

Report 28: Excess non-COVID-19 deaths in England and Wales between 29th February and 5th June 2020

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Summary

There were 189,403 deaths from any cause reported in England from 29th February to 5th June 2020 inclusive, and 11,278 all-cause deaths in Wales over the same period. Of those deaths, 44,736 (23.6%) registered COVID-19 on the death certificate in England, and 2,294 (20.3%) in Wales, while 144,667 (76.4%) were not recorded as having been due to COVID-19 in England, and 8,984 (79.7%) in Wales. However, it could be that some of the 'non-COVID-19' deaths have in fact also been caused by COVID-19, either as the direct cause of death, or indirectly through provisions for the pandemic impeding access to care for other conditions. There is uncertainty in how many of the non-COVID-19 deaths were directly or indirectly caused by the pandemic. We estimated the excess deaths that were not recorded as associated with COVID-19 in the death certificate (excess non-COVID-19 deaths) as the deaths for which COVID-19 was not reported as the cause, compared to those we would have expected to occur had the pandemic not happened. Expected deaths were forecast with an analysis of historic trends in deaths between 2010 and April 2020 using data by the Office of National Statistics and a statistical time series model.

According to the model, we expected 136,294 (95% CI 133,882 - 138,696) deaths in England, and 8,983 (CI 8,051 - 9,904) in Wales over this period, significantly fewer than the number of deaths reported. This means that there were 8,983 (95% CI 5,971 - 10,785) total excess non-COVID-19 deaths in England. For every 100 COVID-19 deaths during the period from 29th February to 5th June 2020 there were 19 (95% CI 13 – 24) cumulative excess non-COVID-19 deaths. The proportion of cumulative excess non-COVID-19 deaths of all reported deaths during this period was 4.4% (95% CI 3.2% - 5.7%) in England, with small regional variations. Excess deaths were highest in the South East at 2,213 (95% CI 327 - 4,047) and in London at 1,937 (95% CI 896 - 3,010), respectively. There is no evidence of non-COVID-19 excess deaths in Wales. Excess non-COVID-19 deaths are occurring in individuals aged 85+ and 75-84, and those aged 45-64. For those aged 85+, excess non-COVID-19 deaths are driven by females, with 6,115 (95% CI 206 – 11,795) deaths in total but no significant findings for males of those ages. For ages 75-84, excess non-COVID-19 deaths are nearly double for females at 2,070 (95% CI 393 – 3,887) than for males at 1,336 (95% CI 938 – 1,710), while for ages 45-64, excess non-COVID-19 deaths for females are at 347 (95% CI 90 – 603), almost half those of males at 681 (95% CI 282 – 1,091). There is no evidence of excess non-COVID-19 deaths for ages 65-74, and those below 45.

Excess non-COVID-19 deaths could be due to non-reporting of COVID-19 on the death certificate or an increase in mortality for non-COVID-19 conditions. Severely ill patients may have been unable to access life-saving emergency treatment because of constraints in healthcare provision, or because they avoided seeking care due to concern over hospital-acquired infection, or to avoid burdening healthcare providers. Further research into reasons for excess non-COVID-19 deaths is warranted.

This report accompanies the weekly update of excess death estimates on the Github website of the Abdul Latif Jameel Institute of Disease and Emergency Analytics (J-IDEA) (<https://j-idea.github.io/ONSdeaths/>) which has been set up to be regularly updated until June 2022.

1. Introduction

There has been extensive coverage in the public and social media about a substantial increase in reported deaths in England and Wales since March 2020, which is not entirely accounted for by the increase in reported Covid-19 deaths [1-4], and calls for reliable estimates of the true death toll of the pandemic [5]. ‘Excess deaths’ is an estimate of the pandemic’s total mortality. It measures the additional deaths in a given time period compared with the number expected. It is not straightforward to estimate expected deaths, because the number of deaths in the absence of the pandemic is inherently unobservable. Expected number of deaths is often approximated by the average all-cause deaths in the corresponding week over the previous five years [6]. However, expected and excess deaths figures are uncertain because there is natural variation in the number of weekly deaths and the recording of these deaths. In this study, we forecast the number of deaths from March 2020 onwards using time series methods instead of the average number of deaths in the same week in the previous five years, and we considered the uncertainty around these estimates using confidence intervals. We analysed the Office of National Statistics (ONS) deaths statistics to compare the number of weekly reported all-cause deaths with the deaths that we would have expected based on deaths reported over the previous ten years.

2. Methods

2.1 Data

The ONS publishes the provisional number of deaths registered in the past week in England and Wales split by gender and age groups and by regions [6]. The statistics are derived from the formal process of death registration in Registry offices in England and Wales in the stated week, which is done online via a dedicated registration system. Figures are based on the date of registration rather than date of death, and they include deaths occurring outside hospital. Registry Offices did continue to take death registrations over the Easter holiday period this year, which may offset the usual drop in registration of deaths occurring in the Easter week. Estimates of death by region are based on area of usual residence. Figures include deaths of non-residents; in 2018 these were 0.24% of all deaths (Table 3 in [7]).

Since the beginning of March 2020, the weekly statistics also report the number of deaths for which the novel coronavirus (COVID-19) is mentioned in the death certificate. A doctor can certify the involvement of COVID-19 based on symptoms and clinical findings – a positive test result for SARS-CoV-2 infection is not required. The death numbers used for this study are different from the daily surveillance figures on COVID-19 deaths published by the Department of Health and Social Care (DHSC) on the GOV.UK website, for the UK as a whole and constituent countries (see Table A1), because these only cover deaths of individuals in hospital who tested swab-positive for SARS-CoV-2 infection.

The figures are provisional and are published by ONS 11 days after the weekends, to allow time for processing of the registration. There is usually a delay of around five working days between occurrence of a death and registration; for deaths occurring in March 2020, there was a mean delay of four days [8]. The percentage of deaths registered within 7 calendar days or fewer has decreased from 87.7% in 2010 to 73.8% in 2018. The percentage of deaths registered within 7 calendar days varies by region and is highest in the North East (81.9%) and lowest in the South East (68.2%) [9].

2.2 Statistical analysis

For the purpose of this study, we divided registered all-cause deaths into different categories (Figure 1, Supplementary Figure A1, Supplementary Figure A2). Registered all-cause deaths (red line) comprise of deaths that mention COVID-19 as cause of death (registered COVID-19 deaths), as well as those that did not mention COVID-19 as cause of death (registered non-COVID-19 deaths). Expected deaths (dashed black line) are the number of deaths that we would have expected without the COVID-19 pandemic. Expected deaths were forecast with a time series model using data from the week ending on January 8th 2020 to the week ending on February 28th 2020. Because they are a statistical forecast, they are uncertain and surrounded by a confidence interval (grey shaded area). Excess all-cause deaths are given by the difference between registered and expected all-cause deaths allowing for the uncertainty in that expectation; excess non-COVID-19 deaths are given by subtracting registered COVID-19 deaths from the difference between registered all-cause deaths and expected all-cause deaths, also allowing for the uncertainty in that expectation. Excess deaths are uncertain, because their estimation relies on expected (forecasted) all-cause deaths.

Supplementary Figure A1 illustrates a week where our estimate of excess non-COVID-19 deaths are not statistically different from expected all-cause deaths; assuming that all deaths due to COVID-19 are recorded as such, we would therefore conclude that all excess deaths are directly caused by COVID-19.

Figure 1 illustrates a week where excess non-COVID-19 deaths are significantly higher than expected all-cause deaths; we would conclude that there are registered non-COVID-19 deaths directly or indirectly caused by the COVID-19 pandemic. Directly caused deaths are underreported COVID-19 deaths that apply to individuals who died *directly* due to COVID-19 (i.e. COVID-19 was the main cause of death) but it was not reported on the death certificate, possibly because there was uncertainty or stigma surrounding the COVID-19 illness, or likely due to unavailability of testing at the beginning of the epidemic. Indirect non-COVID-19 deaths apply to individuals who did not die with COVID-19 as main cause of death, but they died *indirectly* due to the ongoing COVID-19 pandemic. This may have occurred because there was a disruption of healthcare provision and critically ill patients could not access care, or because patients avoided accessing healthcare. Both circumstances led to patients' death, when they might not have died in the absence of the pandemic.

Supplementary Figure A2 illustrates a week where excess non-COVID-19 deaths are significantly lower than expected deaths; we would conclude that the pandemic is associated with a lower number of non-COVID-19 deaths in that week. This situation may arise, for example, due to reporting biases whereby COVID-19 is overreported in the death certificate (i.e. reported presumptively and incorrectly). Another example is mortality displacement, i.e. a certain proportion of deaths earlier in the pandemic occurred in patients that would have died of other conditions in the following weeks, which is then followed by a lower than expected number of non-COVID-19 deaths in the weeks after.

A robust estimation of excess deaths (all-cause and non-COVID-19) relies on a reliable forecasting of expected deaths. We used a local linear trend model with trigonometric seasonality for the week ending on 8/1/2010 to the week ending on 28/2/2020 using weekly registered deaths in England and Wales from the ONS to forecast deaths for March to beginning June 2020. This allowed us to capture the seasonality of the series as well as the growing population trends of older age groups over the past 10 years. The model was then used to forecast the number of expected deaths from the week ending March 6th 2020 to the week ending June 5th 2020.

A local linear trend model with trigonometric seasonality was fitted to the observed data, where the number of reported deaths per week is given by y_t , and expressed in terms of a stochastic trend μ_t , a seasonal component γ_t and a measurement error ε_t :

$$\begin{aligned} y_t &= \mu_t + \gamma_t + \varepsilon_t & \varepsilon_t &\sim N(0, \sigma_\varepsilon^2) \\ \mu_{t+1} &= \mu_t + v_t + \xi_t & \xi_t &\sim N(0, \sigma_\xi^2) \\ v_{t+1} &= v_t + \zeta_t & \zeta_t &\sim N(0, \sigma_\zeta^2) \\ \gamma_t &= \sum_{j=1}^{\lfloor s/2 \rfloor} \gamma_{jt} \\ \gamma_{jt+1} &= \gamma_{jt} \cos \lambda_j + \gamma_{jt}^* \sin \lambda_j + \omega_{jt} \\ \gamma_{jt=1}^* &= -\gamma_{jt} \sin \lambda_j + \gamma_{jt}^* \cos \lambda_j + \omega_{jt}^* \\ \lambda_j &= \frac{2\pi k}{s} \end{aligned}$$

where ε_t , ξ_t , ζ_t , ω_{jt} and ω_{jt}^* are white noise errors which are mutually uncorrelated. The term μ_t allows the level of the trend to increase or decrease, and v_t changes the slope of the trend. The parameters γ_{jt} and $\gamma_{jt=1}^*$ capture the seasonality of the series [10]. Finally, the term $s = 52.18$ is the period and is equal to the average number of weeks in a year accounting for a leap year every four. Since deaths are under-reported in the last week of each year and over-reported in the first week of the year after, the reported deaths for the two weeks are averaged.

The model was estimated for different sex, age groups and regions. To maintain compatibility with previous years, the age groups 0-14, 15-44, 45-64, 65-74, 75-84 and 85+ were used. For each group and week, we present figures with four series:

- 1) Registered all-cause deaths (red line): registered non-COVID-19 plus registered COVID-19 deaths
- 2) Expected (forecast) all-cause deaths (black line with grey interval): The expected number of all-cause deaths forecasted for the week ending on 06/03/2020 to the week ending on 05/06/2020 with 95% confidence intervals
- 3) Registered non-COVID-19 deaths (purple line)
- 4) Predicted all-cause deaths (blue line): the expected number of all-cause deaths predicted for the weeks ending 1/7/2019 to 28/2/2020 based on reported all-cause deaths for the weeks ending 8/1/2010 to 1/7/2019.

