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Excess deaths in England and Wales during the first year of COVID-19

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Abstract

Using officially registered weekly death data, we estimate a baseline count of excess deaths during 2020 in England and Wales. We break down this number by region, age, gender, place, and cause of death. Our results suggest that there were 82,428 excess deaths in 2020 after the pandemic onset. Almost 90% of these excess deaths were due to COVID-19, suggesting that non-COVID-19 excess mortality may have been slightly higher than what has been previously estimated. Regarding deaths not due to COVID-19, individuals older than 45 years old who died at their homes, mainly from heart diseases and cancer, were the most affected. Supported by regional panel event estimates, our results highlight how measures to mitigate the pandemic spread and ease the pressure on healthcare service systems may adversely affect out-of-hospital mortality from other causes.

Keywords: COVID-19; Excess mortality; Lockdown

JEL codes: I10; I18; J10

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1. Introduction

From the early days of the pandemic, governments and public health authorities have been releasing daily reports on the number of deaths related to COVID-19. However, it soon became apparent that the impact of such a major event on overall mortality is not only due to the pressure on health systems, but also due to the changes that significant policy responses, including local or national lockdowns, had on people's lives. As a result, excess mortality, defined as the number of deaths above an expected figure during the same period in previous years, became a key metric of the pandemic's impact (Islam, 2022).

There have been several attempts to estimate excess mortality during the pandemic (Karlinsky and Kobak, 2021; WHO, 2022). The most systematic of those attempts was based on data from 74 countries and estimated there were approximately 18.2 million excess deaths across the world because of COVID-19 between January 2020 and December 2021 (COVID-19 Excess Mortality Collaborators, 2022). Although excess mortality differed across countries, the overall estimate was three times higher than the 5.94 million global reported deaths due to COVID-19 in the same period.

For these estimates to be more meaningful for policy purposes, it is crucial to analyse the causes of death that contribute to the overall excess mortality, and the groups of individuals who have been affected the most. To date, only a few countries around the world have released such data, and studies that analysed them look at specific causes, such as suicides (John et al., 2020), cancer (Lai et al., 2022) or dementia (Gilstrap et al., 2022). Understanding the causes of deaths and identifying the groups that have been mostly affected will support governments and public health authorities to better plan their responses to pandemic outbreaks and their consequences.

Moreover, it is important to compare observed total or group-specific mortality with accurate baseline numbers expected in a no pandemic scenario. Here we focus on England and Wales that had one of the highest rates of all-cause mortality per 100,000 people during the first wave of COVID-19 in 2020 (Kontis et al., 2020). Although the overall picture changed in the second wave of 2020, the UK had still among the highest excess mortality rates for people aged under 65 years in Europe (ONS, 2021a). The Office for National Statistics (ONS) investigated in depth excess mortality during the first year of the pandemic and showed that COVID-19 was the main reason for the increase in overall mortality in 2020, which many deaths not due to COVID-19, which would normally have happened in hospital, happened in private homes instead (ONS, 2021b). Typically, death counts during the pandemic have been benchmarked against past 5-year averages (ONS, 2021a; 2021b; Vandoros, 2020). However, death counts are highly volatile within a single year, therefore 5-year averages for specific months could be problematic. Here we use a variation of a method proposed by Ruhm (2021) to estimate baseline death counts by region, week, demographics, place of death and cause of death.

Previous attempts in the literature focused on the early phase of the pandemic and considered only total mortality due to data limitations (Vandoros, 2020). Our paper provides a more detailed picture of the death causes that contributed to the overall excess mortality in England and Wales, and builds the profile of the groups that were mostly affected. Compared to our panel regression-based number of excess deaths, using 5-year averages at the national level overestimates the share of total excess deaths due to COVID-19 in 2020. Moreover, while the number of excess deaths decreased or stabilized after the first pandemic weeks in hospitals and care homes, it kept rising throughout 2020 in private homes. This was mainly due to excess mortality for those over 45 years old, and the most contributing factors were heart-related diseases and cancer. At the same time, in-hospital mortality from those two causes decreased significantly for this age group. Supported by a panel event analysis, our results are indicative on how responses to mitigate the spread of the pandemic and ease the pressure

on healthcare services may substitute in-hospital for mortality in other places and by causes not directly related to the pandemic itself.

The remaining of this paper is structured as follows. Section 2 describes the data we used and section 3 the methods we employed. Section 4 presents the results, while Section 5 discusses them within the wider literature and concludes.

2. Data

Daily data on the universe of all registered deaths in England and Wales were provided by the ONS. They cover the period between the first week of 2015 and the last week of 2020. Weeks refer to the weekly rather to the annual year. This means that, occasionally, there are some deaths from the previous annual year where the week start (end) dates fall into the previous (following) calendar year. We made the necessary adjustments so that years and months refer to their weekly year values, rather than the calendar ones. The data contained information on gender, region, and age per death registration. Region is classified into nine Government Office Regions, plus Wales. Age is provided in groups as follows: <1, 1-14, 15-44, 45-64, 65-74, and >85 years old. There was also information about the place of death, i.e. usual place of residence, care home, hospital, or elsewhere. Hospitals are inclusive of NHS and non-NHS institutions but exclude psychiatric hospitals. The elsewhere category includes all places not covered by what was available in the data. It is also inclusive of people who were pronounced dead on arrival at hospital or deaths in other persons' residencies. Moreover, the underlying cause of death is provided, under the ICD-10 code classification at the 4-digit level. Deaths involving COVID-19 were also flagged up, whereas COVID-19 was mentioned anywhere on the death certificate, alongside the underlying death cause. We used the information in the data to compute total death counts by gender, age group, region, place of death, and cause of death. Regarding the latter, we considered: total deaths, deaths involving and not involving COVID-19, as well as deaths from: heart

diseases, cancer (malignant neoplasms), stroke (cerebrovascular disease), influenza or pneumonia, diseases of the lower respiratory system, kidney disease, diabetes, Alzheimer's and dementia, Parkinson disease, nervous system diseases, mental and behavioural disorders, infectious diseases, transport accidents, other accidents, suicides, homicides, and complications of medical care.

3. Empirical methodology

3.1 Counterfactual mortality

Figure 1 displays the weekly death count per year. Additionally, it plots the number of deaths registered as due to COVID-19, as well as a 5-year (2015-2019) pre-pandemic national average of total weekly deaths. The latter is a popular benchmark against the actual death counts observed during the pandemic, e.g. Vandoros (2020). The main advantages of this metric is that it is easily understood, straightforward to calculate, and accessible for wider audiences.

[Figure 1 here]

Here we followed a different approach to estimate (a) baseline death counts, and (b) excess deaths registered between the pandemic onset and the last week of 2020. Our approach follows Ruhm (2021), but under the necessary adjustments due to the weekly frequency of our data. The starting point was the observation that total death counts exhibit substantial volatility during specific weeks each year; and particularly during the first 5 weeks (Figure 1). Most of those deaths are registered in January, but for most years (2016-2019) this 5-week period also spans into February. In his paper, Ruhm (2021) worked with monthly death counts that revealed this excess volatility during January. We calculated year-over-year changes of weekly death counts (DW), covering the period 2015-2019:

$$\Delta DW_{wit} = \frac{DW_{wit} - DW_{wit-1}}{DW_{wit-1}} \times 100\% \quad (1)$$

where w indicates the w -th week of year t , i denotes the specified group or cause of death, and $t = 2015, \dots, 2019$. As seen in Table X, changes were higher and more volatile during the first 5-week period of each year. The average standard deviation in the annual weekly change (2015-2019) was 2,201 deaths for the first five weeks, and 675 for the remaining year. This excess volatility was particularly large for deaths from pneumonia & influenza, dementia and Alzheimer's disease, heart diseases, lower respiratory system diseases, and strokes.

Although the virus might have been in England and Wales from as early as the beginning of 2020, the first death due to COVID-19 was officially registered in week 11 of 2020. Therefore, for the remainder of our analysis, we will be denoting as year the period covered between the 11th week of each year through the 10th week of the following year. For instance, 2019 refers to the period between week 11 of 2019 and week 10 of 2020. We will be using the term "calendar year" when referring to years starting in the first week of January and ending in the last week of December.

Following Ruhm (2021), we adjusted for this excess variation in the first weeks of each year, by estimating the counterfactual (baseline) death count that would have happened in the absence of the pandemic based on the following procedure. First, we calculated the annual number of deaths registered from week 11 of each year to week 10 of the following year, i.e. the total annual death count minus the number of deaths during the first 5 weeks of each calendar year. Define this annual death count by D'_{irt} , where i denotes the group (total deaths, gender, cause, etc.), r is the region, and t ranges from 2015 to 2019. Also, define as D_{irt} the total number of deaths registered during each pandemic year, i.e. including the 5 idiosyncratic weeks. Then, we calculated for each region the ratio of average annual deaths of our 5-year

pre-pandemic period compared to the respective number of deaths without including the idiosyncratic weeks as:

$$Ratio_{ir} = \left(\frac{\sum_{t=2015}^{2019} D_{irt}}{\sum_{t=2015}^{2019} D'_{irt}} \right) / 5 \quad (2)$$

Next, for each region, we calculated the share of annual total deaths registered during each week of the year, and averaged it throughout the pre-pandemic period, \bar{w}_{iwr} . This was done in order to distribute the reduced annual death counts, D'_{irt} , throughout each pre-pandemic year. Then our adjusted weekly death count was calculated as follows:

$$D_{wirt}^{adj} = (D'_{irt} \times \bar{w}_{iwr}) \times Ratio_{ir} \quad (3)$$

Therefore, the adjusted weekly death count for each region was the reduced annual (weighted) count multiplied by the average ratio of annual to reduced death count over the pre-pandemic period. Like the Ruhm (2021) study for the US, this ensures that we maintain the total number of deaths before the pandemic, but without the excess volatility observed during the first weeks of each calendar year. The main difference in our case, was that we used weekly data at the regional level for England and Wales, while the US study relied on national-level annual time series. We also applied this method after weekly regional data were collapsed at the national level (England plus Wales). Results were in line.

