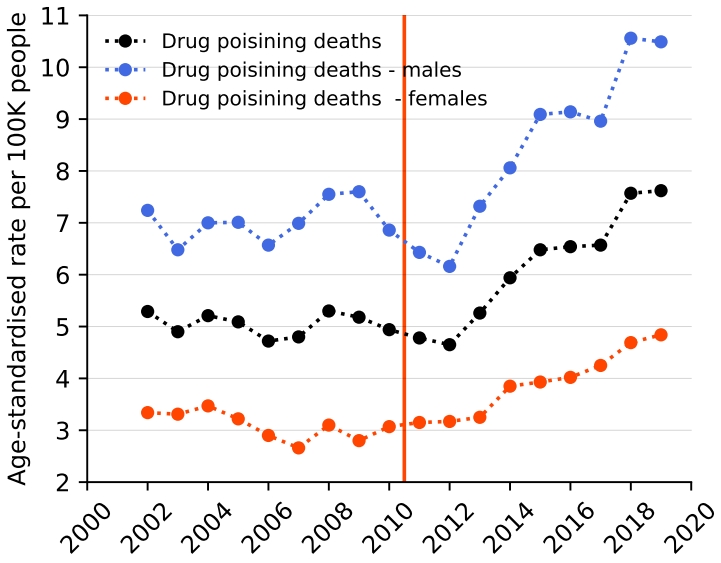

Figure 12: Age-adjusted drug-poisoning mortality rate per 100,000 people in England and Wales between 2001 and 2019.

Notes: Drug poisoning deaths are defined as all deaths coded to accidental poisoning, and to intentional self-poisoning by drugs, medicaments and biological substances, whether or not a drug listed under the UK Misuse of Drugs Act was present in the body.

To test the effect of austerity measures on drug-related mortality we repeat the same calculations as presented before using the difference-in-differences specifications defined in Equation (3.2) and Equation (3.1). One caveat is that the drug-poisoning data is limited to England and Wales, thus excluding about 10 percent of the UK population living in Scot-

land and Northern Ireland. Table 4 presents the pooled difference-in-differences results. The point estimates indicate a strong positive effect of austerity exposure and drug-poisoning mortality rate. Computing the full in-sample distribution of point estimates suggests that the age-adjusted drug-poisoning mortality rate per 100,000 people increased, on average, by 1.5–1.9 for the welfare impact and 0.2–0.8 for the health impact between 2010 and 2019. The total relative impact, *i.e.*, the sum of the relative welfare and health impact, yields an average effect of 1.6 drug-poisoning deaths per 100,000. This is equivalent to about 1000 excess deaths from drug-poisoning over the period 2011–2019. These "preventable deaths" are about 3 percent of all drug-poisoning deaths in the United Kingdom between 2011 and 2019.

Table 4: The impact of austerity on drug-poisoning deaths in the United Kingdom

	Welfare impact	Welfare relative impact	Health impact	Health relative impact	Total relative impact
$\mathbf{1}_{t>2010}(t) \times Impact$	0.004^{***}	0.84^{***}	0.011^{***}	13.3^{**}	0.83^{***}
	(0.001)	(0.151)	(0.003)	(5.473)	(0.150)
Average effect	1.9	1.5	0.2	0.8	1.6
Mean of dep. variable	6.1	6.1	6.1	6.1	6.1
Local authorities	341	336	341	336	336
Observations	5068	5030	5068	5030	5030

Notes: The table reports results from a panel OLS regressions with the dependent variable being age-adjusted drug-poisoning mortality rate per 100,000 people in English and Welsh local authorities between 2002 to 2019. The regressions control for local authority fixed effects as well as region by year fixed effects throughout (country by year in the case of the health impact), as well as for unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors clustered at the local authority level, with standard errors presented in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

Figure 13 illustrates the event study results for the dynamic specification (Equation (3.1)), considering the total relative impact. As before, there is no evidence of systematic divergence before 2010 in a fashion that is correlated with exposure to the austerity shock. After the onset of austerity measures, a clear increase in drug-poisoning mortality is observed. The results indicate an increase of 1–2 drug-related deaths per 100,000 for a one percent decline in healthcare or welfare spending per person per year between 2010 and 2019.

Both Table 4 and Figure 13 present compelling evidence illustrating the connection between austerity measures and the rise in drug-related deaths in the United Kingdom. These findings align with the results of Friebel, Yoo and Maynou (2022) focusing on opioid abuse in England. Nevertheless, while these sources shed light on some of the excess mortality attributed to austerity, they only offer a partial explanation. This underscores the need for further investigation into additional mechanisms that may have contributed to the increased mortality

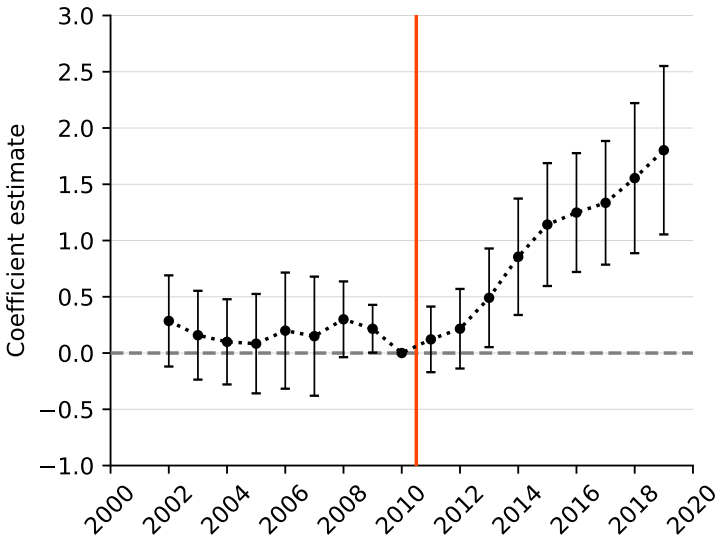

Figure 13: The effect of the combined healthcare and welfare austerity shock on drug-related mortality.