Excess deaths can be computed from the above series. Comparing reported with predicted deaths for the period July 2019 to February 2020 allows us to assess the accuracy of the model in forecasting all-cause deaths; a close match between reported and predicted deaths over the time period before the COVID-19 pandemic instils confidence in the validity of the forecasted all-cause deaths for the period of interest (29th February to 5th June) that we would have expected in the absence of the pandemic.

We also estimated the weekly cumulative excess non-COVID-19 deaths. Cumulative forecasts with confidence intervals were based on 1000 simulations, using the method of Durbin and Koopman (2002) [11], constructing the cumulative distribution and quantiles corresponding to a 95% confidence interval each week. In order to implement this, we consider the observations for the period from March 2020 onwards to be missing. For each series, we calculate the cumulative distribution for up to two years, then average these distributions to find the forecasted expected deaths for each week and the corresponding 95% prediction interval. All series, regardless of aggregation were estimated independently, i.e. England was estimated independently of its regions and age group totals estimated independently of female and male estimations. Therefore, the expected deaths for England, say, may differ slightly from the sum of the expected deaths for its regions. The same applies to the excess non COVID-19 deaths.

To assess the contribution of COVID-19 and excess non-COVID-19 deaths to registered all-cause deaths during March to early June, we calculate the percentage of expected (forecast) all-cause, registered COVID-19 and excess non-COVID-19 deaths on registered all-cause deaths, with confidence intervals around both expected deaths and excess non-COVID-19 deaths. We also calculate the proportion of excess non-COVID-19 deaths to COVID-19 deaths. For each series the model is estimated using the R package KFAS. The source code of the analysis is available at <https://github.com/j-idea/ONSdeaths>.

3. Results

The predicted all-cause deaths for July 2019 to February 2020 match the reported deaths for that period relatively closely (**Supplementary Figures A3, A4 and A5**), demonstrating that our model can forecast all-cause deaths reasonably. However, there is some divergence around the end of December/beginning of January, possibly explained by reporting irregularities over the Christmas holiday period. In younger age groups, the time series underpredicts the variance, especially for younger age groups, which is potentially due to the Poisson variation of the data. All the models are fitted by maximum likelihood under the implicit assumption of normality, with confidence intervals constructed under this assumption. Given the small counts, the assumption of normality may not be a very good approximation and hence the confidence intervals may not be as accurate, which may lead to an underestimation of the variance. On the other hand, the forecast is based on a variance estimated over a few years, but the figures show only a few months and thus may give a misleading view of the variability.

We find evidence of excess deaths in March and April. **Figure 2** shows that the number of reported all-cause deaths (red line) lies above the upper bounds of the 95% confidence interval of expected (forecast) all-cause deaths in England and Wales in April and May 2020, which implies that in these months the number of deaths were significantly higher than expected based on the trend over the past 10 years. This is consistent in each region in England (**Supplementary Figure A6**). Reported all-cause deaths were particularly high in London, the South East, the North West, West Midlands and the East. Deaths reached a peak in the week ending 17th April in London, the North West, the East, the Midlands and North East, and then declined the two following weeks; deaths peaked in the week ending 24th April in the South East, Yorkshire and the Humber, the South West and the East Midlands. Since then, they have been declining albeit not steadily. Excess non-COVID-19 deaths are higher than expected in some regions and some weeks in April. In Wales, North East, East Midlands, South West and Yorkshire and the Humber, excess non-COVID-19 deaths are so small that they lie within the 95% confidence interval in all but one or two weeks in April. This means that for most weeks in the period of interest, non-COVID-19 deaths are not higher than what we would have expected to see in these regions based on historic trends. The delay in reporting (coupled with effects of the bank holiday weekend) may explain the inflection point in the week ending May 8th with the increase in the following week.

Figure 3 shows the number of deaths for older age groups 45-64, 65-74, 75-84, 85+. All-cause registered deaths lie clearly above expected deaths for all age groups. Weekly deaths in these age groups peaked in the weeks ending 17th and 24th April over the observation period. There is empirical evidence of excess non-COVID-19 deaths in the age groups 75-84 and 85+ years old, whereas for age groups 65-74 and 45-64 years, excess deaths lie within the 95% confidence interval for most weeks. Reported deaths are higher among females aged 85+ than men of those ages, but lower than men of the ages 75-84, 65-74 and 45-64 (**Supplementary Figure A7**). For age groups 15-44 years, registered all-cause deaths lie outside the confidence interval for the week for men in week ending 24th April, and for weeks ending 10th April to 1st May for women. There is no evidence of excess non-COVID-19 deaths in May and beginning June.

Table 1 shows the expected (forecast) all-cause deaths, reported COVID-19 deaths and excess non-COVID-19 deaths, expressed as cumulative deaths and as a percentage of reported all-cause deaths by regions between March and early June. In England, there were an estimated 8,373 (95% CI 5,971 - 10,785) excess non-COVID-19 deaths, which constitutes an estimated 4.4% (95% CI 3.2% - 5.7%) of all registered deaths. The confidence interval does not include zero, which implies that we are confident that excess non-COVID-19 deaths were higher than what we would have expected between March and early June if there were no pandemic. However, excess non-COVID-19 deaths make up a smaller proportion of the cumulative reported all-cause deaths than the registered COVID-19 deaths; for every 100 COVID-19 deaths during this period there were 19 (95% CI 13 – 24) cumulative excess non-COVID-19 deaths. The confidence interval for excess non-COVID-19 deaths for Wales does contain zero. This implies that excess non-COVID-19 deaths were not higher than what we would have expected in Wales between March and beginning June. All regions in England had higher excess non-COVID-19 deaths than what we would have expected. Most regions' excess deaths accounted for 6.7-8.4% (central estimate) of all-cause deaths, except East Midlands and Yorkshire and the Humber whose excess deaths accounted for 4.7% (95% CI -2.3% - 11.2%) and 5.9%

(95% CI -0.7% - 11.8%) of all deaths respectively. London and the South East had the highest number of excess non-COVID-19 deaths at 1,937 (95% CI 896 - 3,010) and 2,213 (95% CI 327 - 4,047).

The greatest number of excess non-COVID-19 deaths occur in individuals aged 85 and above (**Table 2**), accounting for 4,295 (95% CI 2,988 - 5,655) of all deaths, a percentage of 5.2% (95% CI 3.6% - 6.8%). For ages 75-84 excess non-COVID-19 deaths account for a greater proportion of all deaths at 6.6% (95% CI 1.4% - 12.1%), which are 3,856 (95% CI 806 - 7,092) excess non-COVID-19 deaths. For individuals aged 65-74 excess non-COVID-19 deaths are not statistically different from expected deaths, but in those aged 45-64 we find 1,057 (95% CI 467 - 1,637) excess non-COVID-19 deaths. There are no excess non-COVID-19 deaths in younger age groups. For those aged 85+, excess non-COVID-19 deaths are driven by females, with 6,115 (95% CI 206 - 11,795) deaths in total but no significant findings for males of those ages. For ages 75-84, excess non-COVID-19 deaths are nearly double for females at 2,070 (95% CI 393 - 3,887) than for males at 1,336 (95% CI 938 - 1,710), while for ages 45-64, excess non-COVID-19 deaths for females are at 347 (95% CI 90 - 603), almost half those of males at 681 (95% CI 282 - 1,091). There is no evidence of excess non-COVID-19 deaths for ages 65-74, and those below 45. There is considerable uncertainty around these central estimates.

When analysing excess non-COVID-19 deaths by week (**Table A2**), we find that in England, total excess non-COVID-19 deaths were highest in the weeks ending April 17th with 3,027 (95% CI 1,489 - 4,566) and April 24th with 3,083 (95% CI 1,545 - 4,621); estimates for excess deaths for the weeks between March and June in England are lower and the confidence intervals do contain zero. Regions only had significant excess non-COVID-19 deaths during the month of April (**Table A3**). For Wales, there is no evidence of excess non-COVID-19 deaths in any week between March and June; the confidence interval for excess deaths contain zero in all weeks except the week ending 08/05 where excess non-COVID-19 deaths are negative. Weekly excess non-COVID-19 deaths are statistically different from expected deaths for some ages in April, but not the other months (**Table A4**).

The proportions of COVID-19 to excess non-COVID-19 deaths by regions and weeks are reported in **Table A5**, with higher proportions suggesting that there were less excess non-COVID-19 deaths compared to reported COVID-19 deaths. There were between -0.95 (95% CI -2.23 - 0.32) and 1.57 (95% CI 0.27 - 2.88) more excess non-COVID-19 than COVID-19 deaths in England overall depending on week, but this becomes insignificant in May onwards as the confidence intervals of these proportions contain zero. In Wales, there was no evidence of excess non-COVID-19 deaths as the confidence interval of these proportions included zero in all weeks. The proportions varied across regions and weeks and the confidence intervals were wide, therefore no distinct trend or pattern can be deduced from the estimates.

4. Discussion

We have estimated excess deaths due to all-causes and split by COVID-19 and other causes between 29th February and 5th June 2020 in England and Wales. These estimates are the difference between reported deaths and expected deaths, i.e. those we would have expected to occur in this period had there been no pandemic; expected deaths were forecasted using time-series econometric methods and weekly data from ONS between 2010 and the week ending 5th of June. Deaths due to all causes were significantly higher than what we would expect based on past trends for all regions and all ages above 45 year in April. In March, all-cause deaths were not significantly higher than expected deaths, with exceptions for some age-groups and regions.

We found evidence that there were excess deaths that were not reported as COVID-19-associated on the death certificate, in England but not Wales. Cumulative excess non-COVID-19 deaths for all regions in England over March to beginning June were estimated at 8,373, but they may be as low as 5,971 or as high as 10,785; the variation arises from uncertainty in the number of deaths expected in the absence of the COVID-19 pandemic and will increase as time goes on. Excess non-COVID-19 deaths constituted between 6.3% and 8.4% of all reported deaths, except in the East Midlands and Yorkshire and the Humber where these proportions were lower. For older age groups in both women and men we found evidence of excess non-COVID-19 deaths. Among individuals who died aged 85+ years, 4,295, or 5.2%, of all reported deaths, were excess deaths not reported as related to COVID-19. Among females and males 75-84, around 7.8% and 4.1% of all deaths were excess non-COVID-19 deaths, respectively. Although there were more deaths in females than males, there is a greater population of older females than males, and the male sex is associated with increased mortality due to COVID-19 [12, 13]. There was considerable uncertainty around these central estimates.

Estimates of excess non-COVID-19 for England and Wales by three other studies give slightly different results to ours, possibly because of differences in methods and time periods. Docherty et al [14] estimated excess non-COVID-19 deaths at 11,260 deaths between 21st March and 24th April 2020, calculated by comparing with expected deaths over the same period between 2015-2019; Felix-Cardoso et al [15] estimated them at 444 for the four-week period starting 5th March, calculated by comparing with expected deaths based on the homologue mean for previous years and adding a standard deviation to account for normal variation; Vandoros [16] estimated them as average weekly deaths of 968 (470.55 to 1464.45) for the weeks ending 8th March to 1st May 2020 using difference-in-difference methods. However, results from a fourth study using an ensemble of Bayesian models that account for seasonality [17] were in agreement with our own, with around 49,200 (44,700-53,300) cumulative excess deaths (both COVID and non-COVID) between mid-February and May 8th, very similar compared to our results of 49,308 (95% CI 43,749-71,141) for beginning March to May 8th.