After removing the excess volatility from the data, we estimated the number of baseline deaths that would have been registered had the pandemic not occurred, i.e. our counterfactual. This was obtained from OLS regressions of the following form:

$$D_{wirt}^{adj} = a_{ir}T_w + b_{ir}T_w^2 + \gamma_r + \lambda_t + u_{wirt} \quad (4)$$

where the outcome variable is expressed in logs, γ and λ are regional and year fixed effects, respectively. The inclusion of a linear or a quadratic time trend, T , was based on estimating separate models and choosing the one with the smallest root mean squared error ($RMSE$). In all cases, models including a quadratic time trend had the smallest $RMSE$ value. The estimation sample covered the pre-pandemic period (2015-2019). By setting the quadratic trend term to its 2020 values, and with year and region indicators being fixed, we obtained the baseline weekly number of deaths from week 11 to week 53 of 2020 onwards. The standard errors of those regressions were used to compute 95% confidence intervals. Weekly excess deaths are calculated as the difference between the observed 2020 counts and our estimated counterfactual mortality.

3.2 Difference-in-differences framework

The construction of a counterfactual mortality measure, allows us to study excess mortality during 2020 under a difference-in-differences (DiD) framework. A control mortality measure to benchmark against actual mortality before and after the pandemic onset will provide some reassurance about the recorded change not being due to unobserved factors. Hence, we consider actual weekly death counts in 2020 as being exposed to the treatment, i.e. the pandemic. Counterfactual weekly death counts in 2020 have been calculated as in sub-section 3.1. However, year now refers to the period between the first and the last week of each year. This was necessary for the construction of “post-intervention” indicator that is necessary in a DiD framework. Our estimated models are of the general form:

$$d_{wrt} = a_0 + a_1Treat_t + a_2Post_{rw} + a_3Treat_t \times Post_{rw} + \delta_r + \varphi_w + u_{wrt} \quad (5)$$

where d is the number of deaths by week w , region r , and year t , where $t = 0,1$. $Treat$ is equal to 1 if weekly deaths refer to the actual counts observed in 2020, and equal to 0 if they refer to the counterfactual, baseline scenario of a no-pandemic year. $Post$ is equal to 1 after

the first week with a death registered as due to COVID-19 in the r -th region. In most of the regions (plus Wales), the first death due to COVID-19 was officially registered in week 12. In North West, West Midlands, and South East the first pandemic-related death was registered at week 11. The coefficient of the interaction term, α_3 , is the DiD parameter of interest. It measures how weekly regional mortality changed after the first death registered as due to COVID-19, relative to a counterfactual no-pandemic scenario. Models also control for regional fixed effects, a quadratic weekly time trend, gender, and place of death, i.e. home, hospital, care home, and elsewhere. For the DiD estimations, daily data were collapsed by year, week, region, place of death, and gender. The DiD estimates are valid under the assumption that actual and counterfactual death counts trended similarly before the pandemic onset, i.e. when $Post = 0$. Given that the onset of the pandemic, in terms of registered deaths explicitly attributed to it, did not occur simultaneously across all regions, we show that this assumption is met using a panel event study specification. Denote as $Onset_r$ a variable indicating the week w in which the first death due to COVID-19 was registered in region r . If deaths per week in each region are denoted as d_{rw} , then the panel event specification is the following:

$$d_{rw} = \alpha + \sum_{j=2}^J \beta_j (Lag\ j)_{rw} + \sum_{k=1}^K \gamma_k (Lead\ k)_{rw} + \delta_r + \varphi_w + \epsilon_{rw} \quad (6)$$

where δ_r and φ_w are region and week fixed effects, ϵ_{rw} is an unobserved error component, and lags and leads to the onset of COVID-19 deaths are defined as below:

$$(Lag\ j)_{rw} = \mathbb{I}[t = Onset_r - j] \text{ for } j \in \{1, \dots, J - 1\} \quad (7)$$

$$(Lead\ k)_{rw} = \mathbb{I}[t = Onset_r + k] \text{ for } k \in \{1, \dots, K - 1\} \quad (8)$$

Therefore, lags and leads are binary indicators on the number of weeks a specific region is away from the onset of deaths due to COVID-19. In Eq. 6 the baseline lag is set where $j = 1$.

4. Results

4.1 Excess number of deaths

Table 1 presents the baseline results regarding overall excess mortality calculated as in subsection 3.1. Moreover, it displays results by gender, age group and region. There were 82,428 excess deaths during weeks 11-53 of 2020; relative to the baseline figure of 413,811 deaths that would have happened in the absence of the pandemic (Appendix Table A.3). Figure 2 displays how cumulative excess deaths evolved after the pandemic onset in week 11 of 2020. Moreover, it compares excess deaths calculated using our regression-adjusted measure of baseline mortality (black lines), versus the commonly used 5-year pre-pandemic average (red line). Results are similar, however, using the 5-year average underestimates excess death counts and produces noisier estimates.

The observed to baseline death ratio was 1.20, and nearly 90% of those excess deaths were registered as due to COVID-19. Figure 3 shows how the share of excess deaths due to COVID-19 evolved over the year. There was a sharp increase in the very first weeks after the pandemic onset and it trended steadily upwards until the last week of the year. Moreover, Figure 3 indicates that using a 5-year average measure of baseline mortality overestimates the share of excess deaths due to COVID-19. Calculating the observed to baseline death ratio by various demographic characteristics reveals that it was particularly increased for males (1.24), those older than 65 years (1.21), and those living in London (1.28) and in West Midlands (1.24).

[Table 1 here]

[Figure 2 here]

[Figure 3 here]

Moreover, Table 2, reveals substantial differences when the observed to baseline death ratio is calculated by place of death. There was a relatively small increase for deaths in hospitals, i.e. the ratio was 1.06, after the pandemic onset. However, this seems to be due to the large increase in excess deaths in care homes (around 12,000) and in homes (around 43,000), where the observed to baseline ratio was 1.31 and 1.45, respectively. State it otherwise, 52.3% of the overall excess death count in 2020 happened at homes, and 85.6% happened at homes and care homes combined. As highlighted by earlier reports, possible factors explaining this trend could be people choosing to stay away from health care settings or choosing to stay at home if terminally ill (ONS, 2021c).

[Table 2 here]

When excluding deaths due to COVID-19, overall observed mortality is not much different from a counterfactual no-pandemic scenario. Deaths not due to COVID-19 modestly increased after the onset of the pandemic but remained relatively low throughout the year (Figure 4). According to the results in Table 3, the observed to baseline death ratio was 1.02, with around 9,000 excess deaths registered between weeks 11 and 53 of 2020. Repeating the analysis by demographic characteristics, this non-pandemic excess mortality was distributed evenly between genders, but there were striking differences across age groups. Persons 45-64 years old were the most affected age group, with more than 3,000 excess deaths not due to COVID-19, representing 34% of the total count, and an observed to baseline death ratio equal to 1.06. There were also more than 6,500 excess deaths from other causes for those aged ≥ 65 years old, however, their observed to baseline death ratio was lower (1.01 to 1.03).

[Table 3 here]

[Figure 4 here]

Regarding the causes of death, for all age groups and places of death, there was increased excess mortality from dementia and Alzheimer's disease, diabetes, Parkinson's disease, and heart-related diseases (Table 4). On the other hand, there were considerably fewer deaths from pneumonia and influenza, diseases of the lower respiratory system, strokes, infectious and parasitic diseases, and other accidents. When considering the place of death, there are some striking results. Observed deaths from all other causes happening in hospitals were actually lower compared to a no-pandemic scenario, i.e. 38,000 less deaths with an observed to baseline ratio equal to 0.80. Instead, there were 40,000 more deaths at home from all other causes relative to a baseline scenario; the observed to baseline ratio was equal to 1.41. This becomes more evident in Figure 5. There were less deaths at hospitals not involving COVID-19 throughout the year after the pandemic onset. Regarding excess deaths at care homes, these increased sharply after the pandemic onset but stabilised a few weeks later; and even trended downwards for the case of deaths not involving COVID-19. Regarding excess deaths at home, however, their count kept rising until the end of the first pandemic year. Moreover, the vast majority of them did not involve COVID-19 but they were due to other causes.