Notes: The dependent variable is age-adjusted drug-poisoning mortality rate per 100,000 people in English and Welsh local authorities between 2002 to 2019. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

in the United Kingdom following the implementation of austerity measures. Specifically, it is necessary to better understand the mechanisms for which the effect of austerity on female life expectancy was larger than on male life expectancy.

5 Conclusion

This paper studies the effects of austerity measures enacted by the UK government after 2010 on life expectancy and mortality. First, we create a comprehensive panel dataset spanning from 2002 to 2019 that is based on administrative data. We then apply a difference-in-differences strategy to assess the impact of welfare benefit cuts and changes in health expenditure on life expectancy and mortality rates.

The findings reveal a decrease of 2.5 to 5 months in life expectancy by 2019, attributed to the austerity measures. Compared to men, women experienced nearly double the impact. Welfare benefit reductions were the main cause of the decline, having a larger impact than the relatively minor changes in healthcare spending. This reduction in life expectancy translates

into a significant setback of three years in life expectancy progress between 2010 and 2019. This is equivalent to 45000 excess deaths over this period.

To better understand the source of the excess deaths, we study drug-related mortality. We identify a clear effect of austerity, accounting for approximately 1000 drug-poisoning deaths. This is only a small fraction of the overall excess deaths. Further exploration into additional mechanisms behind this increased mortality is thus necessary. Such mechanisms can include changes in nutrition or lifestyle induced by austerity, and the quality of healthcare services. This is planned for future work.

Our findings also suggest that the estimates are conservative. We find no direct discernible effects on mortality from cuts in public expenditure on education, police, infrastructure, and other services by 2019. Yet, recognizing their potential latent effects is crucial. Reductions in education spending and delayed changes in lifestyle induced by austerity may have significant mortality implications over an extended horizon, spanning several decades.

Also we find that the adverse effects of reductions in welfare and healthcare expenditures on life expectancy intensify progressively from 2011 to 2019. This is indicative of a lasting impact which is still at play. This impact may also hold relevance for current public health crises, such as the recent COVID-19 pandemic. The broader socio-political implications are further demonstrated by the link between austerity and Brexit, as explored by Fetzer (2019). This, in turn, could exacerbate the negative impact of austerity on life expectancy.

Furthermore, the impact of austerity measures extends beyond mortality. Areas more reliant on welfare benefits, and thus more exposed to welfare cuts, were relatively poorer than less-exposed areas. Thus, our results highlight a regressive impact of austerity measures not only on income post taxes and transfers, but also on health outcomes. This descriptive insight adds an additional dimension to the social welfare impact of austerity.

We also calculate the marginal value of public funds (MVPF) for the studied austerity measures. It suggests that the MVPF of healthcare spending is higher than that of welfare spending. Both calculations are within the typical range of values in the literature (Policy Impacts, 2023).

Austerity, implemented by the British government in response to a financial crisis, aimed to curtail spending and reduce national debt. Paradoxically, this fiscal strategy appears to have contributed to an increase in mortality, potentially offsetting its financial gains. However, it is possible that without austerity, the economic recession in the early 2010s might have been more severe. Hypothetically, this could have resulted in a higher mortality rate. This interplay and the general equilibrium properties of policy changes such as austerity measures remain a subject for future research, extending beyond the scope of this paper.

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A Robustness Checks

This appendix details various robustness checks for ensuring the validity of the results in the paper. It addresses various aspects:

- Addressing possible parallel trends violations using the "Honest" difference-in-differences approach (Rambachan and Roth, 2023)
- Testing for interaction between austerity and recession shocks
- Adding various specifications to the analysis:
  - binary treatment instead of continuous treatment
  - Sensitivity to region-aggregated welfare treatment
  - Defining treatment using other public services
  - Restriction of results to the period before the Brexit referendum
- Addressing the impact of cardiovascular disease mortality

A.1 "Honest" difference-in-differences calculations

Rambachan and Roth (2023) offer "tools for robust inference in difference-in-differences and event-study designs where the parallel trends assumption may be violated." We use these tools to test the robustness of the estimates presented in the paper. This allows confirming a limited sensitivity of the results to violations of parallel trends.

Specifically, we follow the sensitivity analysis laid out by Rambachan and Roth (2023), and "report confidence sets that allow the maximum post-treatment violation of parallel trends to be up to $\bar{M}$ times larger than the maximum pre-treatment violation for different values of $\bar{M}$." We set $\bar{M}$ to 0.6. While this choice is quite arbitrary, we would still be able to check how sensitive the results are to violations of parallel trends. In Figure A.1, we present such analysis for different specifications, including three different treatments and two different outcomes. In all cases, there exists a certain value of M where the violations become significant enough that the estimated coefficient would no longer be significant. However, in all cases, for low values of M, such as $M = 0.3$, the fixed length confidence intervals are all completely above zero or completely below. This gives reasonable confidence in the parallel trends assumption for the main analysis (Rambachan and Roth, 2023).