We used time-series modelling and 10 years of data to establish a counterfactual estimate of expected deaths in the absence of the pandemic. We estimated a local linear trend model with trigonometric seasonality to account for seasonality in deaths, and a general increasing trend due to ageing of the population. This analysis has limitations. There is inherent uncertainty in forecasting deaths. We found that our model does a good job in predicting reported deaths between July 2019 and February 2020 based on data going back to 2010, therefore we are confident that the forecasts

for March to early June were relatively precise. However, there is no guarantee that a model that fits the pre-pandemic time period is forecasting well for the pandemic period that has seen unprecedented changes in hospital care provision, patient behaviour, and many other factors. The uncertainty around our forecasts may not have taken account of all these factors.

Our analysis cannot distinguish between direct and indirect non-COVID-19 excess deaths. Excess non-COVID-19 deaths could be due to underreporting of COVID-19 in the death certificate (direct deaths), to an increase in mortality for conditions unrelated to COVID-19 (indirect deaths), or a combination of both. It is also possible that there is a reduction in demand for emergency care due to even severely ill patients avoiding visiting healthcare providers for fear of hospital acquired SARS-CoV-2 infection, or because they do not want to burden the healthcare system. More granular data would potentially allow further analysis on this point. Under-reporting of COVID-19 on death certificates might have declined over time as awareness of the role of COVID-19 in mortality increased; this could produce artefactual trends in registered COVID-19 deaths and estimated excess non-COVID-19 deaths that are not related to actual trends in cause of death. However, the spatiotemporal age-pattern coincidence of the non-COVID-19 excess with the COVID-19 deaths is suggestive of direct COVID-19 deaths.

As the delay from occurrence of death to registration of that death is variable, our ability to analyse time-trends is limited because we only have data by date of registration and do not have access to dates of occurrence. Our analysis is also limited by not having data broken down simultaneously by age and region. Given the spatiotemporal variation in the incidence of SARS-CoV-2, which is apparent in both hospitalisation data and emerging seroprevalence data, it is unfortunate that we do not have deaths data with greater granularity. Not knowing the cause and location of death means that we cannot test the hypothesis that some excess non-COVID-19 deaths were due to avoidance of healthcare: this hypothesis predicts a relative reduction in deaths in hospital and a corresponding increase in deaths at home due to conditions such as stroke and myocardial infarction.

We can only provide a contemporaneous analysis of excess deaths; it is possible that mortality caused by the pandemic is delayed by weeks, months or years. For example, patients whose elective surgery was postponed during the pandemic may deteriorate and die prematurely some months or years from now. It is also possible that some deaths in April and May are a mortality displacement in form of a short-term forward shift in mortality; i.e. a certain proportion of deaths in April and May occurred in patients that would have died of other conditions in the next months, and linked patient records, for example from a sample case review study, might provide insight into this. Further analysis is needed to determine the true burden of the COVID-19 pandemic in England and Wales.

5. Acknowledgements

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7. Figures, tables and supplementary

7.1 List of Figures & Tables:

Figure 1: Weekly excess non-COVID-19 deaths are higher than expected deaths.

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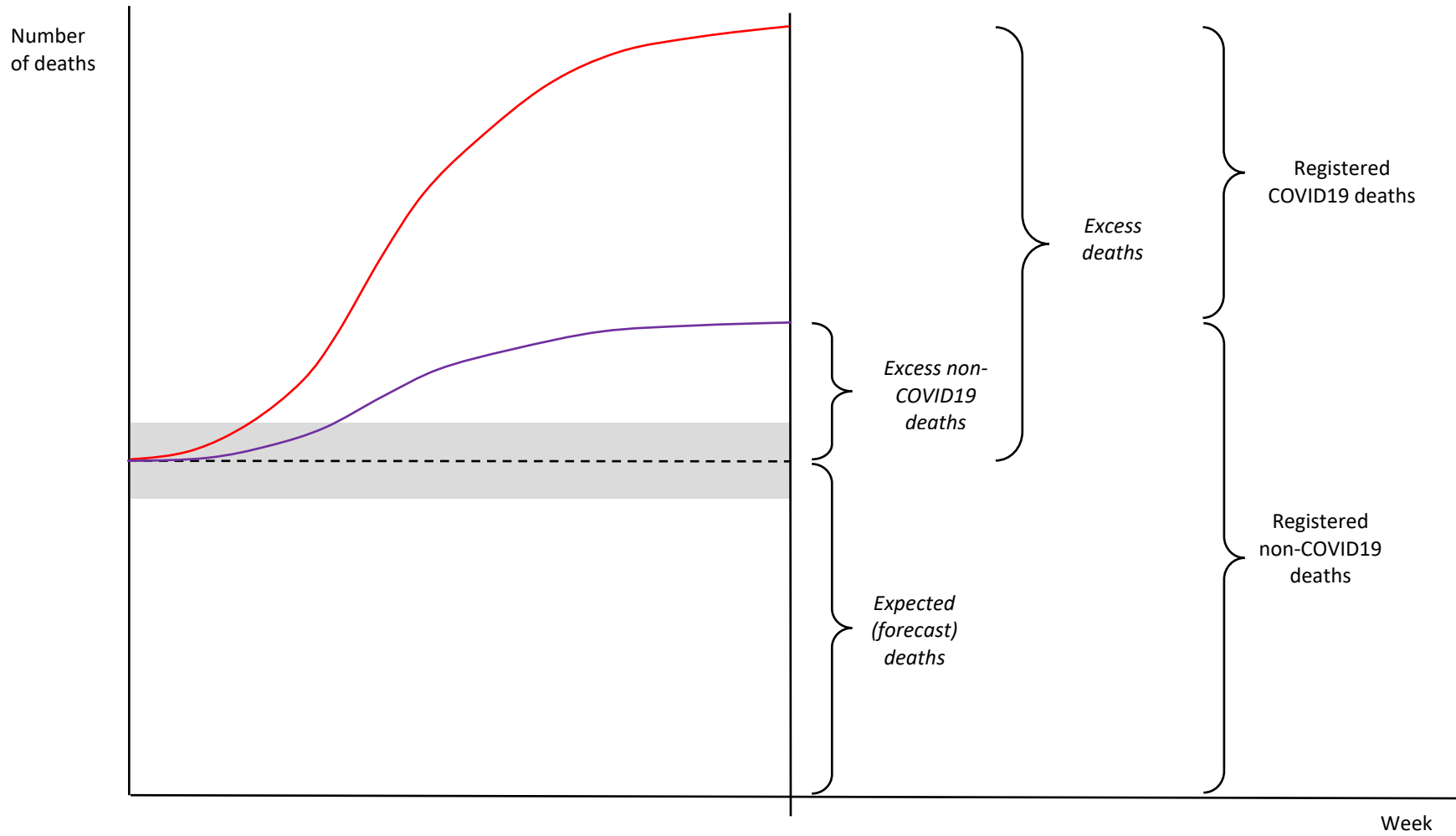


Figure 1: Weekly excess non-COVID-19 deaths are higher than expected deaths

Note: red line: all-cause registered deaths, purple line: registered non-COVID-19 deaths, dashed black line: expected (forecast) deaths with confidence interval; estimated quantities in *italics*

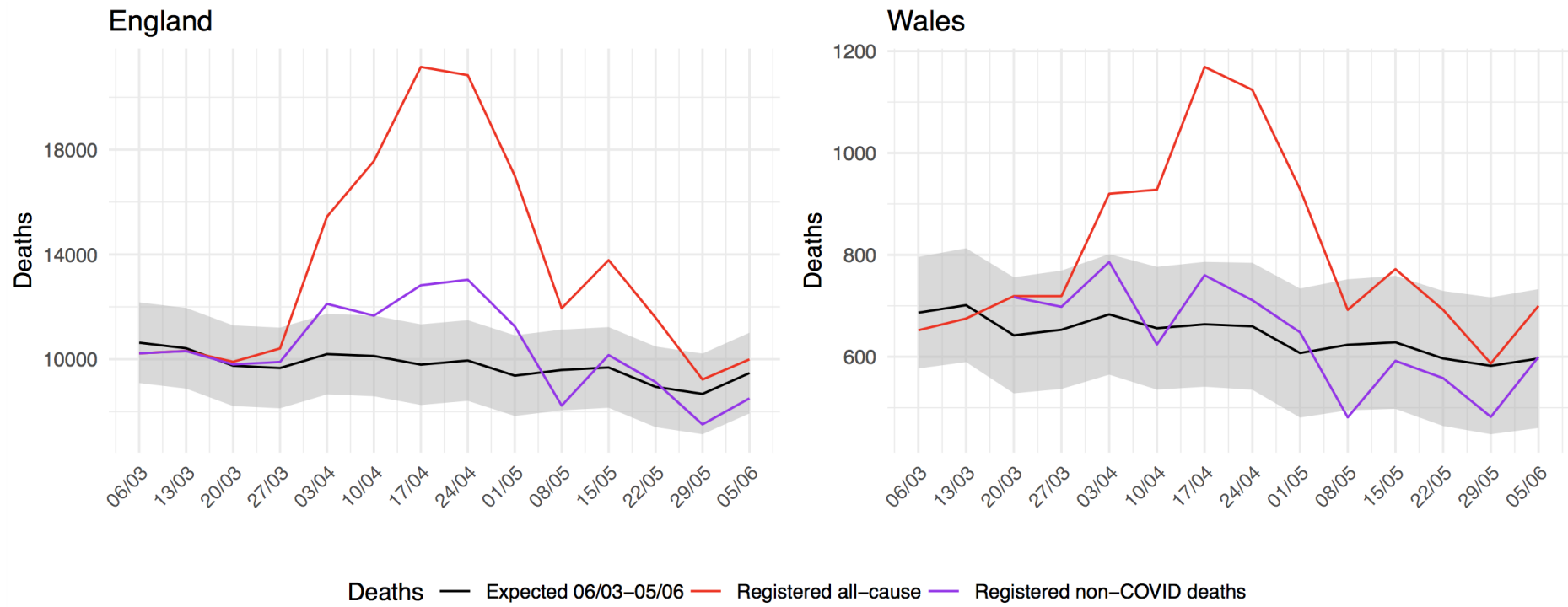


Figure 2: Weekly registered all-cause, expected and registered non-COVID-19 deaths, England & Wales, 06/03/2020 – 05/06/2020.