[Table 4 here]

[Figure 5 here]

The results so far indicated that the burden of overall excess mortality and excess mortality not due to COVID-19 was mainly carried by those 45-64 and ≥ 65 years old. Focusing on deaths not registered as due to COVID-19, Figure 6 displays how cumulative excess deaths evolved over the year for those two age groups. Regarding persons 45-64 years old (panel A), excess mortality due to other causes was solely driven by deaths at home; by the end of the first pandemic year, nearly 6,000 persons of that age group were registered as died at

their usual place of residence, namely the usual residence of the deceased, where this is not a communal establishment. There were fewer deaths at hospital, around 2,000, and very few deaths elsewhere. As expected for this age group, there were very few excess deaths at care home. By the last week of 2020, the net sum of excess deaths across all places of death was 3,119 (2,503 to 3,726), as shown in Table 3.

Regarding those ≥ 65 years old, there were nearly 34,000 excess deaths at home not related to COVID-19 (Figure 6, panel B). At the same time, there were 35,000 less deaths from other causes at hospitals, and nearly 8,500 deaths at care homes, mainly due to their sharp increase right after the pandemic onset. Together with the few number of excess deaths were registered as elsewhere, the cumulative count of excess deaths from all other causes for this age group was 6,649 (3,299 to 9,966) by the end of the year.

[Figure 6 here]

Next, we look what the main causes of death were for those two age groups in each place of death with a substantially increased excess death count from causes other than COVID-19 in 2020. Figure 7 graphs the results. The excess count of deaths for persons 45-64 who died at their usual place of residence, cancer, heart-related diseases, and lower respiratory system diseases were the causes that contributed the most (panel A). For persons ≥ 65 years old who died at home, the most popular causes of death were cancer, heart-related diseases, and dementia (panel B). For the same age group, but for those who died at care homes, dementia was by far the most contributory cause of death, mainly due to the sharp increase right after the first death due to COVID-19 was officially registered in England and Wales (panel C).

[Figure 7 here]

4.2. Difference-in-differences results

Based on our counterfactual death count, there were 82,428 excess deaths in England and Wales in 2020, from week 11 onwards. Nearly all of them, i.e. 82,355 were for people ≥ 45 years old. Most of the excess mortality, 88.9% and 88.1% for all age groups population and those ≥ 45 years old, respectively, was explicitly linked to COVID-19 in the official registries.

To ensure that those results are not driven by unobserved factors we applied a DiD-style analysis restricting the sample to those age groups mostly responsible for the observed excess mortality. We consider observed weekly death counts in 2020 as those exposed to the treatment, i.e. the pandemic year. Counterfactual weekly death counts in 2020 are the control group. For each region, the intervention period begins the week when the first death due to COVID-19 was registered in that region. For 3 regions the post period starts at week 12, for the rest of them is set from week 11 onwards. Table 5 shows the results. Panel A focuses on persons 45-64 years old. Restricting the sample by place of death, there were considerably fewer deaths in hospitals and elsewhere, however, mortality at private homes was significantly higher (columns 1-4). Using deaths registered elsewhere as our base group, and interacting our post with the place of death indicators (column 5) indicates highlights the significantly increased mortality at home for those aged 45-64 years old. Despite the effect that in-hospital mortality was lower for this age group (also shown in panel A of Figure 6), it was not enough to offset the increased number of deaths at private homes.

Regarding persons ≥ 65 years old (panel B), our DiD estimates (columns 1-4) also support that mortality at home was significantly increased, while deaths at hospitals were fewer. This is also confirmed in column 5. Unlike the case of those 45-64 years old, increased mortality at homes was offset by lower in-hospital mortality (see panel B of Figure 6). Regarding deaths at care homes, they were marginally fewer when considering the total period since the pandemic onset in each region.

[Table 5 here]

To examine about pre-trends, we run an event-style analysis as in Eq. (6). We consider weekly death counts (not due to COVID-19) for places of death and age groups that mostly accounted for the observed change in 2020. Figure 8 focuses on persons 45-64 years old. Regarding deaths at home (panel A), there were no detectable trends before the onset in each region. However, since the first deaths due to COVID-19 were registered, weekly death counts were significantly increased, particularly during the first weeks after the onset, and remained high until the end of the year. On the other hand, deaths at hospital for this age group were rather fewer during the first weeks after the onset but they got significantly increased from week 26 onwards (panel B).

[Figure 8 here]

Figure 9 focuses on deaths not due to COVID-19 for those ≥ 65 years old. Panel A shows results for deaths at care homes. There was a sharp increase during the first 5 weeks after the pandemic onset in each region (panel A). However, weekly death counts began to decline since then. They remained lower during the following weeks and they started increasing around 30 weeks after the pandemic onset. Deaths at home also climbed sharply during the first weeks after the first deaths officially due to COVID-19. They declined after week 6, however, they remained higher throughout the year (panel B). In-hospital deaths from all other causes but COVID-19, declined sharply after the pandemic onset, and they were lower for this age group for 25 weeks since the first COVID-19 deaths in each region (panel C). However, towards the end of the year they became significantly higher relative to the reference week, following an upward trend as early as from week 10 after the pandemic onset.

[Figure 9 here]

5. Conclusions

An accurate estimation of excess mortality is crucial for fully understanding how the pandemic affected public health. However, this depends on how detailed the data are and on the procedure adopted to estimate a baseline death count number that would have been observed in a no-pandemic scenario. Here we focus on excess deaths observed in England and Wales during 2020, for which previous reports relied on 5-year averages to calculate a baseline death count (ONS, 2021a; 2021b), and the related literature so far focused only on total mortality (Vandoros, 2020).

Using regional-level weekly panel data, we modify a method proposed by Ruhm (2021) to estimate the baseline number of deaths by gender, age, cause of death, and place of death. Based on our findings, there were 82,428 excess deaths during weeks 11-53 of 2020 in England and Wales. Nearly 90% of those excess deaths were registered as due to COVID-19, a proportion slightly lower than what was originally estimated (ONS, 2022) and lower than the one estimated by the COVID-19 Excess Mortality Collaborators study (2022). Although the differences may be due to different methodologies used as well as the fact that these studies had considered a longer period till the end of December 2021, our findings suggest that non-COVID-19 excess deaths may have been previously underestimated.

When looking at differences by demographic groups for overall excess mortality during the first year of the pandemic, we show that the main groups affected were males, those older than 65 years and those living in London and in West Midlands. The findings are consistent with previous literature on excess mortality in England and Wales that showed regional variations (Kontopantelis et al., 2021) and variations by gender and age (Joy et al., 2020). Yet, when focusing on excess deaths not due to COVID-19, the picture is different; excess mortality was distributed evenly between genders, but there are striking age differences with those individuals over 45 years old were affected the most. This highlights the importance of

analysing excess mortality separately for deaths due to COVID-19 and deaths not related to COVID-19 as the profile of those impacted differs significantly.

When looking at the place of death, 85.6% of all excess deaths happened in non-hospital settings, namely private homes and care homes. Our estimates suggest approximately 43,000 excess deaths during 2020 happened in private homes, a number slightly higher than what was previously estimated (ONS, 2021c).

Across all causes of death there was increased excess mortality from dementia and Alzheimer's disease, diabetes, Parkinson's disease and heart-related disease. This is consistent with previous research on cardiovascular diseases in England which found that the pandemic caused an increase in these conditions both direct (due to infection) and indirect effect (due to unprecedented system strain and associated behaviour changes) (Banarjee et al., 2021). What our findings add is that most of these deaths happened at home alongside death due to cancer, confirming previous evidence showing increase direct and indirect excess deaths in people with cancer in England (Lai et al. 2020). On the other hand, and at the same period there was a reduction in deaths from pneumonia and influenza, stroke as well as infectious diseases and accidents.

Understanding excess mortality during the pandemic is more meaningful when these numbers are broken down by cause of death and demographic characteristics of the groups affected the most. Our findings offer insights towards this direction. Our results though cannot offer a causal link between policy responses during the pandemic and excess deaths. Further work exploring this link is needed.

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Tables & Figures

Table 1. Total observed deaths, excess deaths and deaths from COVID-19 in 2020: Results by gender, age group, and region.

	Observed deaths	Excess deaths	Observed to baseline death ratio	Deaths from COVID-19	% of excess deaths due to COVID-19
Group:	[1]	[2]	[3]	[4]	[5]
All	496,239	82,428 (78,402 to 86,415)	1.20 (1.19 to 1.21)	73,307	88.9% (84.8% to 93.5%)
Males	252,545	49,529 (47,439 to 51,597)	1.24 (1.23 to 1.26)	40,693	82.2% (78.9% to 85.8%)
Females	243,694	32,963 (30,891 to 35,016)	1.16 (1.15 to 1.17)	32,614	98.9% (93.1% to 105.6%)
0-14 years old	2,540	-435 (-536 to -338)	0.85 (0.83 to 0.88)	5	-
15-44 years old	12,634	741 (470 to 1,006)	1.06 (1.04 to 1.09)	715	96.5% (71.1% to 152%)
45-64 years old	59,582	9,734 (9,119 to 10,341)	1.20 (1.18 to 1.21)	6,615	67.8% (64.0% to 72.5%)
≥65 years old	421,483	72,621 (69,271 to 75,938)	1.21 (1.20 to 1.22)	65,972	90.8% (86.9% to 95.2%)
North East	26,518	4,470 (4,457 to 4,480)	1.21 (1.20 to 1.23)	4,443	95.1% (91.0% to 99.7%)
North West	69,085	13,111 (12,566 to 13,650)	1.23 (1.22 to 1.25)	12,344	94.2% (90.4% to 98.2%)
Yorkshire & The Humber	49,435	8,666 (8,269 to 9,059)	1.21 (1.20 to 1.22)	8,201	94.6% (90.5% to 99.2%)
East Midlands	42,534	7,284 (6,941 to 7,624)	1.21 (1.20 to 1.22)	6,232	85.6% (81.7% to 89.8%)
West Midlands	53,122	10,336 (9,920 to 10,749)	1.24 (1.23 to 1.25)	8,142	78.8% (75.7% to 82.1%)
East	51,809	7,259 (6,826 to 7,688)	1.16 (1.15 to 1.17)	6,441	88.7% (83.8% to 94.4%)
London	49,673	10,981 (10,605 to 11,354)	1.28 (1.27 to 1.30)	10,050	91.5% (88.5% to 94.8%)
South East	74,237	10,778 (10,161 to 11,389)	1.17 (1.16 to 1.18)	9,104	84.5% (79.9% to 89.6%)
South West	49,375	4,968 (4,536 to 5,396)	1.11 (1.10 to 1.12)	3,977	80.1% (73.7% to 87.7%)
Wales	30,451	4,374 (4,121 to 4,626)	1.17 (1.16 to 1.18)	4,373	100.0% (94.5% to 106.1%)

Source: Office for National Statistics (ONS).