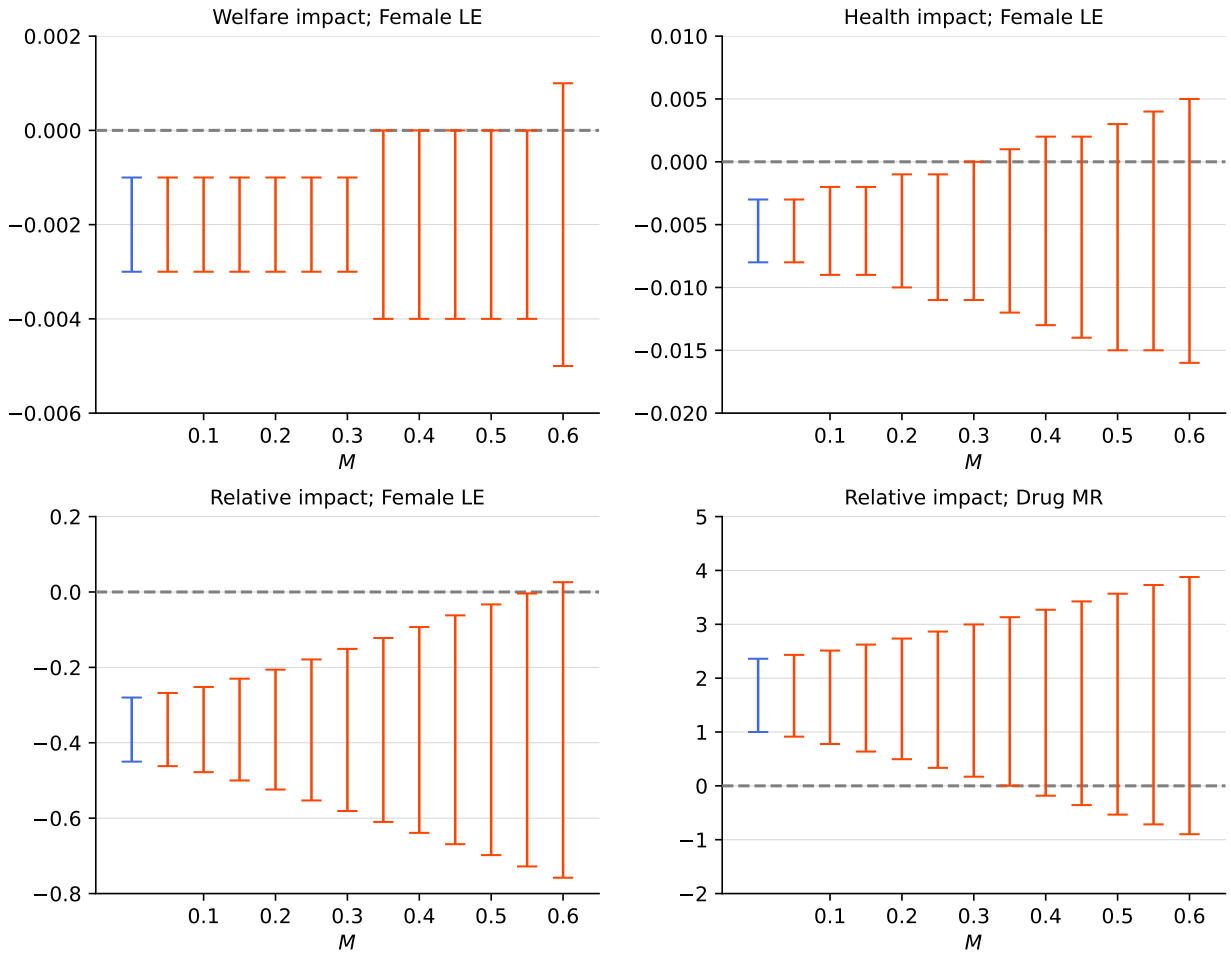

Figure A.1: Sensitivity analysis for different treatments and outcomes in the main analysis.

Notes: The blue confidence intervals refer to the original estimates. The different panels present a sensitivity analysis of the event study results for the total welfare impact on female life expectancy at birth (top left); total health impact on female life expectancy at birth (top right); total relative impact on female life expectancy at birth (bottom left); total relative impact on drug-poisoning mortality rate (bottom right).

A.2 Austerity shocks and recession shocks

The 2010s austerity in the United Kingdom was, to a large extent, a response to the global financial crisis (Fetzer, 2019). Austerity measures were put in place to avoid increasing government debt and help boost economic recovery. Furthermore, the recession that followed the global financial crisis, and the ongoing European debt crisis in the early 2010s, might have an effect on mortality in and of itself. This is supported by some evidence from the United States, arguing that the Great Recession led to reduced mortality across age groups and most causes of deaths, primarily due to reduced pollution (Finkelstein et al., 2024).

