Options for refining the excess mortality methodology

Discussion paper for the Methodological Assurance Review Panel (MARP) 12 November 2024

1. Executive summary

We introduced our new UK-wide approach for estimating excess mortality in February 2024. The estimates produced by the new approach are designated as 'official statistics in development', reflecting the need continuously monitor the performance of our models and further refine the methodology if needed. This paper outlines options for a tranche of such refinements:

- Projecting the baseline trend versus pulling forward the end-of-baseline level when estimating the comparator number of deaths
- Amending the length of the baseline period and improving uncertainty estimates
- Tweaking the specification of age groups used for interaction terms in the model
- Accounting for the effect of public holidays on weekly and monthly death registrations

We are seeking the Panel's view on these options before we publish a set of firm proposals for user consideration and feedback, ahead of implementing any changes to the excess mortality methodology.

2. Introduction

We introduced our new UK-wide approach for estimating excess mortality – the difference between the observed and expected number of deaths in a particular period – on 20 February 2024 [1]. In brief, the expected number of deaths in Week *w* (or Month *m*) is estimated from a quasi-Poisson regression model fitted to mortality rates over a five-year baseline period covering Weeks *w*-52 to *w*-311 (or Months *m*-12 to *m*-71). The model includes demographic characteristics (age, sex, and region of England), a linear trend term, and a deterministic seasonal component. Different models (but with the same specification) are fitted to produce estimates of expected deaths in England and Wales (published by ONS), Scotland (published by National Records of Scotland) and Northern Ireland (published by the Northern Ireland Statistics and Research Agency). Since implementing the new methodology, we have made it clear that our excess mortality estimates are 'official statistics in development' [2], and that we will actively monitor and review the performance of our models with a view to implementing further refinements in the future, if required.

As of week-ending 20 September 2024 (Week 38), a total of 444,865 deaths in England and Wales were expected according to our new methodology, even more than the 444,099 deaths that had been registered over the same weeks in 2020 (the first year of the COVID-19 pandemic). This has led to a cumulative excess mortality in 2024 of -32,114 – the lowest number of excess deaths over Weeks 1-38 in any year of the published back-series (2011 to 2023). Despite this seemingly high number of expected deaths and, correspondingly, low number of excess deaths, the cumulative excess mortality for 2024 year-to-date is broadly in line with what we would expect, given the observed age standardised mortality rate (ASMR) (Figure 1). Notably, the year-to-date cumulative excess mortality in 2024 is comparable to that in 2019, when the ASMR was comparably low.

Figure 1. Cumulative excess deaths plotted against ASMRs over Weeks 1-38, England and Wales, 2011 to 2024

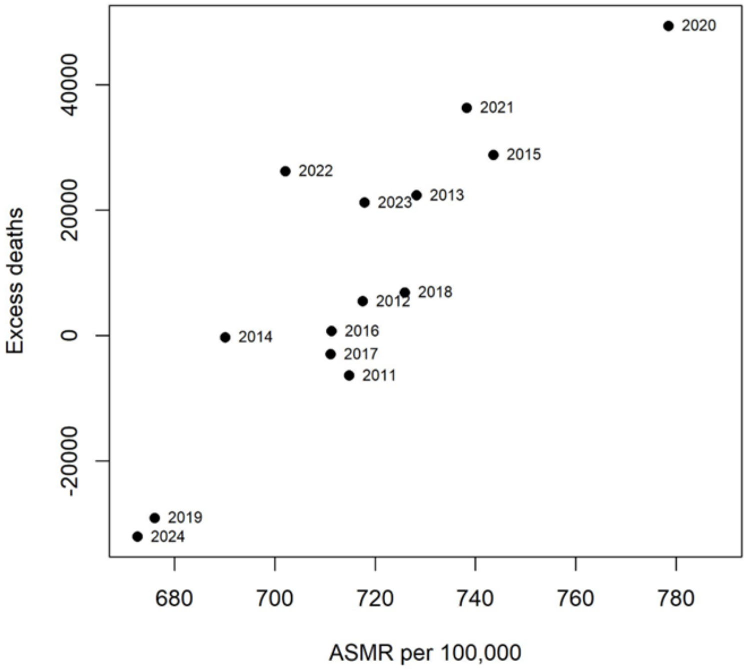


Figure 1 provides some reassurance that the new methodology is performing broadly in line with expectations. Nonetheless, we are laying out several options that have the potential to improve the approach. This paper therefore lays out several potentially emerging issues with the current approach, options for how these issues may be remedied, and the impact on our estimates of implementing these options. None of these options conflict with the fundamental methodology currently in operation; rather, they comprise refinements to the precise model specification and changes to how the model outputs are interpreted and communicated.

This paper is intended to be used as a basis for discussion at the UKSA Methodological Assurance Review Panel (MARP), before the final proposals are published on the ONS website and users invited to comment. ONS and its partner organisations in the cross-UK Excess Mortality Technical Working Group[1] will then consider this feedback before implementing any changes to the methodology. All changes will continue to be implemented in a consistent manner across UK countries, and between ONS and the Office for Health Improvement and Disparities (OHID), to maintain cross-UK and cross-organisational coherence of published estimates.

To assess the impact of each individual option in this paper, the analysis has been conducted on a one-at-a-time basis; hence if more than change is eventually implemented, the true impact of any single change may end up being different to that estimated in this paper, and the overall impact is unlikely to be the sum of the individual impacts estimated here. Further work will consider the impact of all proposed changes simultaneously rather than individually. Note also that the following analysis is currently based on annual and/or monthly data to 2023. We will further develop the analysis to include weekly data, and data for 2024 (year-to-date), before the proposals are finalised and published for user feedback.