Notes: All estimations exclude non-residents. 95% confidence intervals in parentheses. 2020 refers to the period between weeks 11 and 53.

Table 2. Total observed and excess deaths by place of death in 2020.

	Observed deaths	Excess deaths	Observed to baseline death ratio
Place of death:	[1]	[2]	[3]
Total	496,239	82,428 (78,402 to 86,415)	1.20 (1.19 to 1.21)
Hospital	206,601	11,962 (9,553 to 13,950)	1.06 (1.05 to 1.07)
Care home	116,487	27,435 (26,435 to 28,423)	1.31 (1.29 to 1.32)
Home	139,703	43,127 (41,987 to 44,253)	1.45 (1.43 to 1.46)
Elsewhere	33,448	276 (-116 to 663)	1.01 (1.00 to 1.02)

Source: Office for National Statistics (ONS).

Notes: All estimations exclude non-residents. 95% confidence intervals in parentheses. 2020 refers to the period between weeks 11 and 53. Totals may not sum exactly due to rounding.

Table 3. Observed and excess deaths in 2020 not due to COVID-19 by demographic group and by place of death.

	Observed deaths	Excess deaths	Observed to baseline death ratio
Group:	[1]	[2]	[3]
Total	422,932	9,121 (5,095 to 13,108)	1.02 (1.01 to 1.03)
Males	211,852	8,836 (6,746 to 10,904)	1.04 (1.03 to 1.05)
Females	112,254	349 (-1,723 to 2,402)	1.04 (1.03 to 1.05)
0-14 years old	2,535	-440 (-541 to -343)	0.85 (0.82 to 0.88)
15-44 years old	11,919	26 (-245 to 290)	1.00 (0.98 to 1.02)
45-64 years old	52,967	3,119 (2,503 to 3,726)	1.06 (1.05 to 1.08)
≥65 years old	355,511	6,649 (3,299 to 9,966)	1.02 (1.01 to 1.03)
Hospital	156,448	-38,191 (-40,200 to -36,203)	0.80 (0.79 to 0.81)
Care home	97,594	8,542 (7,542 to 9,530)	1.10 (1.08 to 1.11)
Home	136,521	39,945 (38,805 to 41,071)	1.41 (1.40 to 1.43)
Elsewhere	32,369	-803 (-1,195 to -416)	0.98 (0.96 to 0.99)

Source: Office for National Statistics (ONS).
Notes: All estimations exclude non-residents. 95% confidence intervals in parentheses. 2020 refers to the period between weeks 11 and 53. Totals may not sum exactly due to rounding.

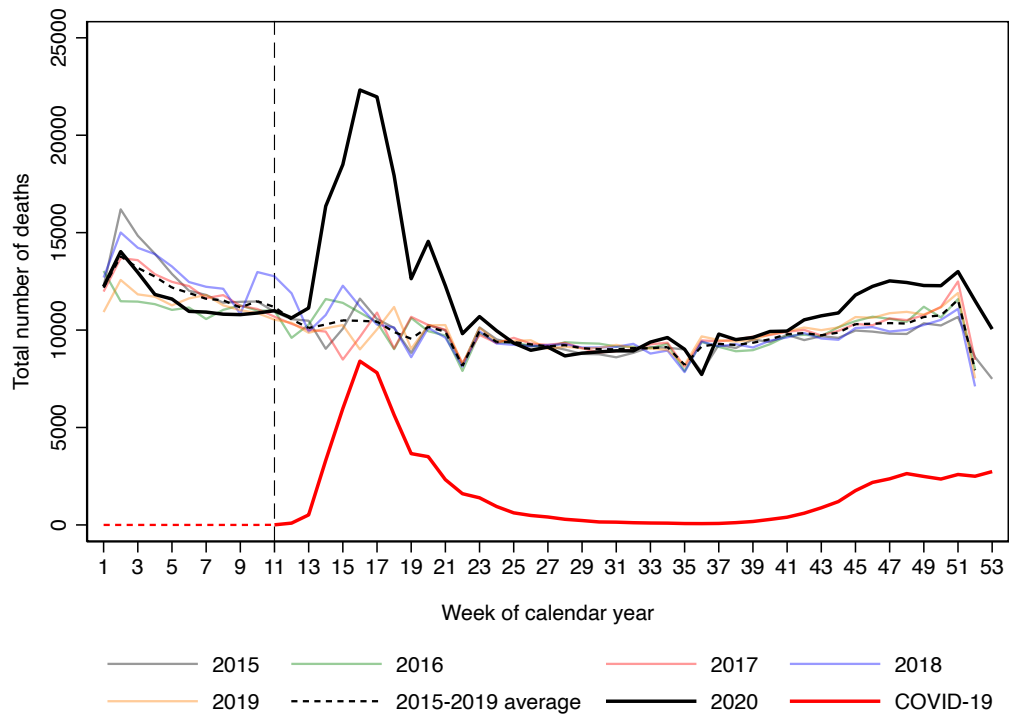
Table 4. Observed and excess deaths in 2020 by cause of death.

	Observed deaths	Excess deaths	Observed to baseline death ratio
Cause of death:	[1]	[2]	[3]
Cancer (malignant neoplasms)	118,173	-415 (-1,486 to 646)	1.00 (0.99 to 1.01)
Pneumonia & influenza	13,875	-6,179 (-6,532 to -5,831)	0.69 (0.68 to .070)
Lower respiratory system	20,649	-2,508 (-2,855 to -2,166)	0.89 (0.88 to 0.91)
Dementia & Alzheimer's disease	54,943	8,681 (8,083 to 9,272)	1.19 (1.17 to 1.20)
Mental & behavioural disorders excluding Dementia & Alzheimer's disease	723	139 (111 to 166)	1.24 (1.18 to 1.30)
Infectious & parasitic diseases	3,408	-1,052 (-1,183 to -925)	0.76 (0.74 to 0.79)
Diabetes	5,637	1,529 (1,425 to 1,630)	1.37 (1.34 to 1.41)
Parkinson disease	5,859	1,596 (1,490 to 1,699)	1.37 (1.34 to 1.41)
Nervous system diseases excluding Parkinson disease	7,506	845 (706 to 982)	1.13 (1.15 to 1.10)
Heart diseases	73,351	1,072 (163 to 1,969)	1.01 (1.00 to 1.03)
Stroke (cerebrovascular disease)	23,455	-3,436 (-3,797 to -3,080)	0.87 (0.86 to 0.88)
Kidney diseases	1,675	-73 (-132 to -17)	0.96 (0.93 to 0.99)
Transport accidents	266	-156 (-176 to -137)	0.63 (0.60 to 0.66)
Other accidents	7,612	-2,216 (-2,435 to -1,827)	0.78 (0.76 to 0.81)
Suicides	234	-203 (-220 to -187)	0.54 (0.52 to 0.56)
Homicides	8	-2 (-3 to -2)	0.77 (0.71 to 0.84)
Complications of medical and surgical care	71	-37 (-43 to -32)	0.66 (0.62 to 0.69)

Source: Office for National Statistics (ONS).
Notes: All estimations exclude non-residents. 95% confidence intervals in parentheses. 2020 refers to the period between weeks 11 and 53.