To test that possible similar effects do not invalidate our findings, we verify that the recession-

induced economic shock in the local level is not related to the austerity shock. Figure A.2 shows that indeed, the welfare shock and the economic shock, measured by the relative decrease in real wages between 2009 and 2013, are uncorrelated across local authorities. Therefore, it is unlikely that the estimated effects of austerity on mortality are in fact due to the economic shock.

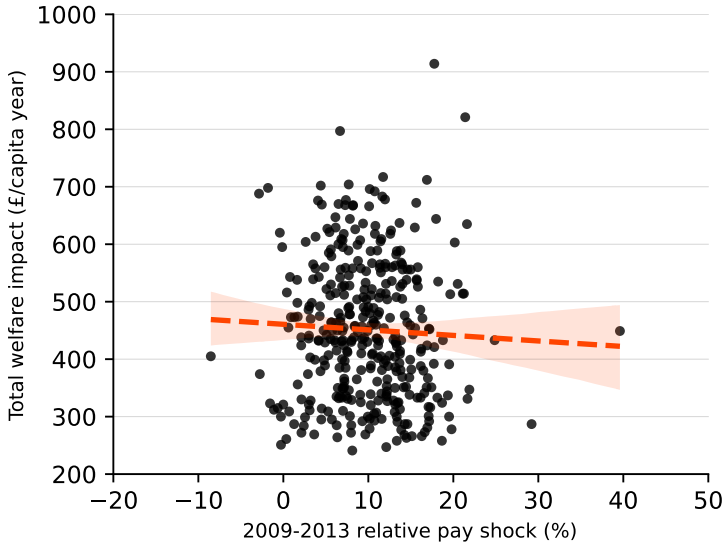

Figure A.2: The welfare shock and the recession economic shock across local authorities in the United Kingdom.

Notes: The austerity shock is taken as the welfare impact variable, as defined above. The economic shock, or relative pay shock, is defined as the relative decrease in real wages between 2009 and 2013 in the local authority level.

A.3 Alternative specifications

A.3.1 Binary treatment specification

The main specification we use in the difference-in-differences analysis is based on a continuous treatment variable since all units are treated. While this is intuitive, it is also useful to consider a specification where the treatment variables are binary. This allows using the intuition for binary treatment difference-in-differences, as well as using matching so that we create balanced treated-untreated subsamples.

To create binary treatment we simply divide all the local authorities into two groups in terms of the welfare treatment – above median treatment intensity and below median treatment intensity. Then, we define the half above the median as treated, and the other half as non-

treated. Similarly, we define another separation of the entire sample based on the health treatment. In each case we run a dynamic specification as follows:

$$y_{i,r,t} = \alpha_i + \theta_{r,t} + \sum_{t \neq 2010} \delta_t \times Year_t \times Treated_{i,j} + \mathbf{x}_{i,t}\beta + \epsilon_{i,r,t}\,, \tag{A.1}$$

where the notation is similar to Equation (3.1), with $Treated_{i,j}$ being 0 or 1, for each unit i for treatment j (welfare or health).

Additionally, we use nearest-neighbor matching with Mahalanobis distance (the distances are determined by all the control variables: unemployment, in- and out-migration relative flows, log of average wages, and log of population. We then re-run Equation (A.1) for the pruned sample.

The results are presented at Figure A.3. They show very similar patterns to what have been found based on the continuous treatment. Matching changes only marginally the results and the error (less than 10% of local authorities are pruned).

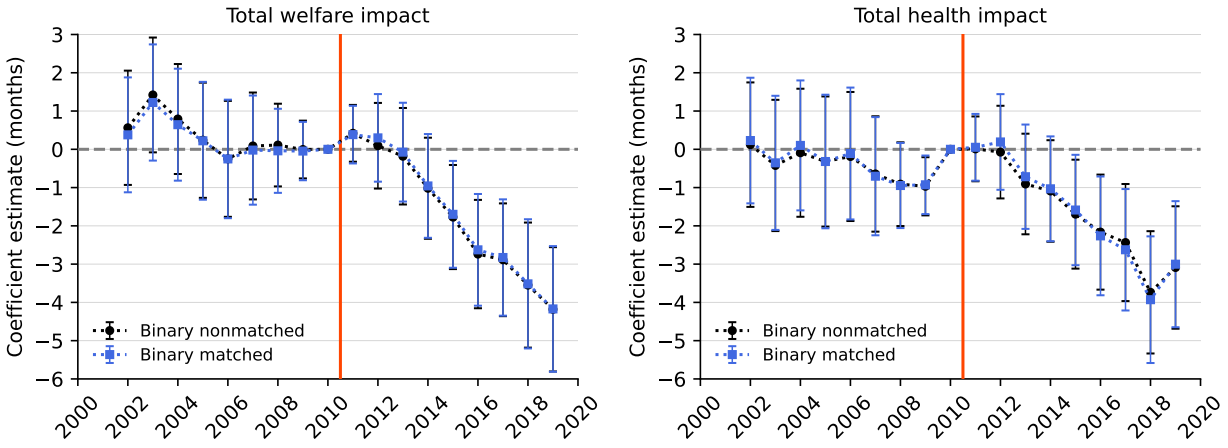

Figure A.3: The effect of binary treatment on female life expectancy at birth.