[1] ONS, Office for Health Improvement and Disparities, Public Health Wales, Welsh Government, National Records of Scotland, Northern Ireland Statistics and Research Agency, and members of the actuarial profession.

3. Projecting the baseline trend versus pulling forward the end-of-baseline level

Issue

Under the current approach, the expected number of deaths in the reference week/month is obtained by projecting the trend from the fitted model forward by one year. This is the expected value in the reference period according to the model and is the minimum mean squared error prediction. However, from a practical viewpoint, there are three potential issues with this approach:

- Extrapolating beyond the support of the observed data can be dangerous as the future is unknown, for example in the event of a sudden turning point in the time series. This is a “textbook” cautionary remark that applies to all statistical modelling in general, but particularly in times of change – as is the case as the UK emerges from the COVID-19 pandemic – when there is greater uncertainty over the future direction of the mortality trend.

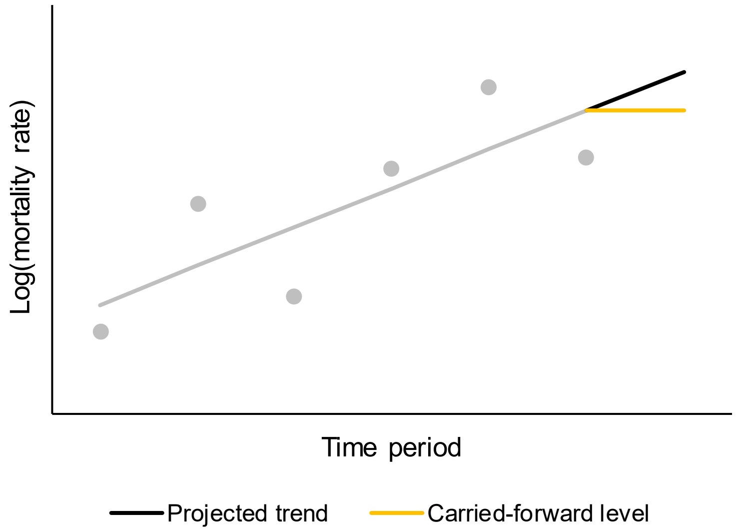
- Large shocks in recent weeks/months of the baseline period will influence the fitted trend and therefore the expected number of deaths in the reference week/month. For example, a relatively large mortality rate in the final weeks/months of the baseline period will pull the trend and therefore the prediction upwards. However, the so-called ‘mortality displacement’ effect implies that a large shock in one direction may tend to be followed by an offsetting movement in the opposite direction. This phenomenon is not accounted for in our model and is therefore a source of inaccuracy in the expected number of deaths in the reference period, which is accentuated by projecting forward the fitted trend.

- It is debatable as to whether the projected trend gives the most appropriate expected number of deaths for the purpose of public health monitoring, particularly in periods of increasing mortality rates. In this situation, an increase in the mortality rate in the reference week/month might be considered notable (and presumably undesirable) from a public health perspective; but the estimated number of excess deaths may not be large, or may even be negative, if the observed mortality rate is in keeping with recent trends. In other words, high levels of mortality in one period are baked into the expectation for the next period, such that gradually worsening population health will not be flagged as abnormal or problematic by our model.

Options

Instead of estimating excess mortality as the difference between the observed number of deaths in the reference period and the *projected trend from the baseline period*, we could instead estimate it as the difference between observed deaths and the *fitted level pulled forward from the end of the baseline period*. These two approaches to estimating the comparator number of deaths in the reference period, against which the observed number of deaths will be evaluated to produce excess mortality, are illustrated in Figure 2.

Figure 2. Illustrative example of using the fitted model in different ways to estimate the comparator number of deaths



Note: this chart is for illustrative purposes only. It is based on mock data and ignores all components other than the trend (age, sex and geography; weekly or monthly seasonality; and the number of working days in a month).

These two approaches are based on the same fitted model, but they imply two different comparator situations and are therefore answering two different questions:

1. What is the difference between the observed mortality rate in the reference period and the rate that would have been expected, had mortality trends continued from the baseline period?

2. What is the difference between the observed mortality rate in the reference period and the mean level of mortality one year earlier? Or put another way, how has the mortality rate changed since last year?

The first question conceives of excess mortality as being a comparison between observed and expected mortality in a particular period. However, for the second question, the comparator is not the *expected* mortality rate; rather, the excess mortality measure simply represents a year-on-year comparison (albeit one that is adjusted for population size and demographic structure, as well as the arrangement of the calendar). Hence the choice of whether to extrapolate the baseline trend or pull forward the end-of-baseline level is as much – if not more – of a conceptual question as a methodological one.

Neither of these conceptualisations of excess mortality is any more correct or incorrect than the other, so we could perhaps justifiably choose to routinely publish both estimates. However, we anticipate that publishing two different excess mortality estimates would not be helpful for users (for example, because they may be left wondering which estimate they should use, or might choose the one that best fits a pre-determined narrative) and would be challenging for statistical producers to communicate. The choice is therefore between:

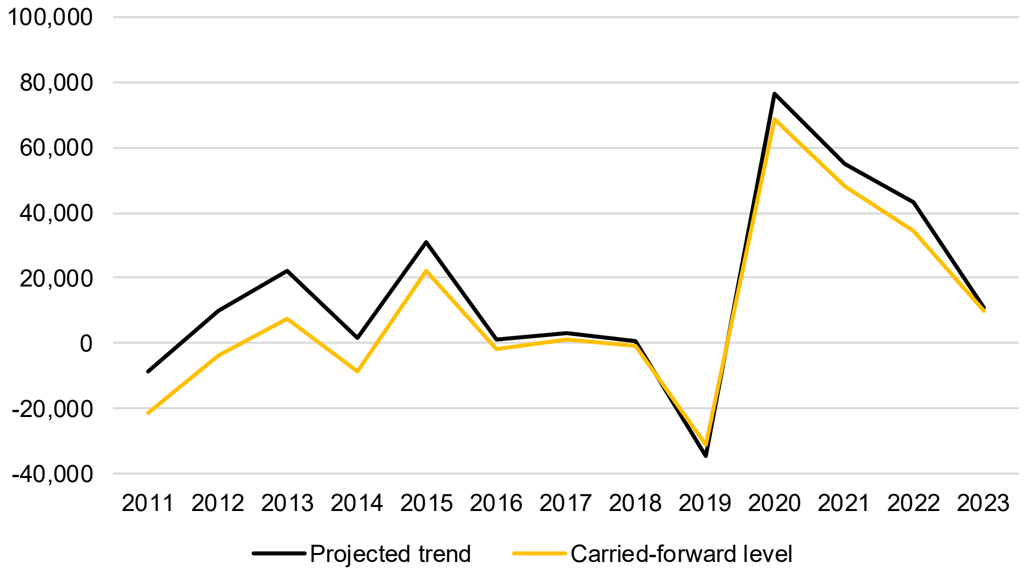
- Continuing to estimate the comparator number of deaths in the reference period by projecting the baseline trend – which is statistically the minimum mean squared error prediction, i.e. the *expected* number of deaths in the reference period

- Or switching to estimating the comparator number of deaths in the reference period by carrying forward the end-of-baseline level – which is less susceptible to shocks and may be less problematic for public health monitoring, but means that the excess mortality measure is no longer an estimate of the number of observed deaths in excess of the *expected* number of deaths in the reference period

Impact

In all years from 2011 to 2023 except 2019, using the pulled-forward level from the end of the baseline period to obtain the comparator number of deaths in the reference period results in smaller estimates of excess deaths (less positive or more negative) than using the project trend as the comparator (Supplementary Table 1). Both time-series follow the same trends and have similar period-on-period movements, including the downturn in excess mortality in 2019 and the peaks during the COVID-19 pandemic (Figure 3).

Figure 3. Annual estimates of excess deaths obtained by using different approaches to estimating the comparator number of deaths, UK, 2011 to 2023



Questions for the MARP

Question 1: Should we continue to estimate the comparator number of deaths in the reference period by projecting the baseline trend (hence the excess mortality measure represents the difference between the observed and *expected* number of deaths in the reference period); or should be switch to using the pulled-forward level from the end of the baseline period (hence the excess mortality measure would represent the difference between the observed number of deaths in the reference period and the mean level of mortality one year previously)?

4. Length of the baseline period and estimating uncertainty

Issue

Our current approach assumes a baseline period length of five years, ending in the same week/month as the current reference period but one year earlier. This baseline period was chosen for consistency with the previous five-year average approach. However, five years is essentially arbitrary; other values could have been adopted, which would have led to different estimates of expected and excess mortality.

A related issue is that this ambiguity over the "correct" choice of baseline period, which can be thought of as a hyper-parameter required to operationalise the model, is not captured in our current estimates of uncertainty.

At present, the estimated numbers of expected and excess deaths are published alongside 95% confidence intervals, which use a variance estimate produced by the Delta method. These confidence intervals capture uncertainty inherent in the linear predictor; that is, they reflect the standard errors associated with the estimated model parameters that are linearly combined to obtain the expected value. However, the confidence intervals do not capture the uncertainty inherent in predicting a specific future value. While they reflect the sampling variability of the linear predictor used to obtain the expected number of registered deaths, they do not reflect the fact that the death registrations themselves also follow a stochastic process. In other words, they recognise uncertainty in $E[y|X]$, but not uncertainty in y. Achieving the latter would result in a wider interval than a confidence interval, known as a prediction interval.

However, uncertainty in the "correct" length of the baseline period is not captured by the current confidence intervals around the estimated numbers of expected and excess deaths, nor would be it be captured by prediction intervals. Instead, a wider set of "uncertainty intervals" would need to be constructed.

Options

Increasing the base case baseline period from five years would offer some protection against extreme values during the baseline period having a disproportionate impact on the estimated number of expected and excess deaths in the reference period. This may be particularly pertinent at present as our five-year baseline period includes the COVID-19 pandemic (albeit after censoring periods that had a high proportion of deaths that were directly attributable to SARS-CoV-2) and any pandemic-related mortality displacement effects.

On the other hand, a longer baseline period will be less responsive to changes in mortality trends (which may be expected post-pandemic compared with pre-pandemic), as trend regimes observed before the turning point will remain within the "memory" of the model for longer and therefore contaminate future expected deaths for longer. A longer baseline period might also make it more difficult to justify modelling the trend as a straight line (in term of the natural logarithm of the mortality rate). Shorter baseline periods imply local linearity in mortality rates, which may be a more reasonable assumption than long-term linearity.

Ultimately, there is no “right” or “wrong” baseline period length (hence the proposal of constructing uncertainty intervals that reflect a range of possible baseline periods), and it is challenging to think of objective criteria that could be used to inform the choice of base case.