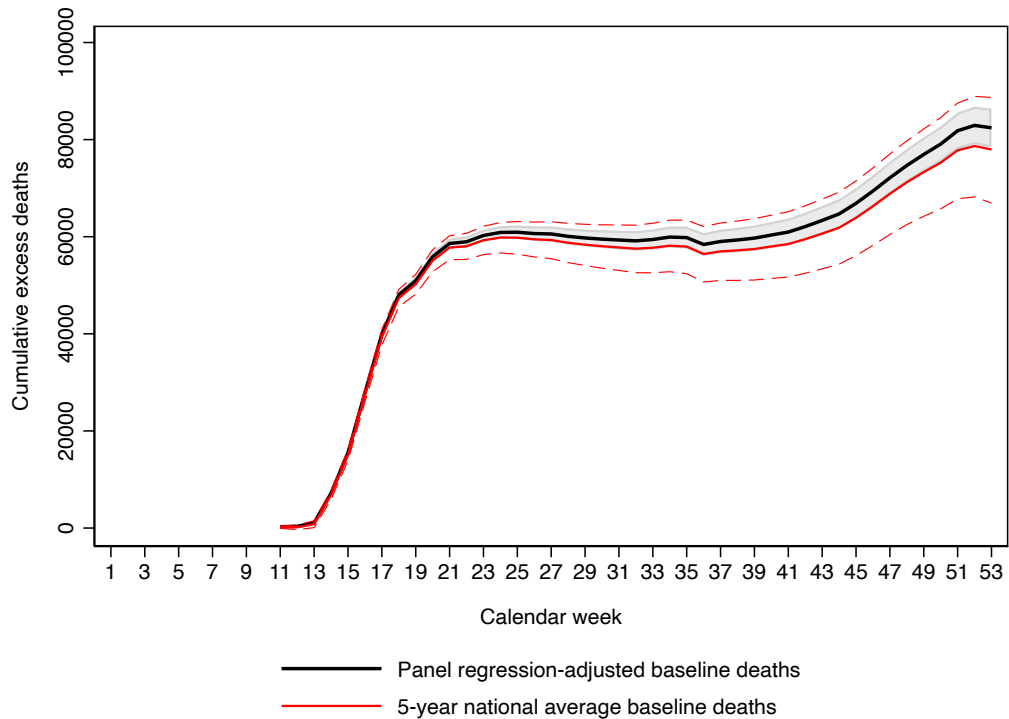
Table 5. Difference-in-differences results.					
	Home	Care home	Hospital	Elsewhere	All
	[1]	[2]	[3]	[4]	[5]
Panel A: Persons 45-64 years old					
Treat × Post	.240*** (.022)	-.061 (.046)	-.146*** (.019)	-.112*** (.033)	-
Treat	.019 (.020)	-.014 (.041)	.033** (.016)	-.035 (.029)	-
Post	-.206 (.180)	-.115 (.365)	.183 (.133)	.235 (.471)	-.007 (.168)
Treat × Post × Care home	-	-	-	-	.051 (.057)
Treat × Post × Home	-	-	-	-	.352*** (.041)
Treat × Post × Hospital	-	-	-	-	-.034 (.039)
Female	-.428*** (.008)	-.279*** (.019)	-.326*** (.008)	-.389*** (.014)	-.359*** (.006)
Weekly trend	Yes	Yes	Yes	Yes	Yes
Place of death fixed effects	-	-	-	-	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared	.841	.518	.834	.725	.927
Observations	2,120	1,760	2,120	2,110	8,110
Panel B: Persons ≥65 years old					
Treat × Post	.314*** (.013)	-.010 (.020)	-.238*** (.012)	.051** (.021)	-
Treat	.026** (.011)	.034** (.016)	-.012 (.010)	-.076*** (.019)	-
Post	-.130 (.170)	.015 (.163)	.220** (.108)	-.108 (.191)	-.001 (.097)
Treat × Post × Care home	-	-	-	-	-.061* (.034)
Treat × Post × Home	-	-	-	-	.263*** (.028)
Treat × Post × Hospital	-	-	-	-	-.289*** (.028)
Female	-.018*** (.006)	.334*** (.010)	.013** (.005)	.029*** (.009)	.090*** (.005)
Weekly trend	Yes	Yes	Yes	Yes	Yes
Place of death fixed effects	-	-	-	-	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared	.923	.825	.920	.857	.947
Observations	2,120	2,120	2,120	2,120	8,480
Source: Office for National Statistics (ONS).					
Notes: All estimations exclude non-residents. Robust standard errors in parentheses.					

Figure 1. Weekly death counts.



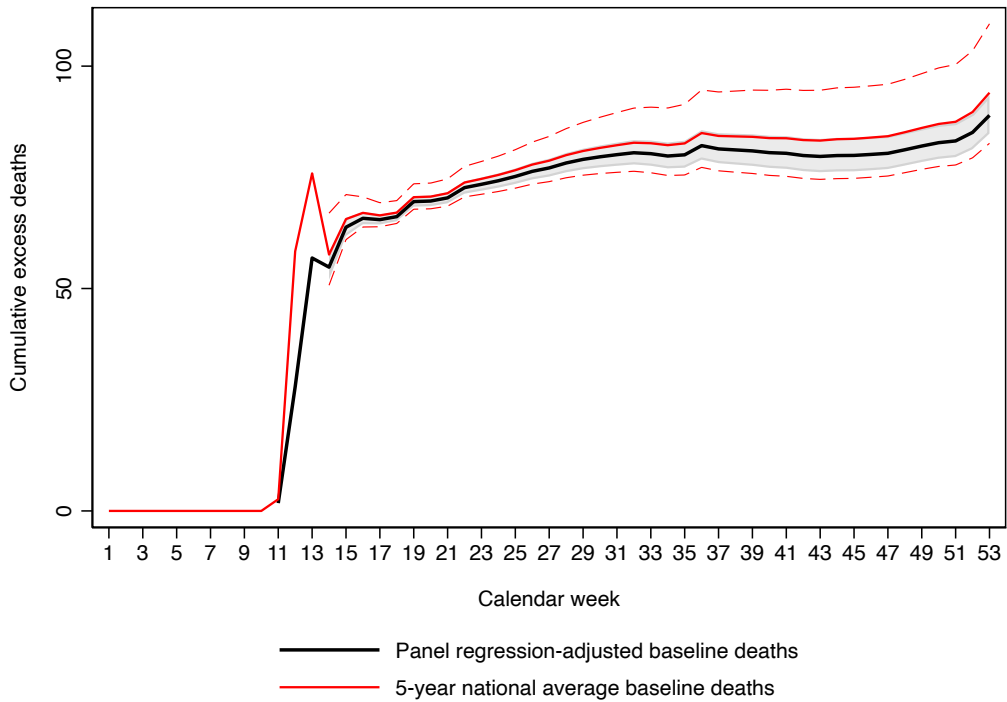
Source: Office for National Statistics (ONS).
Notes: All estimations exclude non-residents.

Figure 2. Cumulative excess deaths in 2020.



Source: Office for National Statistics (ONS).
Notes: Estimations exclude non-residents. 2020 refers to the period between weeks 11 and 53.

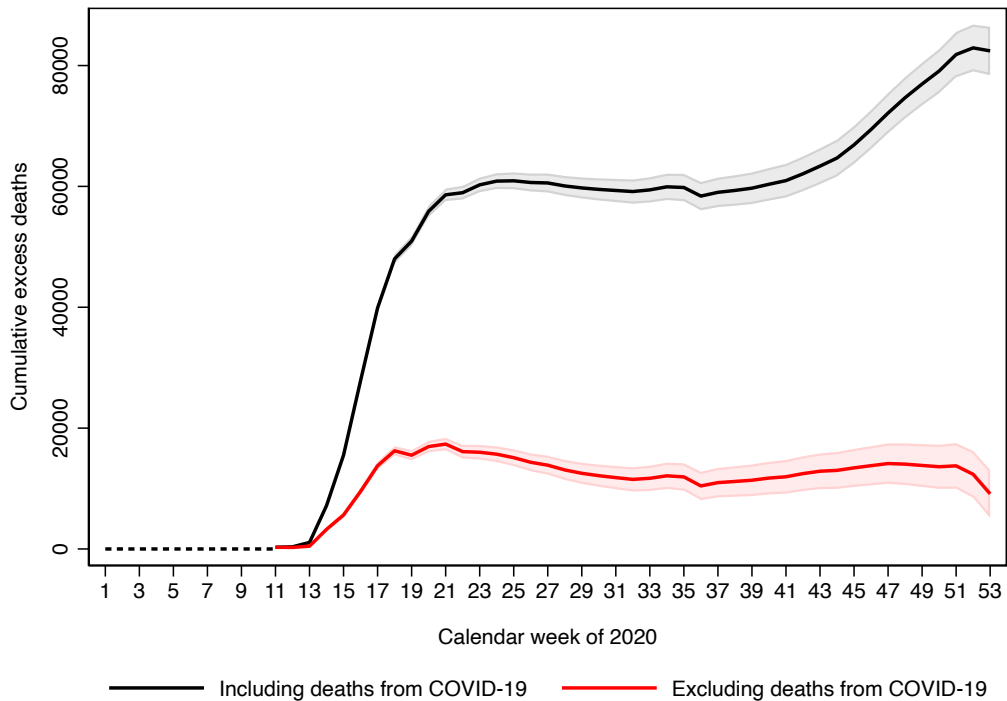
Figure 3. Share of total excess deaths due to COVID-19 in 2020.



Source: Office for National Statistics (ONS).

Notes: Estimations exclude non-residents. 2020 refers to the period between weeks 11 and 53.