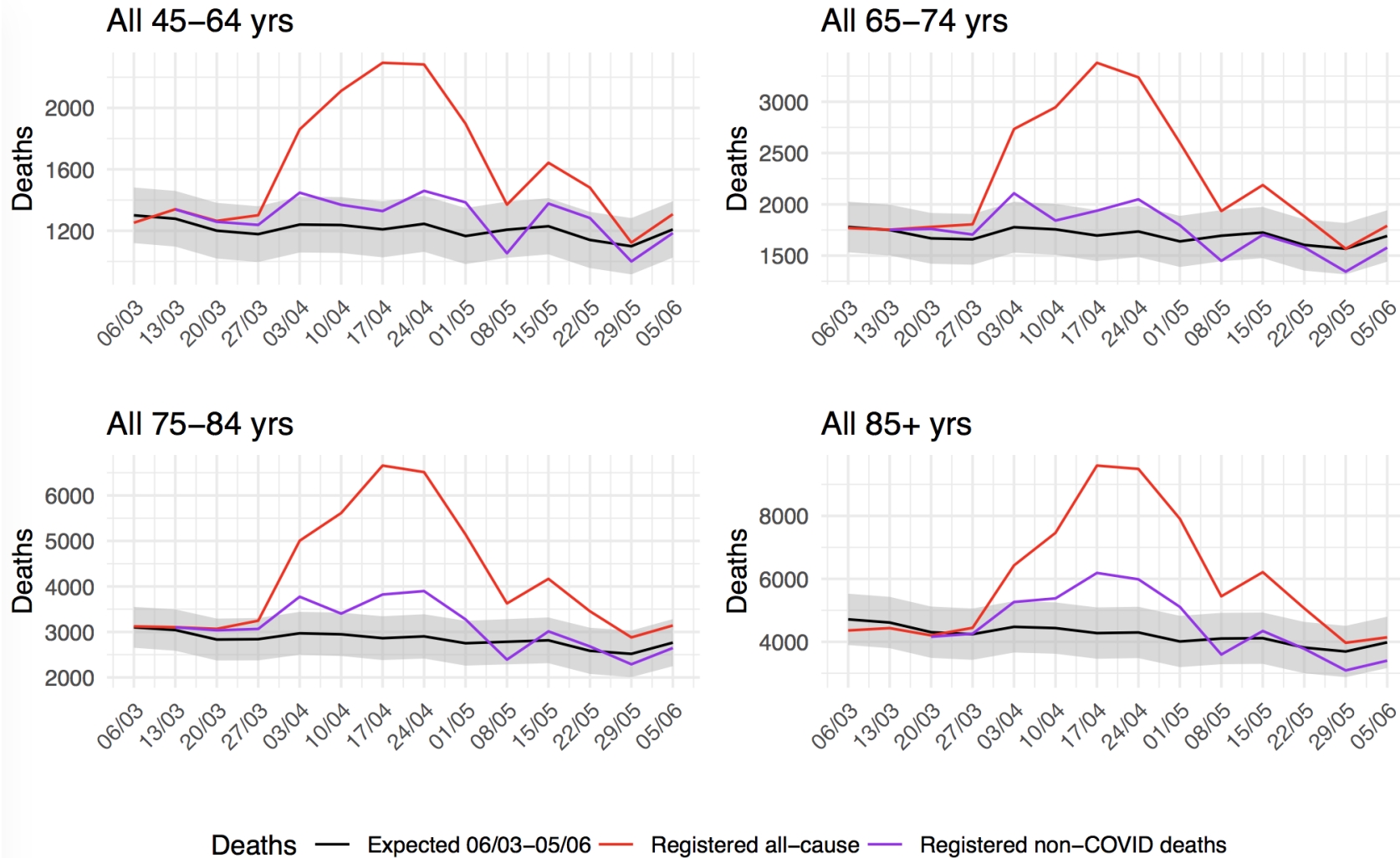


Figure 3: Weekly registered all-cause, expected and registered non-COVID-19 deaths in older ages (45-85+ years), England & Wales, 06/03/2020 – 05/06/2020.

Table 1: Registered all-cause, expected, COVID-19 and excess non-COVID-19 deaths, cumulative and percentage of reported all-cause deaths in England, regions of England, and Wales, 06/03/2020 to 05/06/2020.

Geographic unit	Reported all-cause deaths	Expected deaths		COVID-19 deaths	Excess non-COVID-19 deaths	
	Number	Central estimate	95% confidence Interval (%)	Number (%)	Central estimate (%)	95% confidence interval (%)
England	189,403	136,294 (72.0%)	133,882 - 138,696 (70.7% - 73.2%)	44,736 (23.6%)	8,983 (4.4%)	5,971 - 10,785 (3.2% - 5.7%)
North West	27,717	19,085 (68.9%)	17,416 - 20,869 (62.8% - 75.3%)	7,010 (25.3%)	1,622 (5.9%)	-162 - 3,291 (-0.6% - 11.9%)
North East	10,479	7,194 (68.7%)	6,491 - 7,890 (61.9% - 75.3%)	2,623 (25%)	662 (6.3%)	-34 - 1,365 (-0.3% - 13%)
Yorkshire and The Humber	19,286	13,872 (71.9%)	12,729 - 15,136 (66% - 78.5%)	4,285 (22.2%)	1,129 (5.9%)	-135 - 2,272 (-0.7% - 11.8%)
West Midlands	21,710	14,736 (67.9%)	13,491 - 15,961 (62.1% - 73.5%)	5,277 (24.3%)	1,697 (7.8%)	472 - 2,942 (2.2% - 13.6%)
East Midlands	16,385	12,218 (74.6%)	11,147 - 13,367 (68% - 81.6%)	3,401 (20.8%)	766 (4.7%)	-383 - 1,837 (-2.3% - 11.2%)
East	21,520	15,230 (70.8%)	13,898 - 16,599 (64.6% - 77.1%)	4,603 (21.4%)	1,687 (7.8%)	318 - 3,019 (1.5% - 14%)
South West	18,975	14,973 (78.9%)	13,551 - 16,418 (71.4% - 86.5%)	2,738 (14.4%)	1,264 (6.7%)	-181 - 2,686 (-1% - 14.2%)
London	23,006	12,851 (55.9%)	11,778 - 13,892 (51.2% - 60.4%)	8,218 (35.7%)	1,937 (8.4%)	896 - 3,010 (3.9% - 13.1%)
South East	30,325	21,531 (71.0%)	19,697 - 23,417 (65% - 77.2%)	6,581 (21.7%)	2,213 (7.3%)	327 - 4,047 (1.1% - 13.3%)
Wales	11,278	8,983 (79.7%)	8,051 - 9,904 (71.4% - 87.8%)	2,294 (20.3%)	1 (0%)	-920 - 933 (-8.2% - 8.3%)

Note: Cumulative number of deaths over March to beginning June; proportion of cumulative reported all-cause deaths over March to May; excess non-COVID-19 deaths for which the confidence interval does not contain zero are marked in **bold**. All series, regardless of aggregation were estimated independently, i.e. England was estimated independently of its regions and age group totals estimated independently of female and male estimations. Therefore, the expected deaths for England may differ slightly from the sum of the expected deaths for its regions. The same applies to the excess non COVID-19 deaths.

Interpretation: There were 189,403 provisional deaths reported in England in March to beginning June, and of those 44,736 mentioned COVID-19 on the death certificate, 23.6% of all deaths. Over the two months period, we would have expected only 136,294 deaths based on an econometric analysis of the trend over the past 10 years. The difference is 8,373 excess non-COVID-19 deaths, constituting 4.4% of all reported deaths.

Table 2: Cumulative registered all-cause, expected, COVID-19 and excess non-COVID-19 deaths, cumulative and as a percentage of reported all-cause deaths by sex and age group, 06/03/2020 to 05/06/2020.

Sex and age group (years)		Reported all-cause Number	Expected deaths		COVID-19 deaths Number (%)	Excess non-COVID-19 deaths	
			Central estimate (%)	95% confidence interval (%)		Central estimate	95% confidence interval (%)
All	45-64	22,527	16,918 (75.1%)	16,338 - 17,508 (72.5% - 77.7%)	4,552 (20.2%)	1,057 (4.7%)	467 - 1,637 (2.1% - 7.3%)
	65-74	31,370	23,764 (75.8%)	22,892 - 24,680 (73% - 78.7%)	6,995 (22.3%)	611 (1.9%)	-305 - 1,483 (-1% - 4.7%)
	75-84	58,742	39,665 (67.5%)	36,429 - 42,715 (62% - 72.7%)	15,221 (25.9%)	3,856 (6.6%)	806 - 7,092 (1.4% - 12.1%)
	85+	83,164	59,045 (71.0%)	57,685 - 60,352 (69.4% - 72.6%)	19,824 (23.8%)	4,295 (5.2%)	2,988 - 5,655 (3.6% - 6.8%)
Male	45-64	13,776	10,110 (73.4%)	9,700 - 10,509 (70.4% - 76.3%)	2,985 (21.7%)	681 (4.9%)	282 - 1,091 (2% - 7.9%)
	65-74	18,836	13,903 (73.8%)	13,435 - 14,387 (71.3% - 76.4%)	4,556 (24.2%)	377 (2%)	-107 - 845 (-0.6% - 4.5%)
	75-84	32,296	21,934 (67.9%)	21,560 - 22,332 (66.8% - 69.1%)	9,026 (27.9%)	1,336 (4.1%)	938 - 1,710 (2.9% - 5.3%)
	85+	34,047	22,722 (66.7%)	20,156 - 25,349 (59.2% - 74.5%)	9,132 (26.8%)	2,193 (6.4%)	-434 - 4,759 (-1.3% - 14%)
Female	45-64	8,751	6,837 (78.1%)	6,581 - 7,094 (75.2% - 81.1%)	1,567 (17.9%)	347 (4%)	90 - 603 (1% - 6.9%)
	65-74	12,534	9,862 (78.7%)	9,445 - 10,278 (75.4% - 82%)	2,439 (19.5%)	233 (1.9%)	-183 - 650 (-1.5% - 5.2%)
	75-84	26,446	18,181 (68.7%)	16,364 - 19,858 (61.9% - 75.1%)	6,195 (23.4%)	2,070 (7.8%)	393 - 3,887 (1.5% - 14.7%)
	85+	49,117	32,310 (65.8%)	26,630 - 38,219 (54.2% - 77.8%)	10,692 (21.8%)	6,115 (12.5%)	206 - 11,795 (0.4% - 24%)

Note: Cumulative number of deaths over March and beginning June; proportion of cumulative reported all-cause deaths over March to May; excess non-COVID-19 deaths for which the confidence interval does not contain zero are marked in **bold**. All series, regardless of aggregation were estimated independently, i.e. deaths of all individuals in an age group were estimated independently of its totals estimated independently of female and male estimations. Therefore, the expected deaths may differ slightly from the sum of the expected deaths for both sexes. The same applies to the excess non COVID-19 deaths.

Table A1: Definitions of COVID-19 deaths between different sources.

	DHSC COVID-19 (as published on GOV.UK) before 29 April	DHSC COVID-19 (as published on GOV.UK) from 29 April	ONS COVID-19 deaths registered	ONS COVID-19 death occurrence (actual date of death)	NHS England	Public Health Wales
Coverage	UK (however we only include England and Wales breakdowns for comparable coverage with ONS data)	UK (however we only include England and Wales breakdowns for comparable coverage with ONS data)	Registrations in England and Wales Selected UK figures are included in the weekly release	Registrations in England and Wales In discussions with devolved nations to create UK estimates in the near future	England only	Wales only
Inclusion	Deaths in hospitals Deaths where patient has been tested for COVID-19	Includes any place of death, including care homes and community Deaths where patient has been tested for COVID-19	Any place of death, including care homes and community Deaths where COVID-19 has been mentioned on the death certificate	Any place of death, including care homes and community Deaths where COVID-19 has been mentioned on the death certificate	Deaths in hospitals Deaths where patient has been tested for COVID-19	Includes any place of death, including care homes and community Deaths where patient has been tested for COVID-19
Timeliness	Provided daily but not officially registered	Provided daily but not officially registered	Weekly registrations are 11 days behind because of the time taken to register, process and publish Registered in the week ending 5 June (week 23)	Weekly registrations are 11 days behind because of the time taken to register, process and publish Deaths which occurred in week 23 but were registered up to 13 June	Updated daily for each date of death	Updated daily for each date of death

Source:

<https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregisteredweeklyinenglandandwalesprovisional/weekending5june2020>

Table A2: Weekly deaths in England, 06/03/2020 to 05/06/2020.