We will conduct research into possible methods for estimating prediction and uncertainty intervals around the estimated numbers of expected and excess deaths, for example simulation-based approaches. The method that is finally adopted will need to have good statistical properties, but it will also need to be practically implementable. For example, the processing time must be sufficiently short to facilitate the publication of both weekly and monthly estimates broken down by age group, sex and geography within the computing power constraints of both ONS and devolved administrations. The approach must also be practically implementable by OHID to main cross-organisational consistency; an important consideration here is that OHID additionally produces breakdowns by local authority and area deprivation, as well as cause-specific estimates of excess mortality.

<u>Impact</u>

Figure 4 and Supplementary Table 2 demonstrate the impact on estimated excess mortality of reducing the baseline period length to three or four years, or increasing it to six or seven years. As expected, the three-year baseline period generally produces the most volatile estimates, which lie at the extremes of the range for 12 of the 13 years analysed. Conversely, the estimates produced by the seven-year baseline period are generally much less variable from year to year.

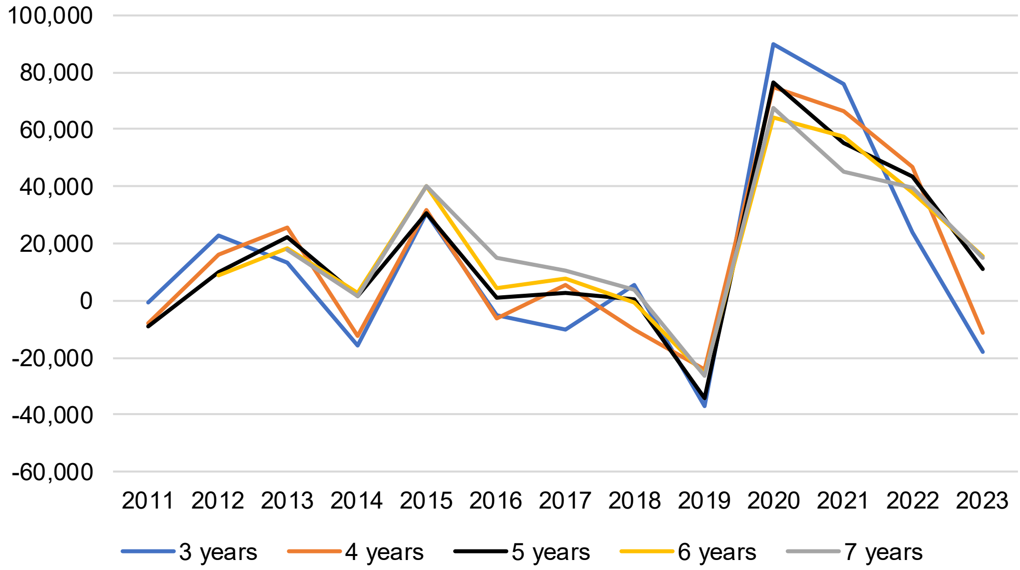
In the latest full year, 2023, estimated excess mortality would remain positive based on a six- or seven-year baseline period (15,417 and 14,880, respectively, compared with 10,994 using the current five-year baseline period), but would become negative based on a four- or three-year baseline period (-11,386 and -17,932, respectively).

Increasing the baseline period from five years would reduce the number of expected deaths in 2024, which may appear to have greater face validity. However, the number of expected deaths for the 12-month period October 2024 to September 2025 remains high irrespective of whether a five- or six-year baseline period is used, and it is now the seven-year baseline that results in a materially lower expected value.

It may therefore be prudent to stick with the current five-year baseline period for the foreseeable future, and allow more time for the post-pandemic mortality trend to stabilise. Increasing the baseline period may simply be deferring matters by prolonging the amount of time that the large swing in mortality rates between 2019 and 2020-2022 (which generates a strong positive trend for recent reference periods) remains in the model fitting period.

Moreover, it would be inappropriate to change the baseline period based on a single year of estimates, or arguably to parametrise the model based on any estimates at all (i.e. using the outputs to inform the inputs), which could be seen as subjective rather than objective decision-making. We certainly want to avoid making frequent tweaks to the approach in a reactionary manner; whatever baseline period we finally settle on should be appropriate over the long-term.

Figure 4. Annual estimates of excess deaths obtained by using different baseline period lengths, UK, 2011 to 2023



We are currently investigating approaches to estimating uncertainty intervals, and we will report empirical comparisons to the current confidence intervals when they are available. There is an open question as to what range of baseline period lengths should be adopted with which to produce the uncertainty intervals around the base case. The impact analysis reported above is predicated on the current five-year baseline period providing the central estimate, with a symmetric range of +/- 2 years around this. But this set-up need not necessarily be the case.

Questions for the MARP

Question 2: Should we continue with the five-year baseline period as the base case, and/or can the Panel suggest any empirical analysis which would provide insights into the "optimal" baseline period length (other than subjective criteria such as the "face validity" of the outputs)?

Question 3: Should we continue to produce confidence intervals around estimates of expected and excess mortality, or should we move to uncertainty intervals?

Question 4: If the Panel thinks we should move to uncertainty intervals, does it have any suggestions over possible approaches to estimating these intervals, and what range of baseline period lengths should we evaluate?

5. Age groups used for interactions

Issue

In our current models, coarse age group is interacted with sex, the trend component and the seasonal component. These coarse age groups are <30 years, 30-69 years, and then five-year age bands up to ≥90 years. OHID includes the same interaction terms in their models [3], but the specification of the coarse age group variable is slightly different: <25 years, 25-49 years, 50-64 years, and then five-year age bands up to ≥90 years. This difference is essentially arbitrary, and harmonising the age groups used in the two sets of models would improve coherence for users.