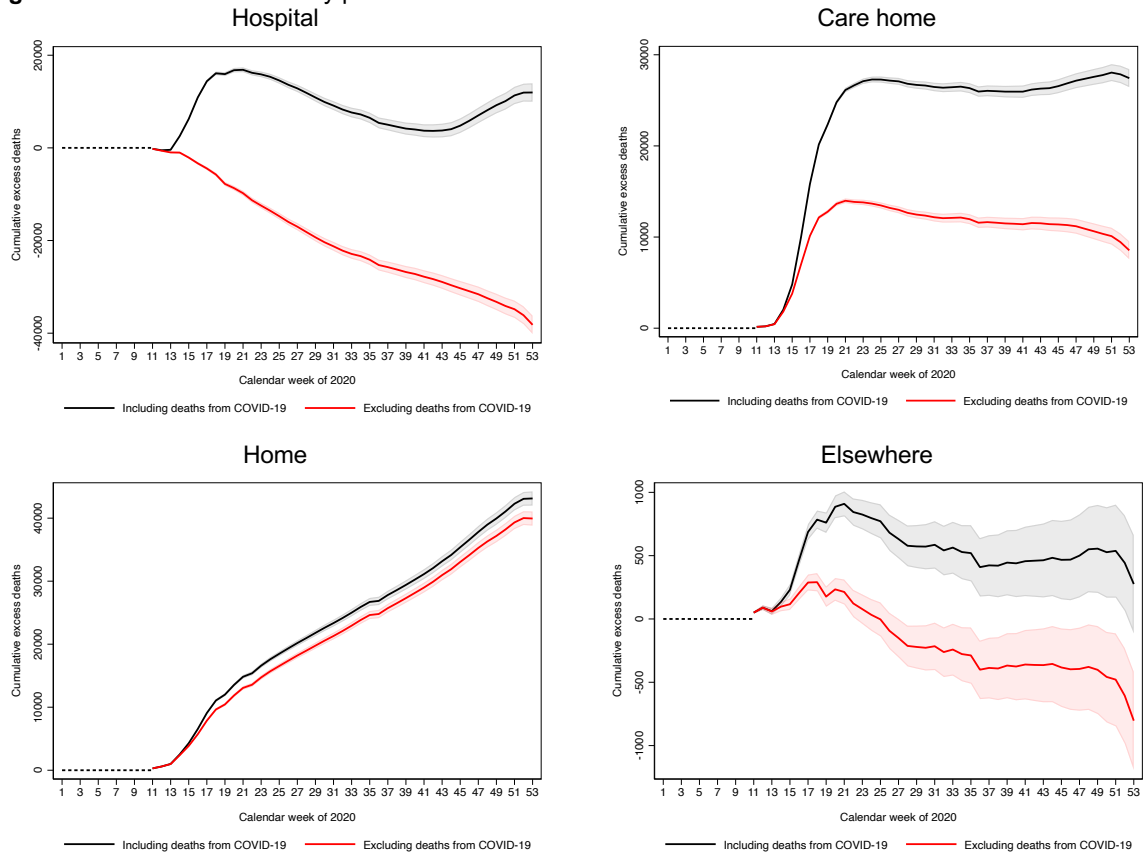
Figure 4. Total excess death count in 2020.



Source: Office for National Statistics (ONS).

Notes: Estimations exclude non-residents. 2020 refers to the period between weeks 11 and 53.

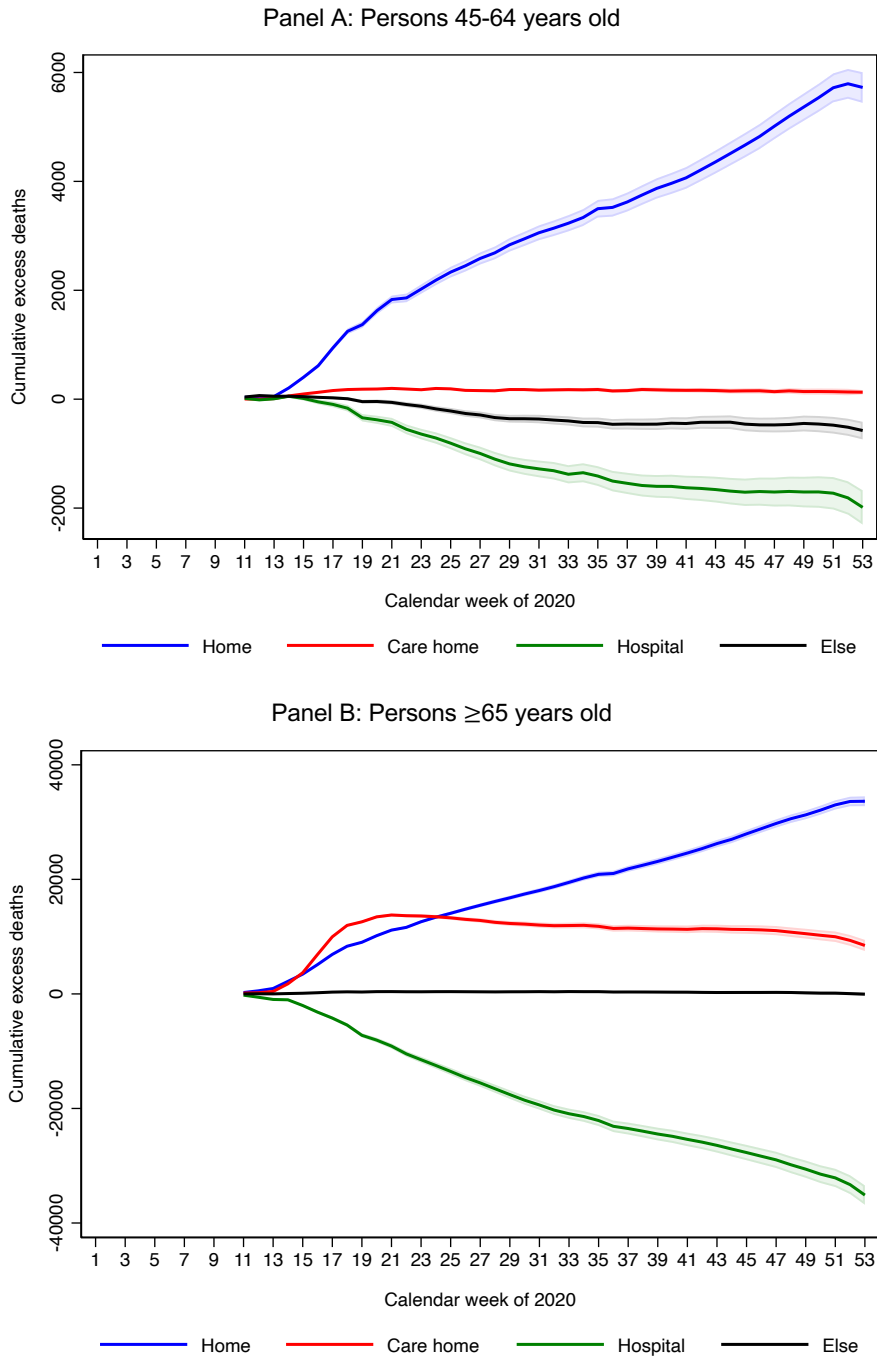
Figure 5. Excess death count by place of death in 2020.



Source: Office for National Statistics (ONS).

Notes: Estimations exclude non-residents. 2020 refers to the period between weeks 11 and 53.

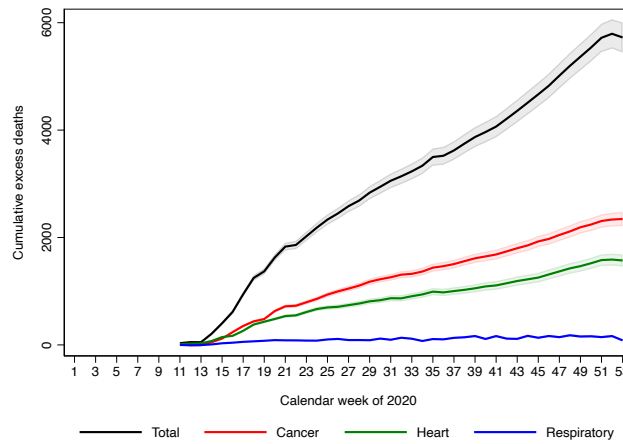
Figure 6. Excess deaths not due to COVID-19 in 2020 by age group and place of death.



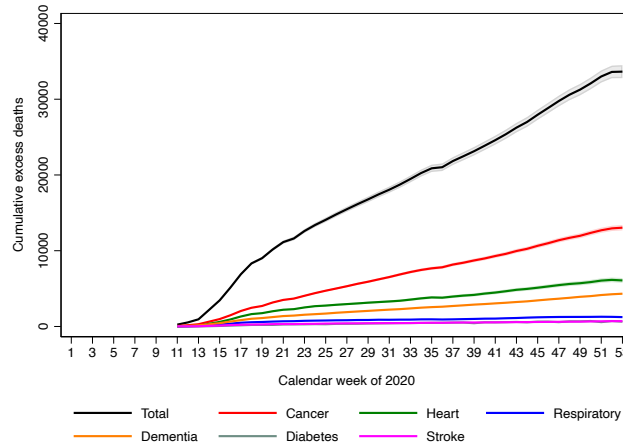
Source: Office for National Statistics (ONS).

Notes: All estimations exclude non-residents. 95% confidence intervals in shaded areas. 2020 refers to the period between weeks 11 and 53.