Notes: The dependent variable is female life expectancy at birth measured in months. The graph plots point estimates of the interaction between a binary measure of the incidence of austerity (welfare – left; health – right) and a set of year fixed effects across local authorities in England, Scotland, Wales and Northern Ireland (the latter only for the health treatment). The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

A.3.2 Sensitivity to region-aggregated welfare treatment

There is a key difference between using welfare and health total impacts. Healthcare spending is defined in the region level rather than the local-authority level. Therefore, when

considering the health treatment, the term $\theta_{r,t}$ in Equation (3.2) and Equation (3.1) needs to be replaced by $\theta_{c,t}$ which accounts for country-year fixed effects, and not region-year fixed effects. More specifically, since Wales, Scotland, and Northern Ireland are each both a region and a country, the c in $\theta_{c,t}$ would be considered as either England or not (*i.e.*, Wales, Scotland, or Northern Ireland). This difference, as well as the aggregation of the treatment into a regional level makes this specification potentially less accurate than in the case of the welfare treatment.

To test that this change does introduce large biases and errors in the results we first repeat the calculations in Table 1 and Figure 7 with a welfare treatment that is aggregated by region. The region-aggregated total welfare impact values are also taken from Beatty and Fothergill (2014), and are essentially population-weighted averages of the local-authority level values. Table 5 presents a comparison of the pooled difference-in-differences point estimates between the two welfare treatments. It shows the results are qualitatively identical.

Table 5: The impact of austerity on life expectancy in the United Kingdom – welfare results; local authority vs. region results

	Female at 65	Female at 65 (region)	Female at birth	Female at birth (region)
$\mathbf{1}_{t>2010}(t) \times Welfare$	-0.012***	-0.012***	-0.011***	-0.019***
	(0.002)	(0.003)	(0.002)	(0.004)
Average effect (months)	-5.2	-5.6	-4.8	-9.0
Mean of dep. variable (years)	20.6	20.6	82.4	82.4
Local authorities	379	379	379	379
Observations	6822	6822	6822	6822

Notes: Table reports results from a panel OLS regressions with the dependent variable being life expectancy in English, Welsh and Scottish local authorities between 2002 to 2019. The regressions control for local authority fixed effects as well as region by year fixed effects throughout. Standard errors clustered at the local authority level, with standard errors presented in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

Figure A.4 shows a comparison between the dynamic estimates (Equation (3.1)). It shows some difference between the region-aggregated and local-authority level treatments. The region-aggregated treatment is qualitatively similar, but the overall estimated effect is somewhat larger. Taking errors into account, however, it is difficult to distinguish between the two treatments.

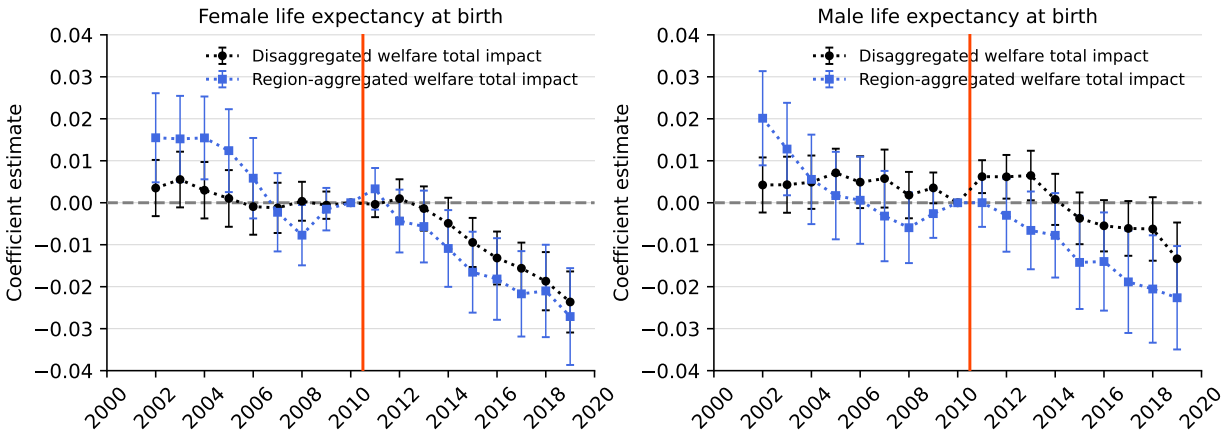

Figure A.4: The effect of the welfare austerity shock on life expectancy at birth.

Notes: The dependent variable is female (left) and male (right) life expectancy at birth measured in months. The estimates in black use total welfare impact in the local-authority level and region-year fixed effects. The estimates in blue use region-aggregated welfare impact values and country-year fixed effects. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England, Scotland, and Wales. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

A.3.3 Defining treatment using other public services

In the paper the definition of treatment is based on two aspects of austerity – welfare benefit cuts and changes in healthcare spending. In practice, other publicly funded services such as policing, infrastructure spending, and education were also affected, and substantially decreased in real terms between 2010 and 2015. We defined two additional treatment specifications for police spending and for total services excluding police and healthcare. The latter, like the healthcare treatment defined in Section 2, is given only by region. The police expenditures are given by police force area, a geographical unit smaller than a region and larger than a local authority.

In the event studies depicted in Figure A.5, we present results for the dynamic specification (Equation (3.1)) for life expectancy at birth among females given the two additional treatment definitions. The case of police spending is indicative of a negative effect of the treatment on life expectancy, however it is not statistically significant. Estimating a pooled difference-in-differences also reveals an insignificant effect, albeit negative.