Week ended	Reported all-cause deaths	Expected deaths		COVID-19 deaths	Excess non-COVID-19 deaths	
	Number	Central estimate (%)	95% prediction interval (%)	Number (%)	Central estimate (%)	95% prediction interval (%)
6/3/20	10,225	10,631 (104.0%)	9,092 - 12,169 (88.9% - 119%)	0 (0%)	-406 (-4%)	-1,944 - 1,133 (-19% - 11.1%)
13/3/20	10,317	10,419 (101.0%)	8,880 - 11,957 (86.1% - 115.9%)	5 (0%)	-107 (-1%)	-1,645 - 1,432 (-15.9% - 13.9%)
20/3/20	9,903	9,754 (98.5%)	8,215 - 11,292 (83% - 114%)	100 (1%)	49 (0.5%)	-1,489 - 1,588 (-15% - 16%)
27/3/20	10,412	9,666 (92.8%)	8,127 - 11,204 (78.1% - 107.6%)	515 (4.9%)	231 (2.2%)	-1,307 - 1,770 (-12.6% - 17%)
3/4/20	15,443	10,196 (66.0%)	8,658 - 11,734 (56.1% - 76%)	3,330 (21.6%)	1,917 (12.4%)	379 - 3,455 (2.5% - 22.4%)
10/4/20	17,563	10,125 (57.6%)	8,586 - 11,663 (48.9% - 66.4%)	5,899 (33.6%)	1,539 (8.8%)	1 - 3,078 (0% - 17.5%)
17/4/20	21,157	9,794 (46.3%)	8,256 - 11,332 (39% - 53.6%)	8,335 (39.4%)	3,028 (14.3%)	1,490 - 4,566 (7% - 21.6%)
24/4/20	20,841	9,952 (47.7%)	8,413 - 11,490 (40.4% - 55.1%)	7,806 (37.5%)	3,083 (14.8%)	1,545 - 4,622 (7.4% - 22.2%)
1/5/20	17,004	9,374 (55.1%)	7,835 - 10,912 (46.1% - 64.2%)	5,748 (33.8%)	1,882 (11.1%)	344 - 3,421 (2% - 20.1%)
8/5/20	11,946	9,591 (80.3%)	8,052 - 11,129 (67.4% - 93.2%)	3,716 (31.1%)	-1,361 (-11.4%)	-2,899 - 178 (-24.3% - 1.5%)
15/5/20	13,783	9,686 (70.3%)	8,148 - 11,225 (59.1% - 81.4%)	3,624 (26.3%)	473 (3.4%)	-1,066 - 2,011 (-7.7% - 14.6%)
22/5/20	11,586	8,947 (77.2%)	7,408 - 10,485 (63.9% - 90.5%)	2,455 (21.2%)	184 (1.6%)	-1,354 - 1,723 (-11.7% - 14.9%)
29/5/20	9,228	8,677 (94.0%)	7,139 - 10,215 (77.4% - 110.7%)	1,715 (18.6%)	-1,164 (-12.6%)	-2,702 - 374 (-29.3% - 4.1%)
5/6/20	9,995	9,472 (94.8%)	7,933 - 11,010 (79.4% - 110.2%)	1,488 (14.9%)	-965 (-9.7%)	-2,503 - 574 (-25% - 5.7%)

Table A3: Weekly excess non-COVID-19 deaths by region, 06/03/2020 to 05/06/2020.

Week ended	East	East Midlands	London	North East	North West	South East	South West	West Midlands	Yorkshire and The	England	Wales
06/03/20	-29 (-231 - 171)	-29 (-174 - 115)	-29 (-185 - 127)	13 (-78 - 104)	17 (-188 - 223)	29 (-244 - 304)	-19 (-212 - 173)	-62 (-256 - 131)	33 (-129 - 195)	-405 (-1,944 - 1,132)	-34 (-143 - 74)
13/03/20	37 (-165 - 241)	-24 (-172 - 122)	-22 (-180 - 136)	52 (-40 - 145)	28 (-181 - 238)	113 (-164 - 390)	5 (-189 - 201)	56 (-139 - 251)	-25 (-189 - 139)	-106 (-1,645 - 1,431)	-26 (-137 - 85)
20/03/20	-22 (-228 - 182)	54 (-95 - 204)	39 (-120 - 199)	22 (-71 - 116)	51 (-162 - 265)	93 (-186 - 373)	68 (-129 - 266)	54 (-142 - 251)	16 (-149 - 183)	49 (-1,489 - 1,587)	74 (-38 - 188)
27/03/20	79 (-127 - 287)	17 (-134 - 169)	129 (-32 - 290)	14 (-81 - 109)	122 (-95 - 340)	232 (-50 - 514)	34 (-165 - 234)	-62 (-261 - 135)	-6 (-175 - 161)	231 (-1,307 - 1,769)	45 (-71 - 161)
03/04/20	287 (77 - 497)	162 (8 - 316)	365 (202 - 528)	102 (5 - 198)	282 (60 - 504)	271 (-13 - 556)	243 (41 - 446)	304 (104 - 504)	225 (55 - 396)	1,916 (378 - 3,455)	102 (-15 - 221)
10/04/20	255 (44 - 467)	122 (-33 - 278)	386 (222 - 550)	34 (-62 - 132)	273 (47 - 499)	264 (-23 - 551)	151 (-52 - 356)	264 (63 - 466)	114 (-56 - 286)	1,539 (0 - 3,077)	-31 (-152 - 88)
17/04/20	537 (324 - 751)	189 (30 - 347)	532 (366 - 698)	165 (67 - 264)	478 (249 - 708)	424 (134 - 714)	282 (75 - 489)	481 (278 - 683)	265 (92 - 439)	3,027 (1,489 - 4,566)	96 (-26 - 218)
24/04/20	364 (148 - 579)	268 (108 - 429)	441 (274 - 608)	143 (43 - 243)	514 (281 - 747)	524 (232 - 816)	294 (85 - 503)	530 (326 - 734)	330 (155 - 506)	3,083 (1,545 - 4,621)	51 (-73 - 175)
01/05/20	314 (96 - 531)	130 (-31 - 292)	287 (119 - 456)	110 (9 - 211)	284 (47 - 521)	395 (100 - 690)	112 (-99 - 323)	326 (120 - 531)	250 (72 - 427)	1,882 (344 - 3,420)	40 (-85 - 167)
08/05/20	-124 (-344 - 95)	-100 (-264 - 63)	-118 (-288 - 51)	-12 (-115 - 89)	-127 (-368 - 112)	-192 (-489 - 104)	-105 (-319 - 107)	-151 (-358 - 55)	-97 (-276 - 81)	-1,360 (-2,899 - 177)	-142 (-271 - -13)
15/05/20	64 (-157 - 285)	104 (-61 - 270)	59 (-111 - 230)	83 (-20 - 186)	7 (-236 - 251)	114 (-185 - 413)	137 (-77 - 353)	67 (-141 - 275)	163 (-16 - 344)	472 (-1,065 - 2,011)	-36 (-166 - 94)
22/05/20	109 (-114 - 332)	23 (-144 - 191)	58 (-114 - 230)	30 (-74 - 134)	-13 (-261 - 233)	122 (-179 - 424)	84 (-133 - 302)	71 (-137 - 281)	27 (-154 - 210)	184 (-1,354 - 1,722)	-38 (-171 - 93)
29/05/20	-62 (-287 - 163)	-102 (-271 - 67)	-93 (-267 - 80)	-43 (-149 - 61)	-175 (-426 - 75)	-119 (-423 - 184)	-25 (-244 - 194)	-141 (-352 - 69)	-70 (-254 - 113)	-1,164 (-2,702 - 374)	-100 (-234 - 34)
05/06/20	-107 (-334 - 120)	-66 (-238 - 105)	-102 (-278 - 72)	-45 (-152 - 61)	-81 (-336 - 172)	-87 (-393 - 218)	-27 (-249 - 194)	-29 (-241 - 183)	-87 (-272 - 98)	-964 (-2,503 - 573)	3 (-132 - 139)

Note: Shaded cells indicate estimates with confidence intervals not including 0, with blue shading indicating estimates in positive excess, and green indicating estimates in negative excess.

Table A4: Weekly excess non-COVID-19 deaths in England and Wales by sex and age, 06/03/2020 to 05/06/2020. Blue shading indicates estimates with confidence intervals not including 0.

Week ended	All				Female				Male			
	45-64	65-74	75-84	85+	45-64	65-74	75-84	85+	45-64	65-74	75-84	85+
6/3/20	-48 (-229 - 132)	-10 (-256 - 236)	21 (-427 - 470)	-352 (-1,167 - 461)	-16 (-94 - 61)	2 (-109 - 114)	16 (-211 - 243)	-26 (-482 - 430)	-31 (-148 - 84)	-12 (-160 - 135)	-24 (-264 - 216)	-22 (-289 - 244)
13/3/20	60 (-120 - 241)	2 (-244 - 248)	59 (-394 - 514)	-178 (-993 - 636)	6 (-72 - 84)	-19 (-132 - 92)	23 (-206 - 254)	62 (-420 - 544)	54 (-62 - 171)	22 (-125 - 170)	6 (-234 - 246)	64 (-210 - 339)
20/3/20	57 (-123 - 239)	91 (-155 - 338)	202 (-256 - 662)	-145 (-960 - 669)	16 (-61 - 94)	36 (-76 - 148)	92 (-141 - 326)	113 (-393 - 619)	41 (-75 - 158)	54 (-93 - 203)	80 (-159 - 321)	45 (-236 - 328)
27/3/20	60 (-121 - 241)	47 (-200 - 294)	225 (-239 - 690)	14 (-800 - 828)	36 (-41 - 114)	-4 (-116 - 108)	88 (-148 - 325)	174 (-354 - 703)	23 (-93 - 140)	51 (-97 - 199)	106 (-133 - 347)	143 (-146 - 434)
3/4/20	207 (26 - 389)	330 (83 - 578)	804 (333 - 1,274)	790 (-24 - 1,605)	53 (-25 - 131)	86 (-26 - 199)	330 (90 - 570)	588 (37 - 1,140)	154 (37 - 271)	244 (95 - 392)	443 (203 - 684)	506 (209 - 803)
10/4/20	131 (-50 - 313)	86 (-161 - 333)	454 (-21 - 930)	944 (129 - 1,759)	43 (-34 - 122)	30 (-82 - 143)	221 (-22 - 464)	763 (190 - 1,335)	88 (-29 - 205)	55 (-93 - 203)	203 (-36 - 444)	485 (181 - 790)
17/4/20	118 (-63 - 301)	242 (-6 - 490)	959 (478 - 1,441)	1,912 (1,097 - 2,727)	74 (-3 - 152)	127 (14 - 240)	501 (255 - 748)	1,538 (944 - 2,131)	44 (-72 - 161)	114 (-34 - 263)	427 (187 - 668)	678 (366 - 989)
24/4/20	215 (32 - 397)	313 (65 - 562)	995 (509 - 1,482)	1,689 (874 - 2,504)	79 (0 - 157)	93 (-19 - 206)	494 (244 - 743)	1,400 (787 - 2,013)	136 (18 - 253)	220 (71 - 368)	471 (230 - 712)	594 (275 - 912)
1/5/20	219 (36 - 401)	157 (-91 - 405)	523 (32 - 1,015)	1,099 (284 - 1,914)	79 (1 - 158)	88 (-24 - 202)	278 (26 - 531)	1,090 (458 - 1,722)	139 (22 - 257)	68 (-80 - 216)	215 (-25 - 455)	313 (-11 - 638)
8/5/20	-153 (-336 - 28)	-245 (-494 - 3)	-393 (-889 - 103)	-508 (-1,323 - 306)	-81 (-159 - -2)	-71 (-185 - 41)	-149 (-405 - 105)	65 (-585 - 715)	-72 (-190 - 44)	-173 (-322 - -24)	-273 (-513 - -32)	-269 (-600 - 62)
15/5/20	147 (-35 - 330)	-21 (-271 - 227)	196 (-305 - 698)	229 (-585 - 1,044)	72 (-6 - 150)	-1 (-115 - 111)	118 (-139 - 377)	432 (-236 - 1,101)	75 (-42 - 193)	-20 (-169 - 128)	47 (-193 - 287)	100 (-237 - 438)
22/5/20	143 (-39 - 326)	-22 (-272 - 226)	96 (-409 - 603)	-39 (-854 - 775)	44 (-34 - 123)	-10 (-124 - 103)	98 (-163 - 359)	283 (-402 - 970)	98 (-19 - 216)	-12 (-162 - 136)	-31 (-271 - 209)	-18 (-362 - 325)
29/5/20	-99 (-282 - 83)	-223 (-473 - 26)	-229 (-741 - 282)	-601 (-1,416 - 213)	-38 (-117 - 39)	-77 (-191 - 36)	-95 (-359 - 169)	-30 (-734 - 673)	-60 (-178 - 57)	-146 (-295 - 3)	-164 (-405 - 76)	-266 (-616 - 84)
5/6/20	-23 (-206 - 159)	-113 (-363 - 136)	-117 (-634 - 398)	-581 (-1,396 - 233)	-20 (-99 - 57)	-35 (-149 - 78)	21 (-245 - 288)	-61 (-781 - 659)	-2 (-120 - 115)	-78 (-227 - 71)	-169 (-410 - 70)	-216 (-572 - 140)