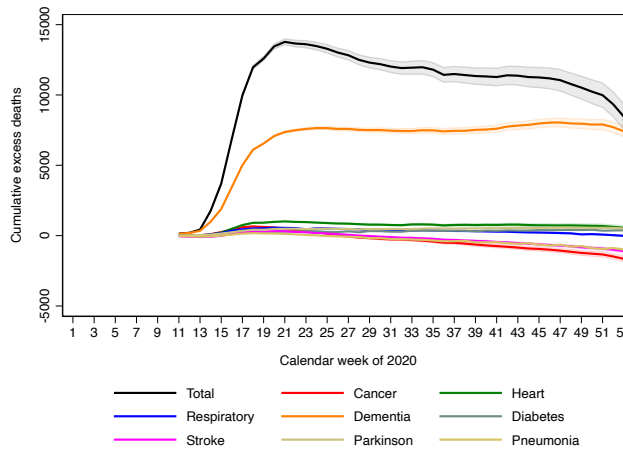
Figure 7. Excess deaths not due to COVID-19 in 2020 by age group, place of death, and cause of death.
 Panel A: Excess deaths at home for persons 45-64 years old



Panel B: Excess deaths at home for persons ≥ 65 years old



Panel C: Excess deaths at care homes for persons ≥ 65 years old

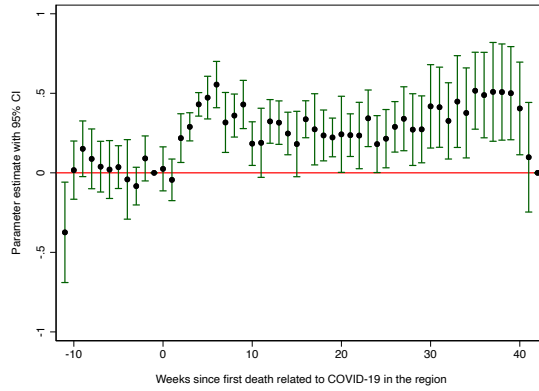


Source: Office for National Statistics (ONS).

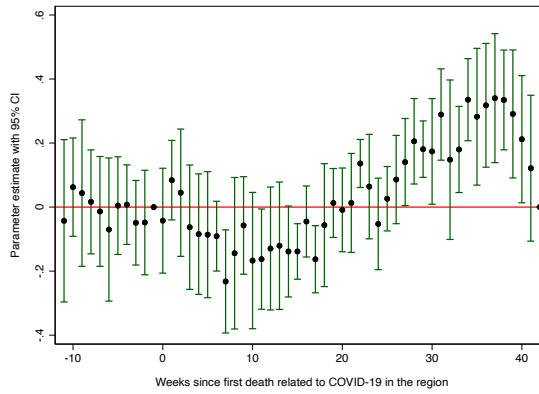
Notes: All estimations exclude non-residents. 95% confidence intervals in shaded areas. 2020 refers to the period between weeks 11 and 53.

Figure 8. Panel event estimates for persons 45-64 years old.

Panel A: Deaths at home



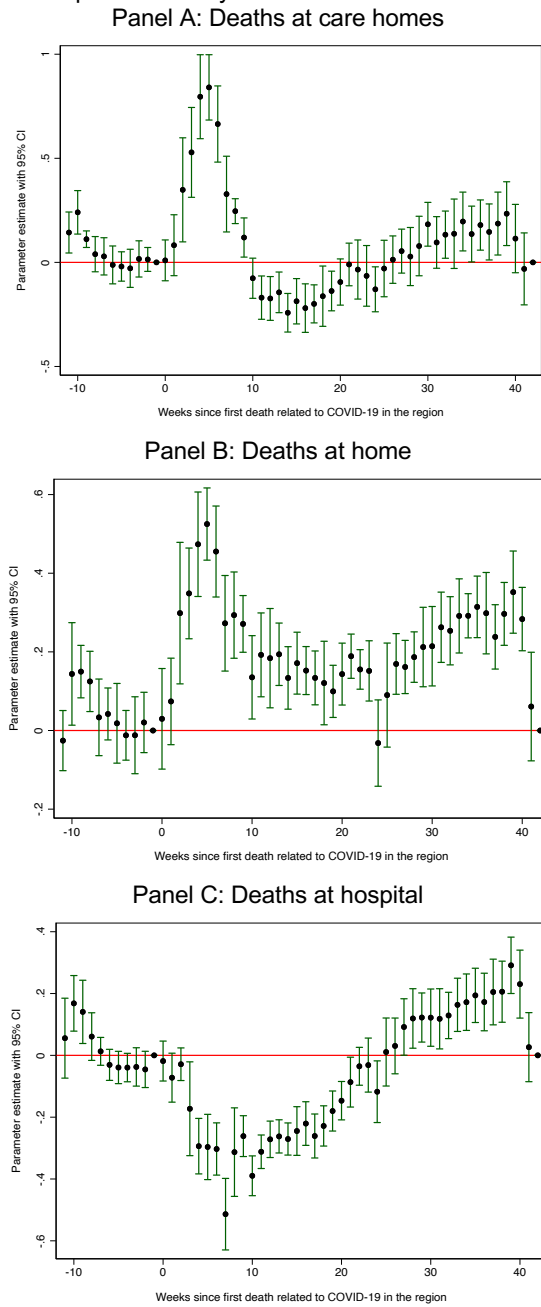
Panel B: Deaths at hospital



Source: Office for National Statistics (ONS).

Notes: All estimations exclude non-residents. 95% confidence intervals are based on robust standard errors.

Figure 9. Panel event estimates for persons ≥ 65 years old.



Source: Office for National Statistics (ONS).

Notes: All estimations exclude non-residents. 95% confidence intervals are based on robust standard errors.

Appendix

Table A.1. Year-over-year changes in total weekly death counts				
Week number	Mean annual change	Standard deviation of annual change	Minimum annual change	Maximum annual change
1	-332	1,284	-1,771	781
2	-906	3,242	-4,716	2,216
3	-753	2,570	-3,382	2,128
4	-551	2,135	-2,584	1,536
5	-403	1,773	-1,994	1,440
6	-98	942	-862	1,101
7	-1	1,034	-1,239	1,075
8	-34	716	-852	757
9	-108	260	-420	196
10	-148	1,649	-2,103	1,897
11	-100	1,760	-2,224	2,070
12	-47	1,435	-1,516	1,569
13	-155	96	-268	-63
14	264	1,846	-1670	2,553
15	46	3,092	-2,910	3,793
16	-652	1,595	-2,199	1,557
17	-134	464	-616	498
18	268	1,030	-1,095	1,075
19	53	1,601	-2,073	1,792
20	-4	284	-318	318
21	68	490	-405	642
22	10	318	-296	410
23	-6	228	-282	182
24	-24	112	-159	115
25	35	279	-362	256
26	79	177	-129	300
27	-36	134	-198	123
28	39	231	-120	381
29	73	344	-256	554
30	81	427	-455	546
31	160	330	-243	556
32	66	270	-198	311
33	-18	334	-474	262
34	-31	261	-406	199
35	-198	668	-1107	374
36	455	730	-56	1532
37	61	287	-257	323
38	83	379	-235	598

39	-4	645	-558	695
40	97	358	-287	473
41	47	272	-288	319
42	161	217	-163	285
43	77	246	-151	427
44	134	539	-459	634
45	173	407	-210	563
46	178	545	-437	767
47	262	738	-670	938
48	284	630	-504	928
49	113	683	-499	851
50	232	607	-668	641
51	308	1,145	-1,409	917
52	-273	882	-1,356	482

Source: Office for National Statistics (ONS).

Notes: Data cover the period between the first week of 2015 and the last week of 2019. Deaths for non-residents are excluded.

Table A.2. Year-over-year changes for deaths registered in first five weeks of year by cause of death				
Cause of death	Mean annual change	Standard deviation of annual change	Minimum annual change	Maximum annual change
All causes	-2,943	9,643	-11,746	6,263
Cancer (Malignant Neoplasms)	-95	406	-407	501
Pneumonia & Influenza	-602	1,943	-2,545	1,426
Lower respiratory system	-401	1,395	-1,891	1,144
Dementia & Alzheimer's disease	-537	2,447	-2,660	2,149
Mental & behavioural disorders excluding Dementia & Alzheimer's disease	4	8	-6	11
Infectious & parasitic diseases	-54	86	-150	24
Diabetes	-6	122	-115	122
Parkinson disease	-31	155	-182	117
Nervous system diseases excluding Parkinson disease	-30	153	-179	105
Heart diseases	-499	1,225	-1,554	881
Stroke (Cerebrovascular disease)	-349	559	-948	173
Kidney diseases	-15	38	-54	38
Transport accidents	1.5	26	-26	36
Other accidents	37	62	-19	113
Suicides ¹	14	56	-63	68
Homicides	-4	7	-13	4
Complications of medical and surgical care	9	28	-19	40s

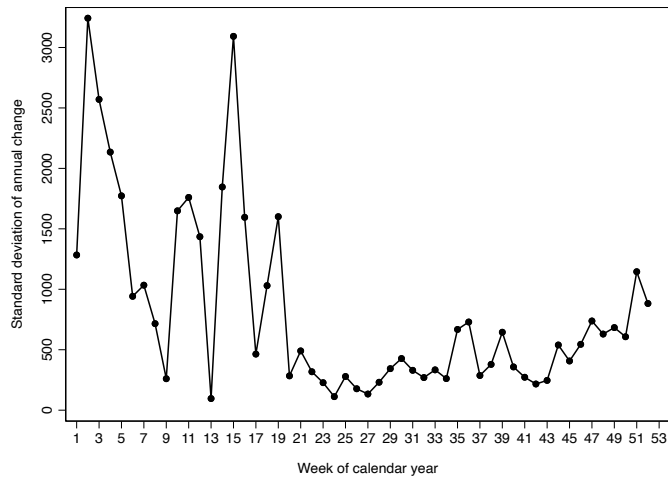
Source: Office for National Statistics (ONS).