For the total services treatment Figure A.5 indicates that the parallel trends assumption is violated. This makes it difficult to attribute a clear effect to this treatment. While there seems to be a growing negative effect of the second half of the 2010s, it is inconclusive.

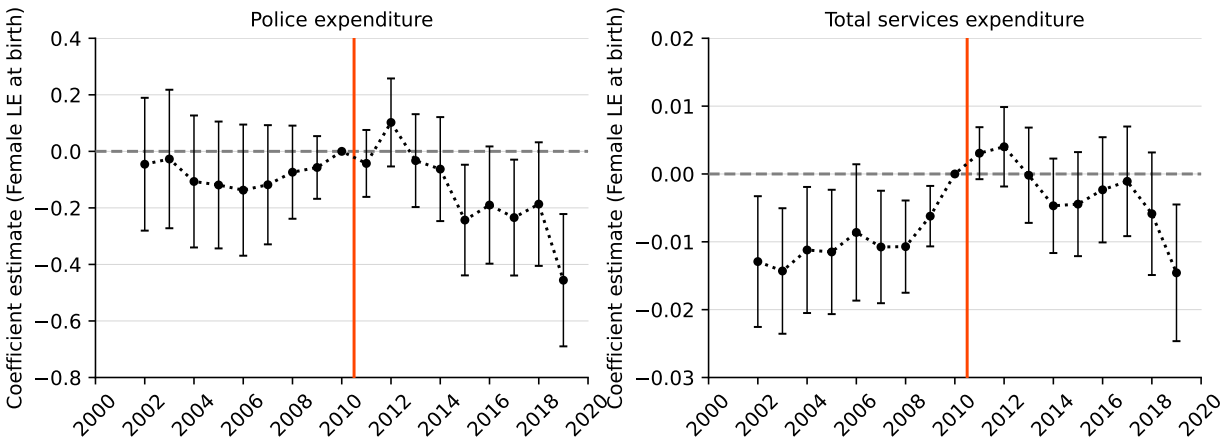

Figure A.5: The effect of additional austerity measures on female life expectancy at birth.

Notes: The dependent variable is female life expectancy at birth measured in months. The graph plots point estimates of the interaction between the incidence of the austerity measures (reduction in police spending in the left, and reduction in total services spending in the right) and a set of year fixed effects across local authorities in England, Northern Ireland, Scotland, and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

A.3.4 Restriction of results to the period before the Brexit referendum

It is possible that the observed effect is, in part, an outcome of the Brexit referendum results, rather than of austerity measures. In the June 2016 Brexit referendum the British public voted in favor of leaving the European Union. This was a largely unexpected outcome with potentially negative effects on the British economy and the welfare of British people (Born et al., 2017; Kavetsos et al., 2018). If these effects are correlated with the treatment used in the main analysis, then it is possible that the effects estimated and discussed above, are partly explained by the Brexit referendum results. To address this concern we rerun the main analysis while limiting the years of the analysis to 2002–2015. This is displayed for the pooled difference-in-differences in Table 6, and for the event study plot in Figure A.6. They both show that a significant effect already exists before the Brexit referendum. The referendum might have contributed further to the trends brought by austerity, but it cannot explain the main results described above.

Table 6: The impact of austerity on life expectancy in the United Kingdom before 2016

	Welfare impact	Welfare relative impact	Health impact	Health relative impact	Total relative impact
$\mathbf{1}_{t>2010}(t) \times Impact$	-0.004*	-0.983***	-0.007	-40.3**	-0.982***
	(0.002)	(0.348)	(0.010)	(16.2)	(0.344)
Average effect (months)	-1.8	-1.8	-0.1	-2.5	-1.8
Mean of dep. variable (years)	82.1	82.1	82.1	82.1	82.1
Local authorities	378	373	378	373	373
Observations	5051	5005	5051	5005	373

Notes: The table reports results from a panel OLS regressions with the dependent variable being female life expectancy at birth in English, Northern Irish, Scottish, and Welsh local authorities between 2002 to 2015. The regressions control for local authority fixed effects as well as region by year fixed effects throughout (country by year in the case of the health impact), as well as for unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors clustered at the local authority level, with standard errors presented in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