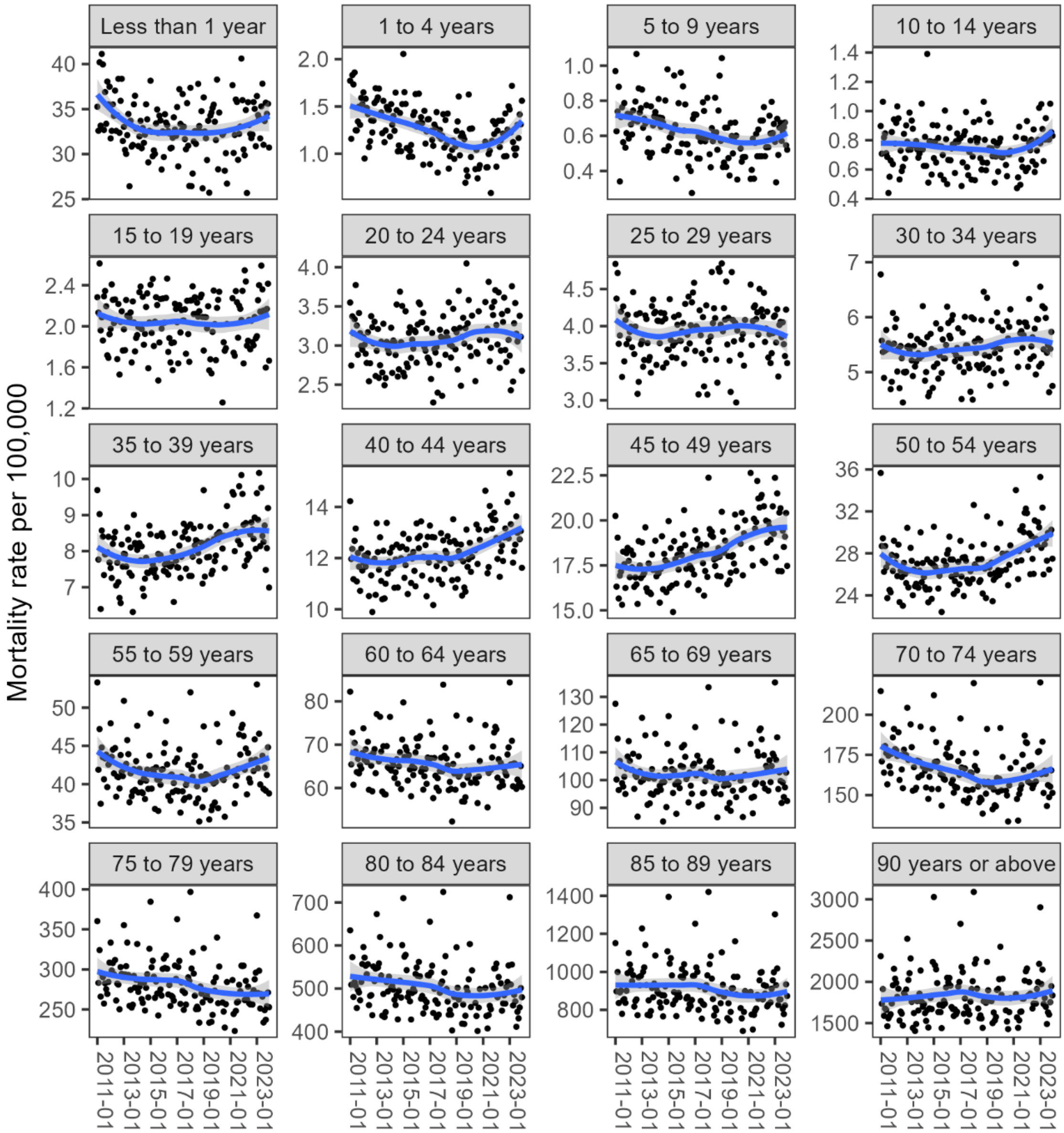
While we do not intend to make the age groups any coarser than they already are, as this would reduce the quality of the current estimates, there is potential to make the groups finer. There is limited opportunity for finer groups at younger ages due to low counts of deaths. However, there is a need to explore different upper thresholds for the middle coarse age group (currently 30-69 years), beyond which five-year age bands are used.

Figure 5 illustrates monthly age-specific mortality rates for the UK from 2011 to 2023, stratified by five-year age band. While there is a clear upward trend in the mortality rates for age groups 35-39 years to 50-54 years, this trend is attenuated in the 55-59 years group, and has disappeared or even reversed from the 60-64 years group onwards. This heterogeneity in mortality trends within the 30-69 years age range suggests that this age group is too coarse.

Supplementary Table 3 shows Bayesian Information Criterion[2] (BIC) values from the monthly models for England and Wales, using different thresholds at which five-year age bands begin in the specification of the coarse age group variable. Although our current specification (five-year age bands starting from ≥70 years) produces the lowest BIC for most months before the start of the COVID-19 pandemic, lower thresholds are preferred during and after the pandemic, suggested an evolution of the “optimal” specification of the coarse age variable.

[2] Differences in BIC give an indication of between-model differences in parsimony: the trade-off between increased goodness-of-fit (quantified as a function of the log-likelihood) and model complexity (quantified as a function of the number of estimated parameters) when more granular age groups are included and therefore more coefficients need to be estimated. The model with the lowest BIC value is taken to be the most parsimonious model.

Figure 5. Age-specific mortality rates with LOESS smoother applied, UK, January 2011 to December 2023



Options

We propose to amend the coarse groups in our models to <30 years, 30-59 years (instead of the current 30-69 years), and then five-year age bands up to ≥90 years. This only applies to the coarse age groups interacted with sex, the trend component and the seasonal component. The current fine age groups used to estimate the main effects of age are not affected.