Table A5: Ratio of excess non-COVID-19 to COVID-19 deaths by region, 03/04/2020 - 05/06/2020.

Week ended	East	East Midlands	London	North East	North West	South East	South West	West Midlands	Yorkshire and The	England	Wales
3/4/20	1.02 (0.27 - 1.76)	0.88 (0.04 - 1.71)	0.31 (0.17 - 0.45)	0.76 (0.04 - 1.48)	0.68 (0.15 - 1.21)	0.66 (-0.03 - 1.35)	1.57 (0.27 - 2.88)	0.76 (0.26 - 1.26)	1.3 (0.32 - 2.28)	0.58 (0.11 - 1.04)	0.77 (-0.12 - 1.65)
10/4/20	0.45 (0.08 - 0.83)	0.29 (-0.08 - 0.66)	0.26 (0.15 - 0.37)	0.12 (-0.22 - 0.46)	0.3 (0.05 - 0.55)	0.36 (-0.03 - 0.76)	0.51 (-0.18 - 1.2)	0.33 (0.08 - 0.58)	0.31 (-0.15 - 0.77)	0.26 (0 - 0.52)	-0.11 (-0.5 - 0.29)
17/4/20	0.64 (0.39 - 0.9)	0.34 (0.06 - 0.62)	0.29 (0.2 - 0.38)	0.35 (0.14 - 0.56)	0.35 (0.18 - 0.52)	0.38 (0.12 - 0.64)	0.56 (0.15 - 0.98)	0.48 (0.28 - 0.68)	0.39 (0.13 - 0.64)	0.36 (0.18 - 0.55)	0.24 (-0.06 - 0.54)
24/4/20	0.45 (0.18 - 0.71)	0.48 (0.19 - 0.76)	0.31 (0.2 - 0.43)	0.34 (0.1 - 0.58)	0.43 (0.23 - 0.62)	0.43 (0.19 - 0.66)	0.55 (0.16 - 0.95)	0.6 (0.37 - 0.84)	0.44 (0.21 - 0.67)	0.4 (0.2 - 0.59)	0.12 (-0.18 - 0.43)
1/5/20	0.5 (0.15 - 0.84)	0.3 (-0.07 - 0.67)	0.37 (0.15 - 0.58)	0.35 (0.03 - 0.67)	0.31 (0.05 - 0.57)	0.41 (0.1 - 0.71)	0.28 (-0.25 - 0.8)	0.5 (0.19 - 0.82)	0.39 (0.11 - 0.66)	0.33 (0.06 - 0.6)	0.14 (-0.31 - 0.6)
8/5/20	-0.33 (-0.92 - 0.25)	-0.3 (-0.79 - 0.19)	-0.27 (-0.66 - 0.12)	-0.05 (-0.42 - 0.33)	-0.21 (-0.62 - 0.19)	-0.35 (-0.89 - 0.19)	-0.38 (-1.16 - 0.39)	-0.34 (-0.81 - 0.13)	-0.23 (-0.64 - 0.19)	-0.37 (-0.78 - 0.05)	-0.68 (-1.28 - -0.07)
15/5/20	0.16 (-0.39 - 0.71)	0.33 (-0.19 - 0.85)	0.16 (-0.31 - 0.63)	0.34 (-0.08 - 0.75)	0.01 (-0.38 - 0.41)	0.19 (-0.31 - 0.69)	0.58 (-0.33 - 1.48)	0.18 (-0.37 - 0.72)	0.36 (-0.04 - 0.76)	0.13 (-0.29 - 0.55)	-0.2 (-0.93 - 0.52)
22/5/20	0.37 (-0.39 - 1.13)	0.1 (-0.65 - 0.86)	0.26 (-0.52 - 1.05)	0.15 (-0.37 - 0.67)	-0.04 (-0.66 - 0.59)	0.3 (-0.44 - 1.04)	0.67 (-1.06 - 2.4)	0.25 (-0.48 - 0.97)	0.09 (-0.52 - 0.71)	0.07 (-0.55 - 0.7)	-0.29 (-1.28 - 0.7)
29/5/20	-0.3 (-1.41 - 0.8)	-0.57 (-1.51 - 0.38)	-0.81 (-2.33 - 0.7)	-0.31 (-1.06 - 0.44)	-0.62 (-1.51 - 0.27)	-0.44 (-1.57 - 0.69)	-0.24 (-2.38 - 1.89)	-0.77 (-1.92 - 0.38)	-0.3 (-1.08 - 0.48)	-0.68 (-1.58 - 0.22)	-0.95 (-2.23 - 0.32)
5/6/20	-0.57 (-1.78 - 0.64)	-0.44 (-1.57 - 0.69)	-0.91 (-2.46 - 0.64)	-0.4 (-1.35 - 0.54)	-0.33 (-1.34 - 0.69)	-0.4 (-1.8 - 1)	-0.33 (-2.94 - 2.29)	-0.19 (-1.53 - 1.16)	-0.41 (-1.3 - 0.47)	-0.65 (-1.68 - 0.39)	0.04 (-1.33 - 1.4)

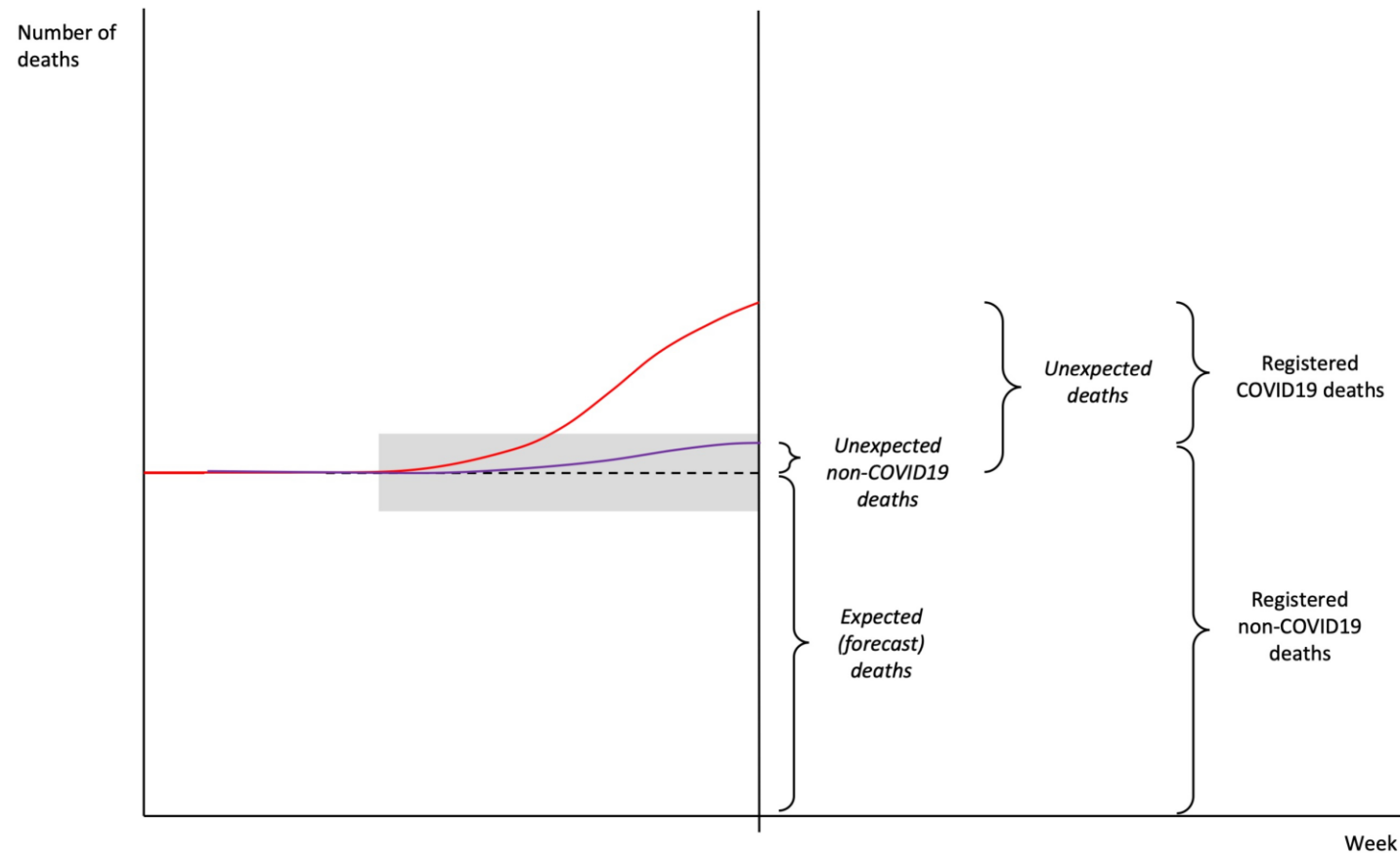


Figure A1: Weekly excess non-COVID-19 deaths are not different than expected deaths.

Note: red line: all-cause registered deaths, purple line: registered non-COVID-19 deaths, dashed black line: expected (forecast) deaths with confidence interval; estimated quantities in *italics*.