Notes: Data cover the period between the first week of 2015 and the last week of 2019.

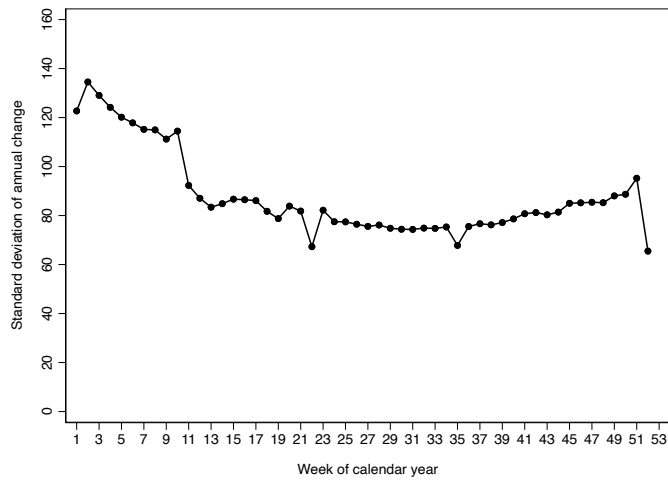
Table A.3. Baseline (counterfactual) death counts that would have been observed in the absence of the COVID-19 pandemic.			
Group	Baseline deaths	Cause of death	Baseline deaths
All	413,811 (409,824 to 417,837)	Cancer	118,588 (114,527 to 119,659)
Males	203,016 (200,948 to 205,106)	Pneumonia & influenza	20,054 (19,706 to 20,407)
Females	210,731 (208,678 to 212,803)	Lower respiratory system	23,157 (22,815 to 23,504)
0-14 years old	2,975 (2,878 to 3,076)	Dementia & Alzheimer's	46,262 (45,671 to 46,860)
15-44 years old	11,893 (11,628 to 12,164)	Other mental disorders	733 (691 to 778)
45-64 years old	49,849 (49,241 to 50,463)	Infectious diseases	4,473 (4,346 to 4,604)
≥65 years old	348,862 (345,545 to 352,212)	Diabetes	4,108 (4,007 to 4,212)
Place of death: Hospital	194,639 (192,651 to 196,648)	Parkinson	4,259 (4,154 to 4,367)
Place of death: Care home	89,053 (88,064 to 90,052)	Other nervous system diseases	6,661 (6,524 to 6,800)
Place of death: Home	96,576 (95,450 to 97,716)	Heart diseases	72,279 (71,382 to 73,188)
Place of death: Elsewhere	33,172 (32,785 to 33,564)	Stroke	26,891 (26,535 to 27,252)
North East	21,848 (21,638 to 22,061)	Kidney	2,057 (1,987 to 2,130)
North West	55,974 (55,435 to 56,519)	Transport accidents	1,295 (1,222 to 1,373)
Yorkshire & The Humber	40,769 (40,376 to 41,166)	Other accidents	9,736 (9,347 to 10,045)
East Midlands	35,250 (34,910 to 35,593)	Suicides	4,189 (4,024 to 4,360)
West Midlands	42,786 (42,373 to 43,202)	Homicides	213 (193 to 235)
East	44,550 (44,121 to 44,983)	Complications of medical care	751 (706 to 797)
London	38,692 (38,319 to 39,068)		
South East	63,459 (62,847 to 64,076)		
South West	44,407 (43,379 to 44,839)		
Wales	26,076 (25,852 to 26,330)		

Source: Office for National Statistics (ONS).
Notes: All estimations exclude non-residents. Data refer to the period between weeks 11 and 53 of 2020. 95% confidence intervals in parentheses.

Figure A.1. Standard deviation of annual change in total weekly death counts .
 Panel A: Actual death counts



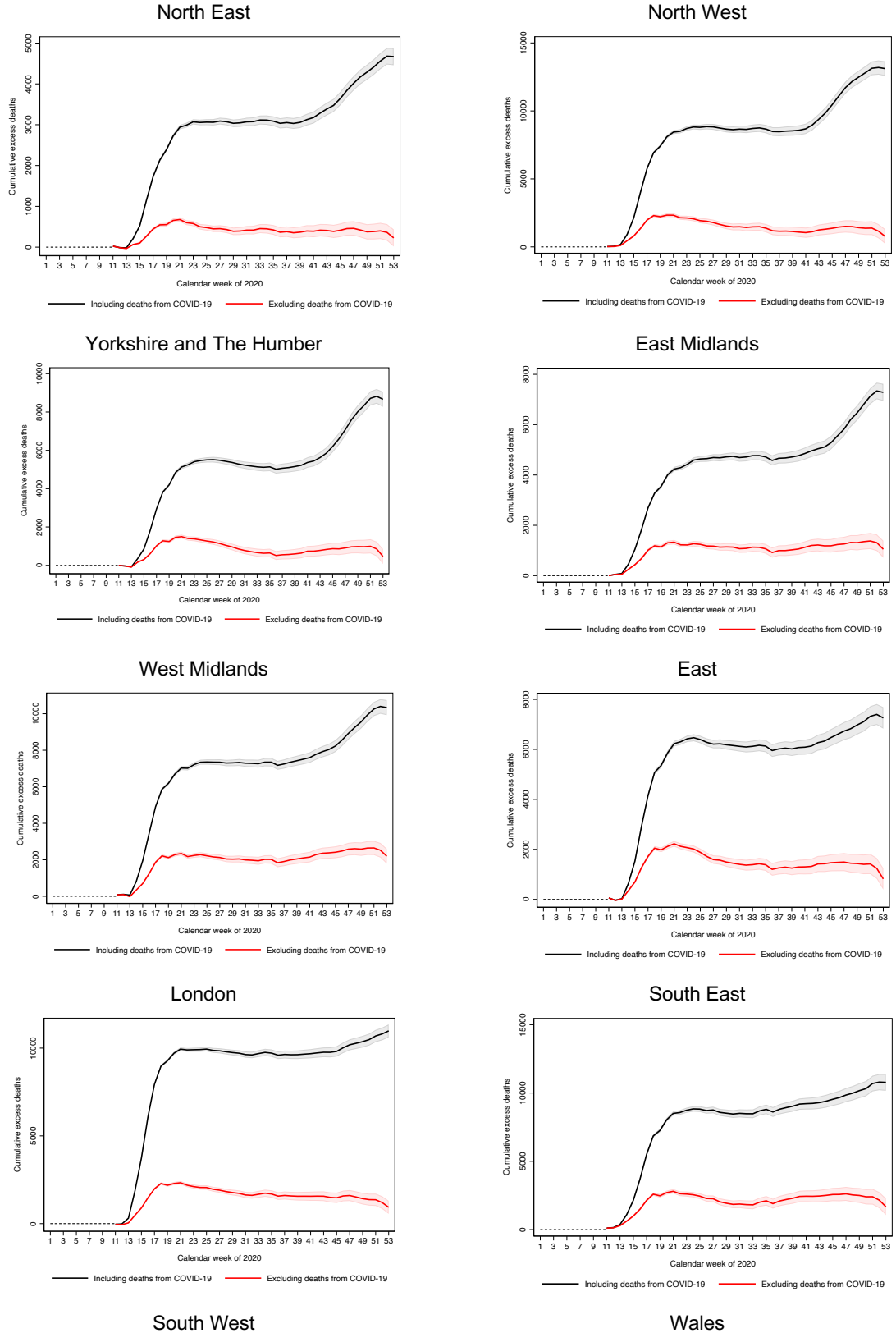
Panel B: Adjusted death counts

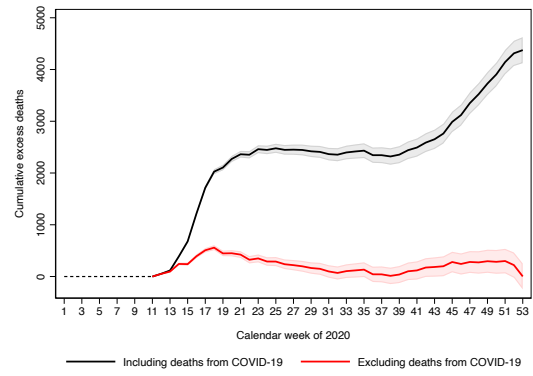
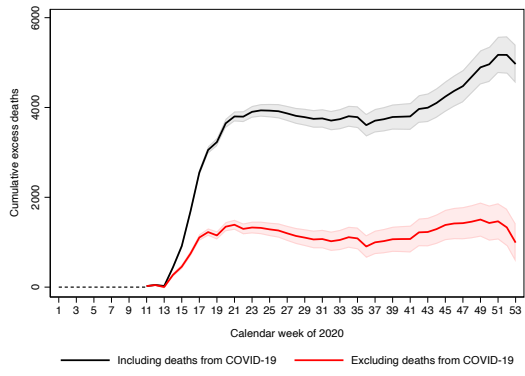


Source: Office for National Statistics (ONS).

Notes: Estimations exclude non-residents. Death counts include all causes of deaths.

Figure A.2. Total excess death count by region





Source: Office for National Statistics (ONS).
 Notes: Estimations exclude non-residents.