We will work with OHID to ensure the same coarse age bands are applied in their models for consistency.

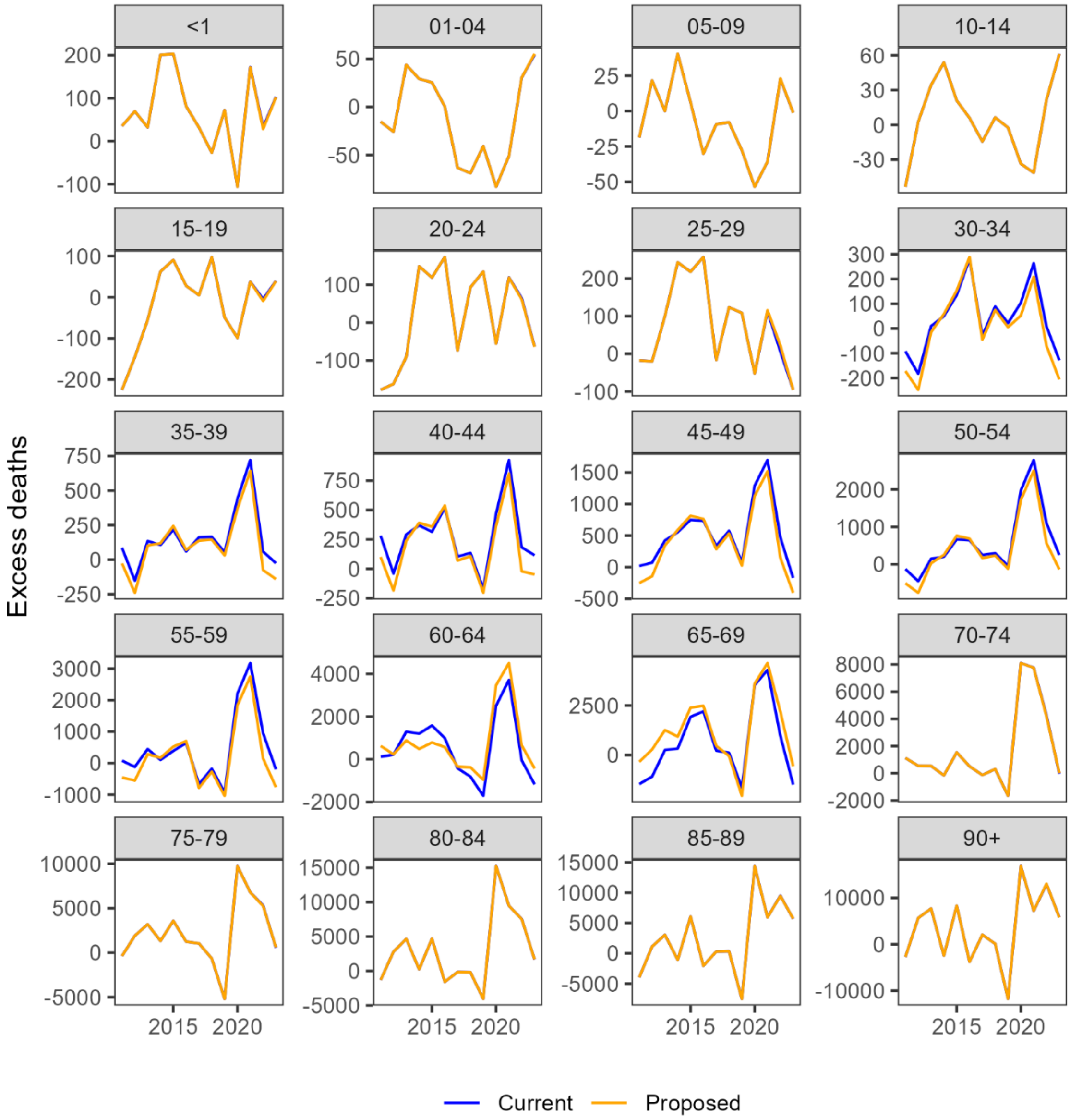
Impact

Supplementary Table 4 demonstrates that the proposed change in the specification of the coarse age groups used in interaction terms has only a marginal impact on the overall estimates of excess mortality, with the biggest absolute change occurring in 2022 (proposed = 43,187, current = 43,456). However, Figure 6 illustrates that the change has a more notable impact on the age-specific rates for the five-year age bands within the affected 30-69 years range.

Questions for the MARP

Question 5: Does the Panel agree with our proposal to change the coarse age groups used in interaction terms: from <30 years, 30-69 years, and then five-year age bands up to ≥90 years; to <30 years, 30-59 years, and then five-year age bands up to ≥90 years?