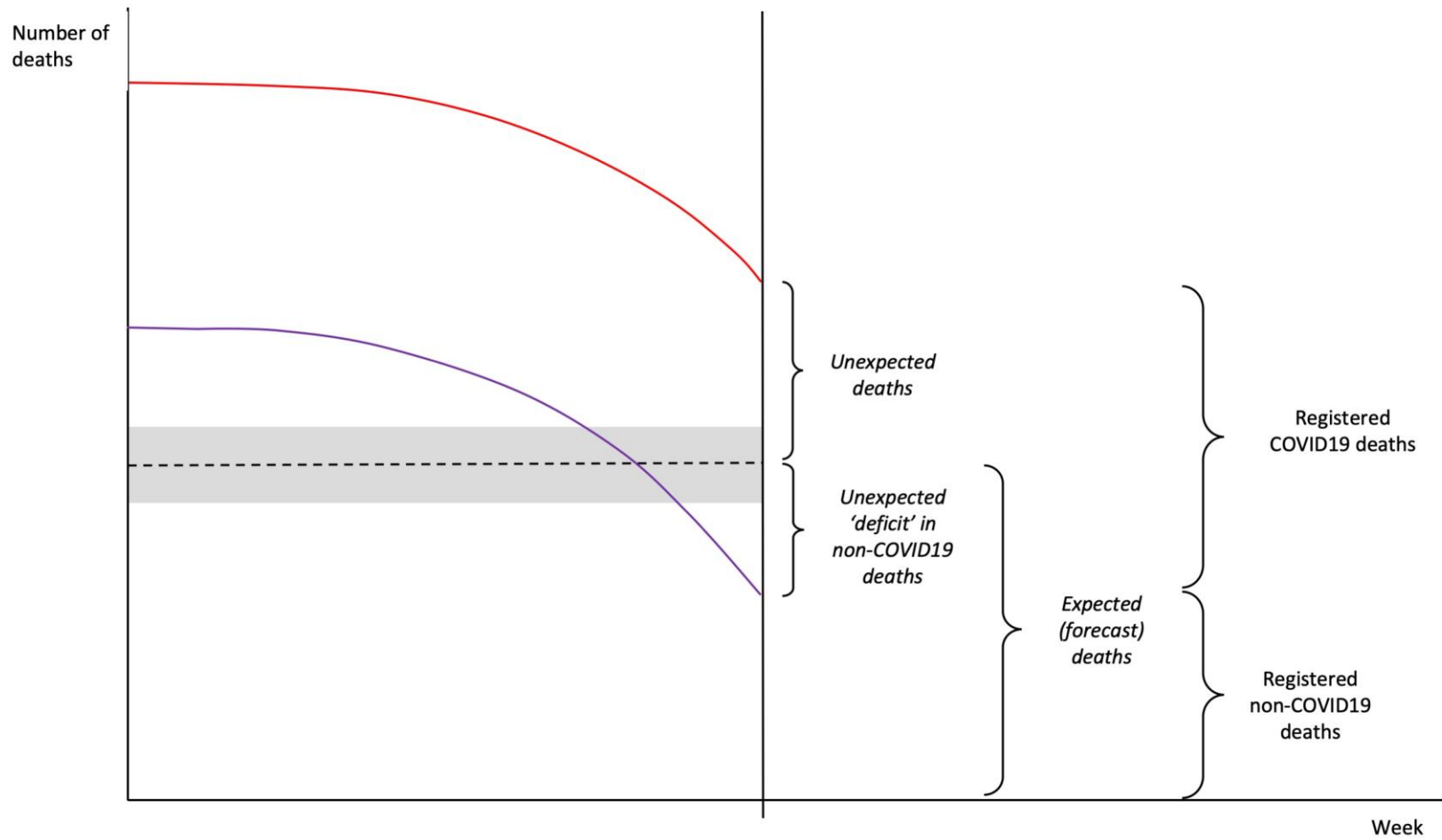


Figure A2: Weekly excess non-COVID-19 deaths are lower than expected deaths.

Note: red line: all-cause registered deaths, purple line: registered non-COVID-19 deaths, dashed black line: expected (forecast) deaths with confidence interval; estimated quantities in italics.

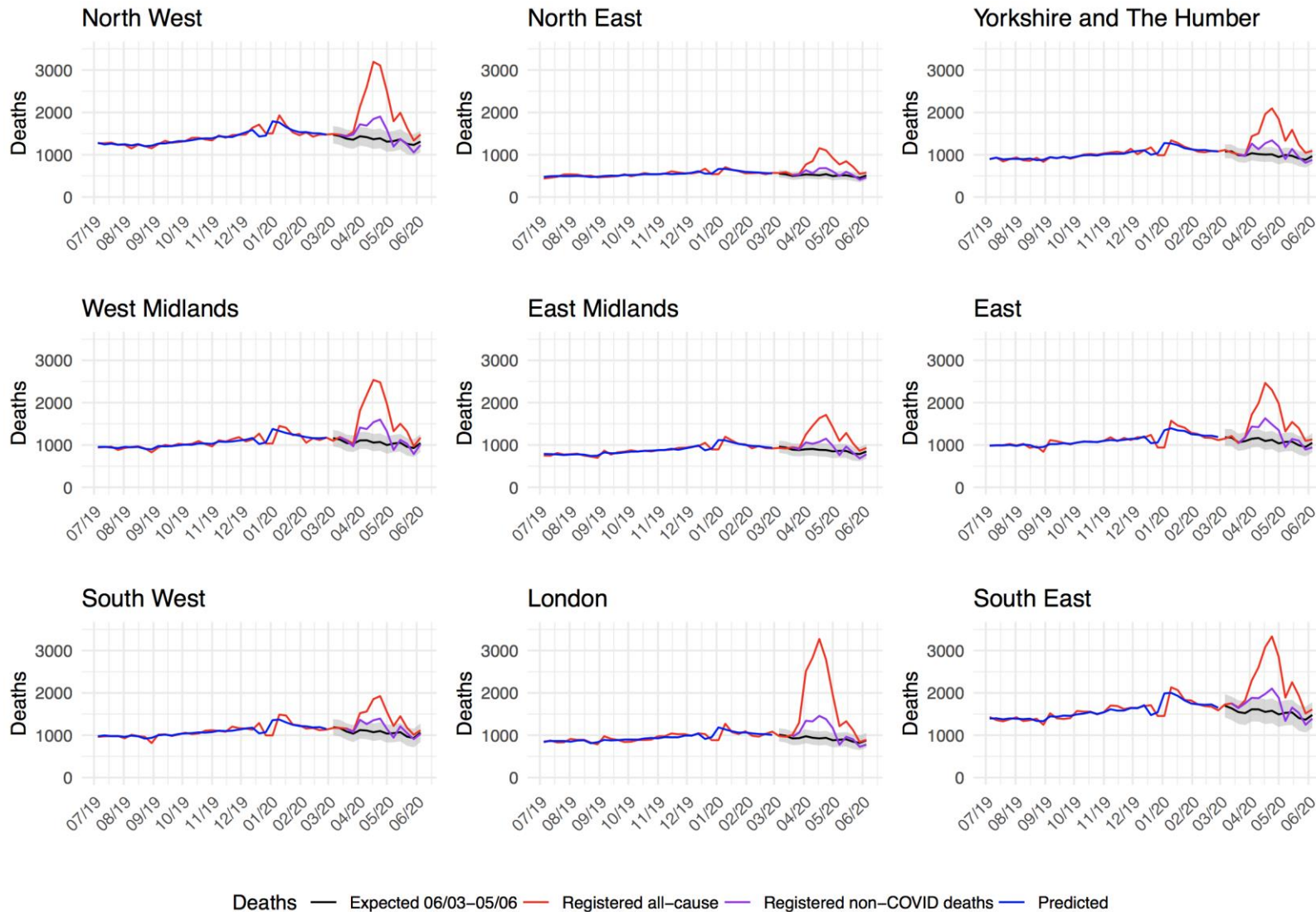


Figure A3: Weekly registered all-cause, predicted, expected and registered non-COVID-19 deaths by region, England & Wales, 01/07/2019 – 05/06/2020.

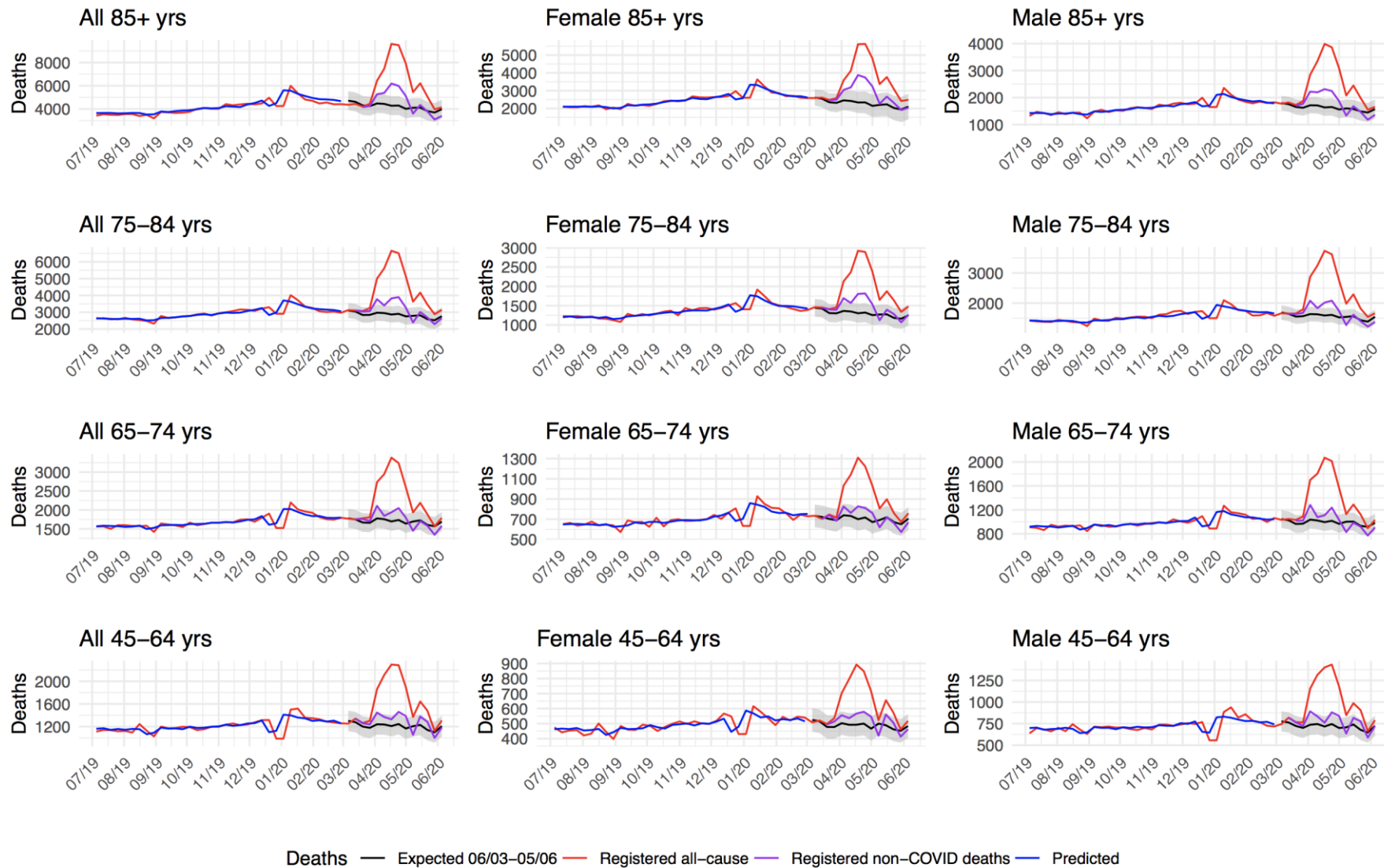


Figure A4: Weekly predicted, registered all-cause, expected and registered non-COVID-19 deaths by gender and older ages (45-85+ yrs), England & Wales, 1/7/2019 – 05/06/2020.