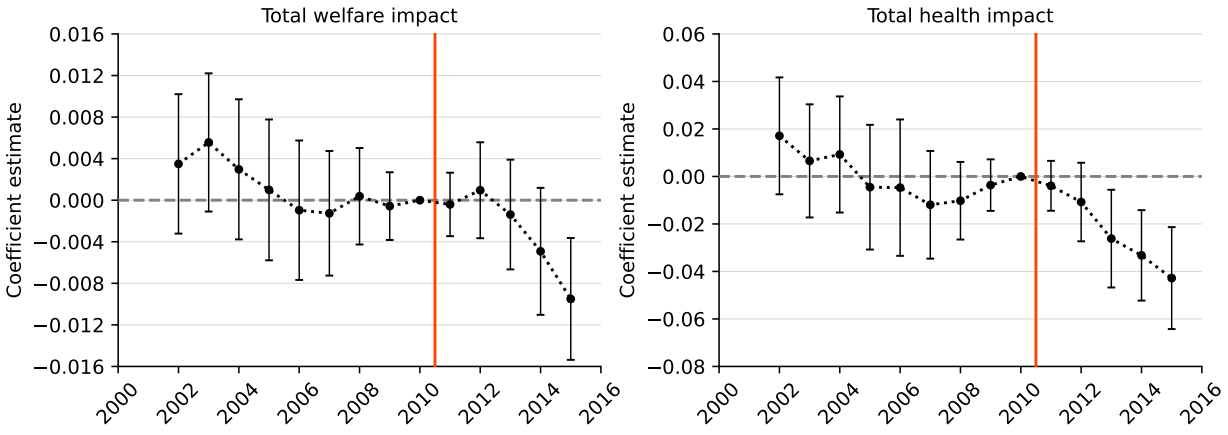

Figure A.6: The effect of austerity measures on female life expectancy at birth by 2015.

Notes: The dependent variable is female life expectancy at birth measured in months. The graph plots point estimates of the interaction between the incidence of the austerity measures and a set of year fixed effects across local authorities in England, Northern Ireland, Scotland, and Wales. The regressions control for local authority unemployment, in- and out-migration relative flows, log of average wages, and log of population. Standard errors are clustered at the local authority level with 95 percent confidence intervals indicated.

A.4 Cardiovascular disease mortality

The key motivation for this paper is the observed slowdown of the life expectancy improvements in the United Kingdom after 2010. These trends (shown in Figure 2) are not unique to the United Kingdom. Specifically, a similar trend has been observed in the United States. In the United States, in which there was no large scale austerity after 2010, the trend has been largely attributed to slower improvements in cardiovascular disease (CVD) mortality (Mehta, Abrams and Myrskylä, 2020). Other deaths, and in particular drug-related deaths

have been substantially increasing as well (Mehta, Abrams and Myrskylä, 2020; Case and Deaton, 2021). Slower improvements in CVD mortality occurred in the United Kingdom between 2010 and 2019 (Cheema et al., 2022; World Health Organization, 2023). However, the change is not as substantial as in the United States (Mehta, Abrams and Myrskylä, 2020). This is presented in Figure A.7, which illustrates the CVD mortality rates in the United Kingdom and the United States.

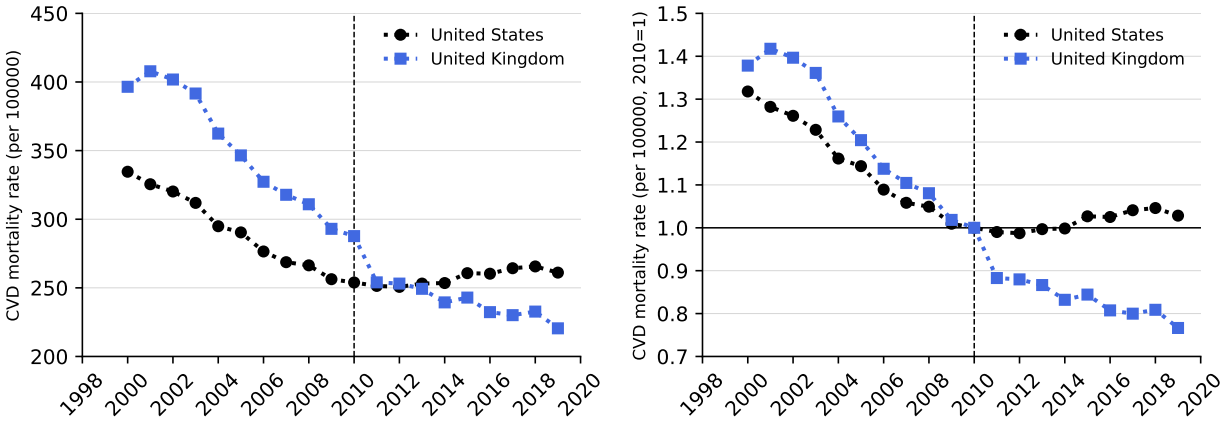

Figure A.7: Cardiovascular disease mortality rates in the United States (black) and the United Kingdom (blue), 2000–2019.

Notes: Left) Crude CVD mortality rate (per 100000 people); Right) Crude CVD mortality rate normalized to 1 in 2010. Source: World Health Organization (2023).

The data on CVD deaths by local authority in the United Kingdom are only accessible from 2013 (NOMIS, 2023). Consequently, difference-in-differences methodology, as employed in the primary analysis of this paper, cannot be applied. However, we can descriptively check whether the change in CVD mortality rate between 2013 and 2019 correlates with the treatment variables employed in our primary analysis. Figure A.8 shows the lack of such correlation. The observed data suggest an inherent lack of association between exposure to austerity measures and the change in CVD mortality rate during the specified period. This ensures that the key results are not influenced by underlying, unobserved variations in CVD mortality, which could potentially be erroneously associated with exposure to austerity measures.

This can also be shown dynamically. Figure A.9 presents the average CVD mortality rate in high-exposure vs. low-exposure to austerity measures across local authorities. It shows that at least from 2013 to 2019, there is no indication of any divergence between the mortality rates over time, in neither of the treatments, welfare nor health.