Figure 6. Annual age-specific estimates of excess deaths obtained by using the current and proposed specifications of the coarse age group variable in the model, UK, 2011 to 2023



6. Accounting for public holidays

<u>Issue</u>

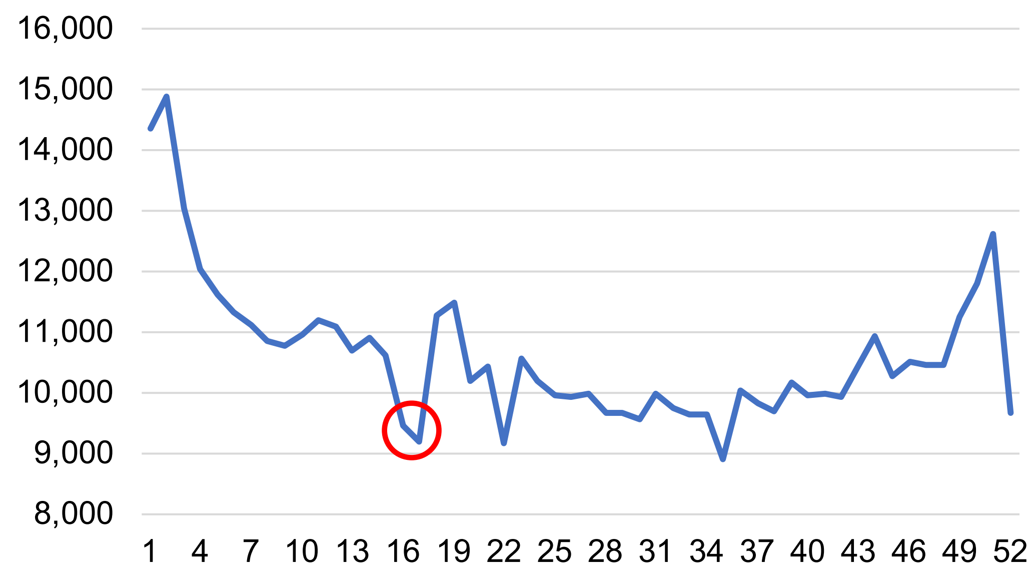
Mortality rates are naturally subject to seasonal variation, i.e. regular peaks and troughs in certain months every year. For example, mortality rates tend to be highest in the winter months due to cold weather and the spread of seasonal illnesses such as influenza. However, as our mortality statistics are based on when deaths were *registered* rather than when the deaths actually occurred, mortality rates are also affected by calendar effects due to the presence of public holidays. On these days, registration offices are closed and thus no registration activity takes place, with the lost workload being “made up” afterwards.

Taking 2011 as an example, Figure 7 demonstrates a reduced number of death registrations in Week 16 (which contained the Good Friday public holiday) and Week 17 (which contained the Easter Monday public holiday in England, Wales and Northern Ireland), as circled on the chart. (The troughs in Weeks 22, 35 and 52 are also caused by the presence of public holidays in these weeks: the Spring bank holiday in May, the Summer bank holiday in August, and the Christmas Day and Boxing Day bank holidays in December, respectively.)

In the weekly data, these holidays move between mortality recording weeks from year to year, therefore their effects do not get absorbed into the seasonal term in the model. For example, Good Friday was in Week 16 in 2011, Week 14 in 2012, and as early as Week 12 in 2016.

In the monthly data, most public holidays fall in the same month every year, hence their effects are accounted for in the seasonal term. The exceptions are Good Friday and Easter Monday (which can be in March or April, or straddle the two months) and any one-off public holidays (e.g. in 2012, the late May bank holiday was moved to the first Thursday in June, and there was an additional bank holiday the following day to mark the Queen’s Platinum Jubilee).

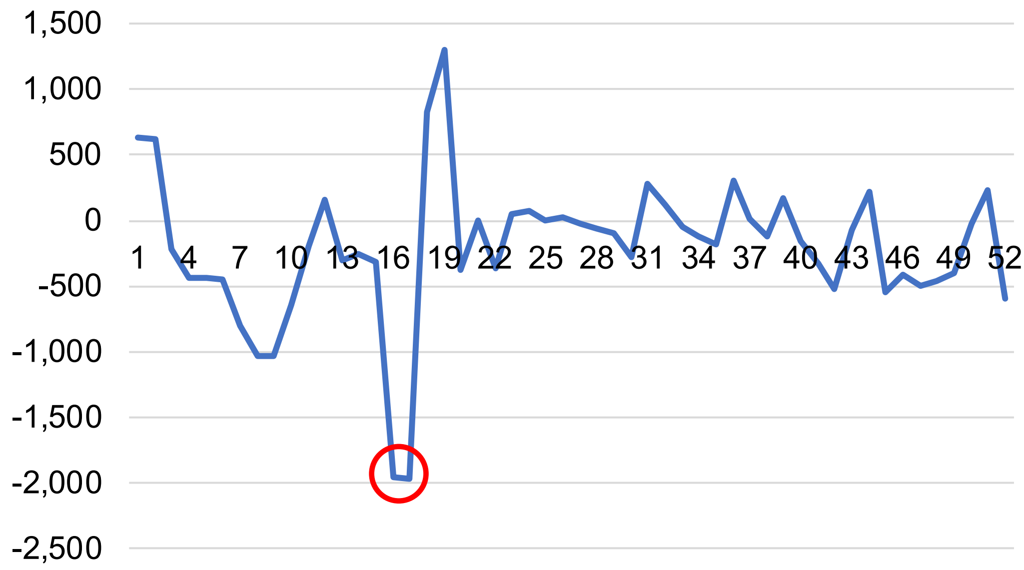
<u>Figure 7. Weekly registered deaths, UK, 2011</u>



Despite their substantial impact on death registrations, public holidays (other than those absorbed by the seasonal component) are not currently accounted for in our models. This decision was based on the fact that individual registration offices in Scotland and Northern Ireland may close on days that are different from the nationally designated public holidays, hence an adjustment based on the dates of national public holidays may not be appropriate. In the interests of UK-wide consistency, a decision was taken to not adjust for public holidays in any UK country, pending further investigation.