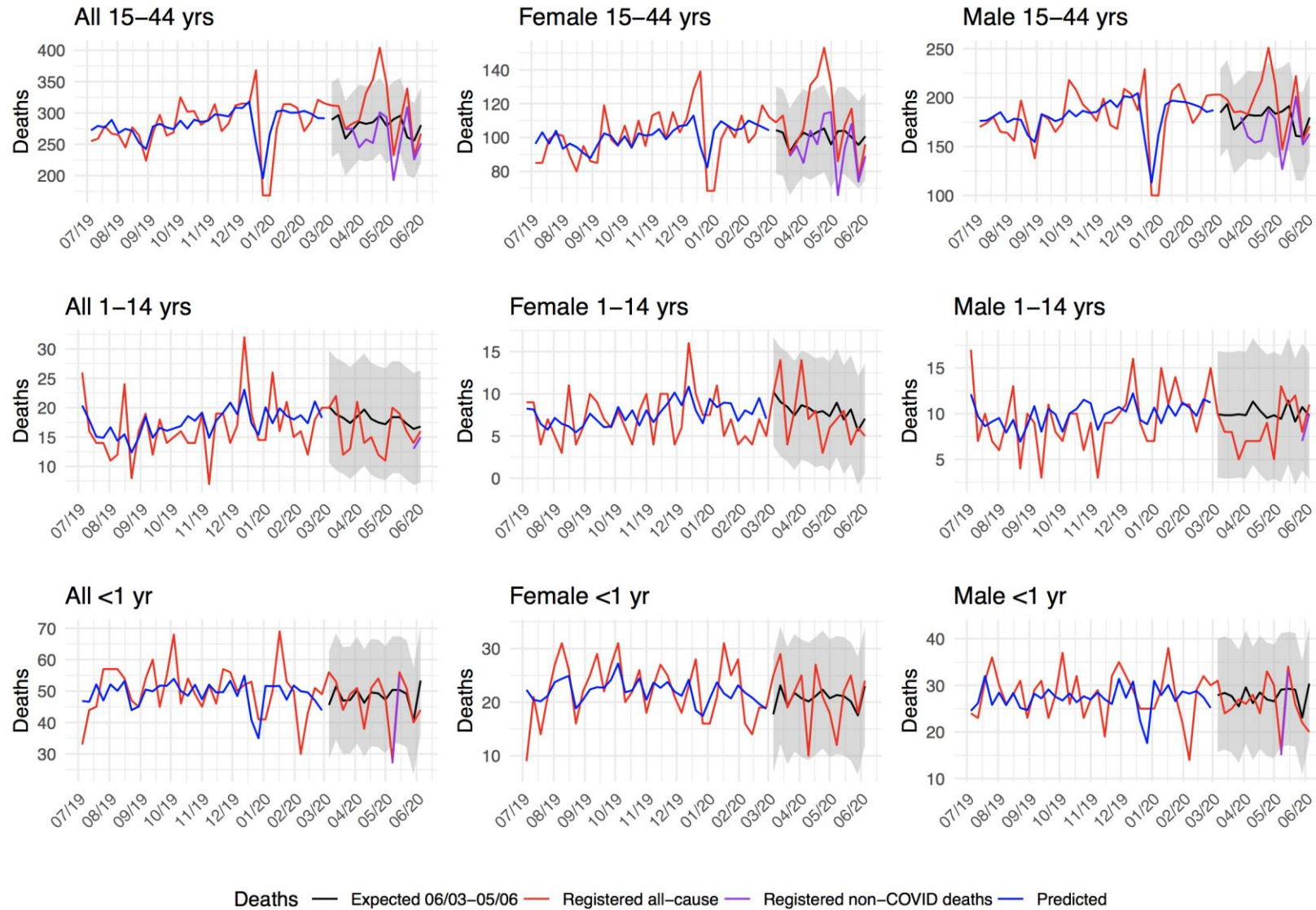


Figure A5: Weekly predicted, registered all-cause, expected and registered non-COVID-19 deaths by gender and younger ages (0-44 yrs), England & Wales, 1/7/2019 – 05/6/2020.

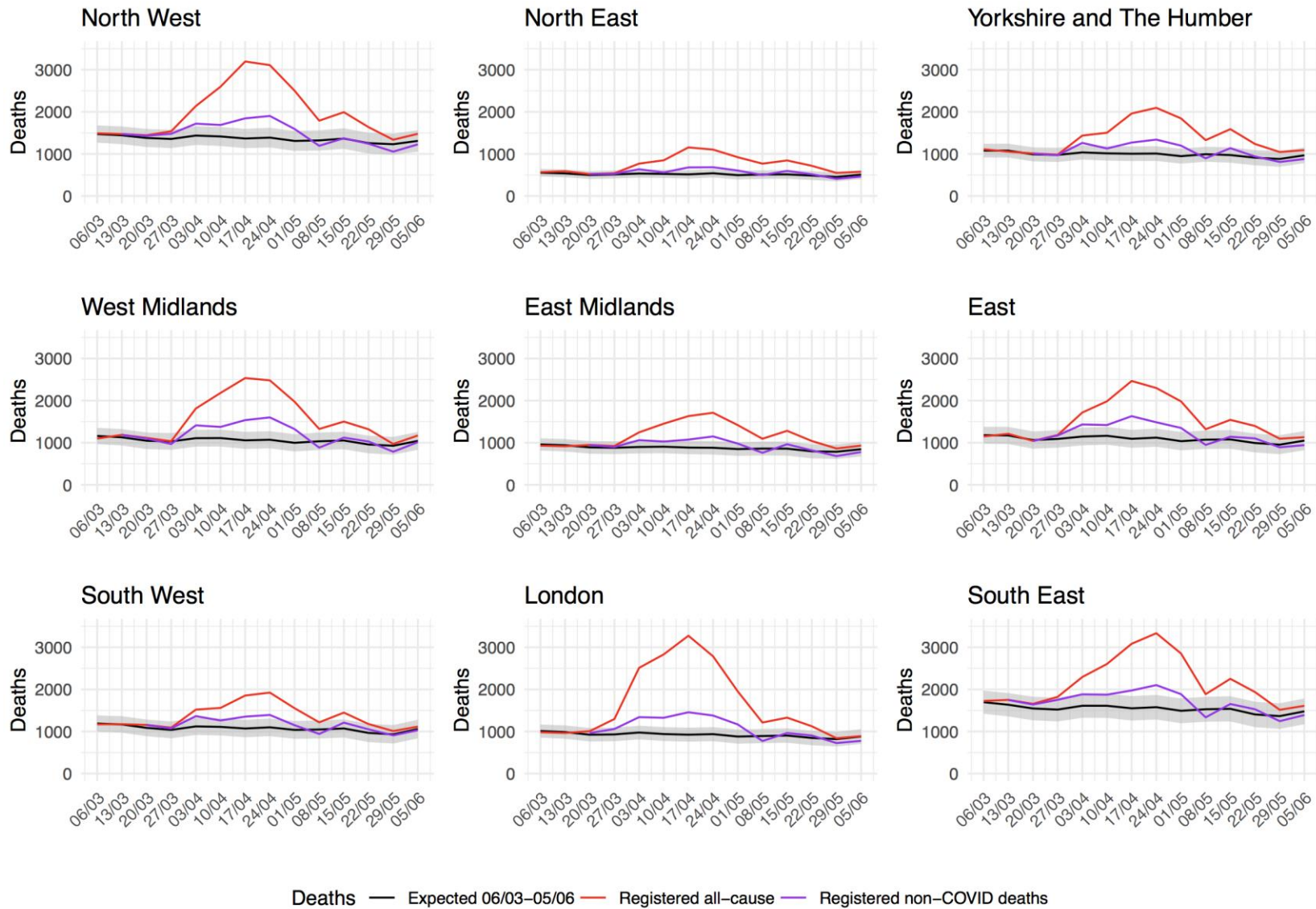


Figure A6: Weekly registered all-cause, expected and registered non-COVID-19 deaths by region, 06/03/2020 – 05/06/2020.

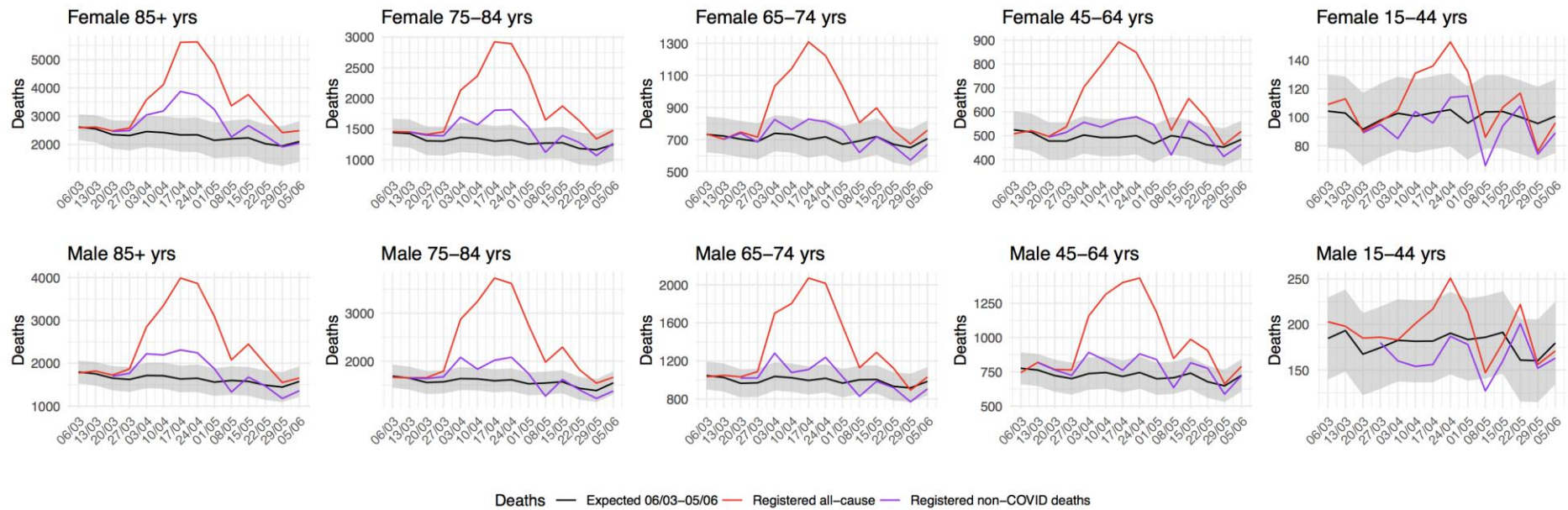


Figure A7: Weekly registered all-cause, expected and registered non-COVID-19 deaths by sex and age (15-85+ yrs), England & Wales, 06/03/2020 – 05/06/2020.