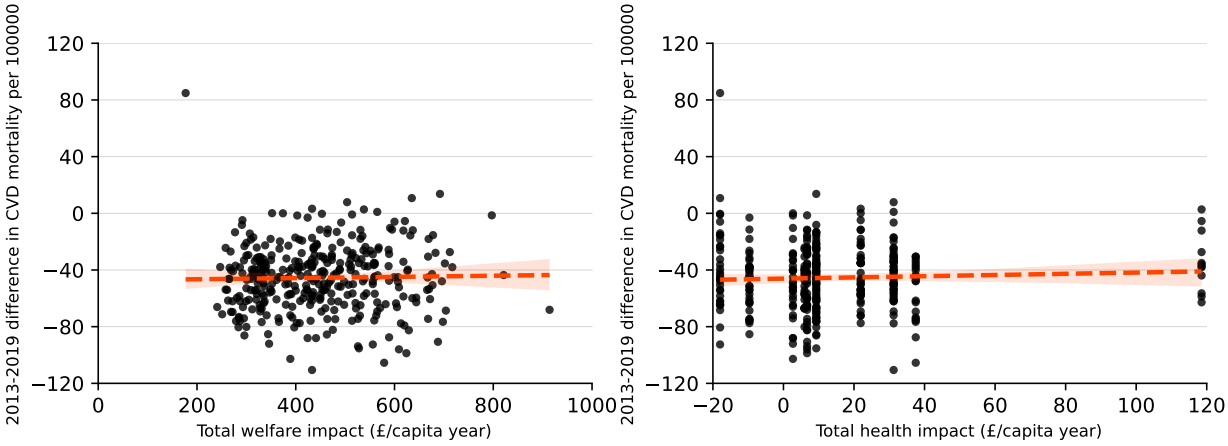

Figure A.8: The association between exposure to austerity and CVD mortality rate.

Notes: Left) A scatterplot showing the difference in CVD mortality rate (per 100000 people) between 2013 and 2019 plotted against the total welfare impact across local authorities; Right) A scatterplot showing the difference in CVD mortality rate (per 100000 people) between 2013 and 2019 plotted against the total health impact across local authorities.

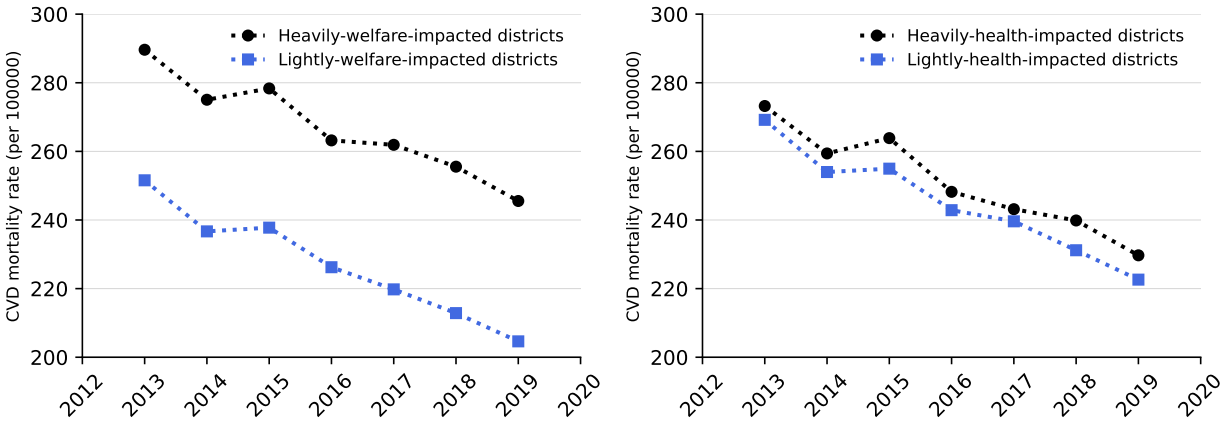

Figure A.9: Parallel trends in CVD mortality across exposure levels to austerity.

Notes: The charts show the average CVD mortality rate between 2013 and 2019 in a group of local authorities that are more exposed to austerity and less exposed to austerity. More-exposed (less-exposed) areas are defined as areas with impact higher (lower) than the median exposure to the austerity measures. The left panel considers exposure to the total welfare impact. The right panel shows exposure to the total health impact.

B Descriptive Statistics of Dataset

Table 7 presents descriptive statistics of key variables in our dataset.

Table 7: Descriptive statistics of key variables

	Observations	Mean	Std. Dev.	Min.	Max.
Population (2019)	380	175753	147453	2409	1893700
Female life expectancy at birth (2019)	380	83.1	1.6	78.3	87.9
Female life expectancy at 65 (2019)	380	21.2	1.1	18.0	25.4
Male life expectancy at birth (2019)	380	79.4	1.8	73.1	84.7
Male life expectancy at 65 (2019)	380	18.7	1.1	15.3	23.1
Drug poisoning mortality rate per 100,000 (2019)	333	7.8	4.0	2.5	31
Total welfare impact (£/ year / capita)	380	448.6	120.7	241	914
Total health impact (£/ year / capita)	380	19.1	19.3	-3.6	95.2
Total education impact (£/ year / capita)	380	60.7	19.4	37.3	167.0
Real pay (£2002)	373	21105	5081	14463	63914
Unemployment (2019)	379	3.59	1.1	1.5	8.2