An inevitable consequence of this approach is that UK-wide consistency has been achieved at the expense of optimality in any specific country, and at the UK-level as a whole. For example, Figure 8 illustrates weekly estimated excess deaths at UK-level in 2011. There is a notable dip in Weeks 16 and 17 due to the two Easter holidays (circled on the chart), followed by a large peak in Weeks 18 and 19, which is likely indicative of registration offices "catching up" on lost activity over Easter. These large swings in estimated excess mortality are an artifact of the current methodology not accounting for calendar-based changes in registration activity, not a real-world event that would require a public health response.

Figure 8. Estimated weekly excess mortality, UK, 2011



Options

We aim to improve the goodness-of-fit of our models across all UK countries (or at least not make goodness-of-fit worse for any country) whilst maintaining UK-wide consistency in our approach. For this purpose of this initial investigation, we have focussed on the effects of Easter in the monthly data. Our proposed approach involves excluding each of the two bank holidays (or just Good Friday in Scotland) from the number of working days for the month in which the bank holiday falls. (Note that the number of working days, i.e. weekdays, in each month is included as an explanatory variable in our current modelling approach.) We also then allow for various "catch-up" periods to reflect the fact that registration activity is not simply lost on a bank holiday; rather, it is deferred to later date. We investigate catch-up periods of one week, two weeks, three weeks, and four weeks (where each week consists of five working days), as well as a no catch-up period to act as a benchmark. Lost activity on a bank holiday is assumed to be made-up uniformly over the catch-up period.

To illustrate this approach:

- In 2011, Good Friday fell on 22 April and Easter Monday fell on 25 April. Therefore, for England, Wales and Northern Ireland, two days were subtracted from the number of working days in April. However, assuming a one-week (five-day) catch-up period, there were four days of catch-up activity in April (26-29 April), hence 1.6 days are added back onto the number of working days (as each catch-up day represents 0.4 days' worth of activity, i.e. two lost days spread over five catch-up days). This results in a net correction of -0.4 days in April. One of the five catch-up days falls in May (2 May), hence 0.4 days' worth of activity are added onto the number of working days in May, leaving the overall net effect of the adjustment to be neutral across April and May, as required. In Scotland, where only the Good Friday is a bank holiday, the entire catch-up period falls in April (25-29 April), hence there is no adjustment to the number of working days in either April or May.

- In 2012, Good Friday fell on 6 April and Easter Monday fell on 9 April. Therefore, two days are subtracted from the number of working days in April for England, Wales and Northern Ireland; and one day is subtracted for Scotland. However, the one-week catch-up period also falls fully in April, hence there is no overall adjustment to the number of working days.

- In 2013, Good Friday fell on 29 March and Easter Monday fell on 1 April. Therefore, one day is subtracted from the number of working days in March for all countries; and one day is also subtracted from the number of working days in April for England, Wales and Northern Ireland. As the one-week catch-up period falls fully in April, two days' worth of activity are added back onto the number of working days in England, Wales and Northern Ireland; and one days is added back in Scotland. In both cases, this results in a net addition of one working day in April, leaving the overall net effect of the adjustment to be neutral across March and April, as required

Note that our "bottom-up" approach to modelling, whereby separate models are fitted to data for individual countries before the estimates are aggregated upwards, allows us to reflect the differing arrangements of public holidays across the different countries. For example, both Good Friday and Easter Monday are national holidays in England, Wales and Northern Ireland, but only the former is a national holiday in Scotland.

Supplementary Table 5 shows the number of reference months for which each candidate model specification minimises the BIC and is thus the best fitting model for estimating expected deaths in that month[3]. For each geography, accounting for Easter effects generally provides a better fit to the data than ignoring these effects. Our current modelling approach, which does not account for Easter effects, is preferred for just two out of 156 months (1.3%) for England and Wales, 28 out of 156 months (17.9%) for Scotland, and nine out of 156 months (5.8%) for Northern Ireland. These results suggest that, in the cases of Scotland and Northern Ireland (where individual registration offices may close on days that are different from the nationally designated public holidays), even an imperfect adjustment is probably better than no adjustment at all.

[3] All the model specifications under consideration involve the same number of estimated coefficients, hence differences in BIC between models reflect only differences in goodness-of-fit (quantified as a function of the log-likelihood), rather than the trade-off between goodness-of-fit and model complexity (quantified as a function of the number of estimated parameters).

The modal candidate adjustment (i.e. the one that minimises the BIC most often) is the one that assumes a three-week catch-up period for England and Wales and Northern Ireland, and the one that assumes a four-week catch-up period for Scotland. While it is possible to employ different model specifications for different countries, we will assume a three-week catch-up period across all countries for the purpose of this illustration (which may be desirable for consistency in any case). This model specification outperforms the current approach (i.e. no Easter adjustment) for the majority of reference months in every country: 98.1% of months for England and Wales, 75.0% for Scotland, and 85.9% for Northern Ireland.

Before a decision is made on whether to implement adjustments for public holidays, further work is required to estimate the effects of holidays other than Easter (which would be necessary only for weekly estimates). We will also investigate OHID's approach to accounting for public holidays in their excess mortality models. This involves modelling log(person-working-days at risk) as an offset term, rather than log(population at risk) as in our current models; thus eliminating the need to estimate the effect of the number of working days in the model and effectively fixing its coefficient to be 1. An advantage of this approach is that it preserves the annual estimates of excess mortality (it simply "moves" some expected deaths between neighbouring periods), but more wok is needed to establish whether it can be implemented with weekly data (OHID only produces monthly estimates).

If we were to implement public holiday adjustments in our routine publications, we would still caveat the estimates for the periods including and following public holidays. Users would need to interpret these estimates cautiously as any adjustments will inevitably be imperfect. However, these estimates would likely have greater utility than at present, for which the affected periods must essentially be ignored altogether.

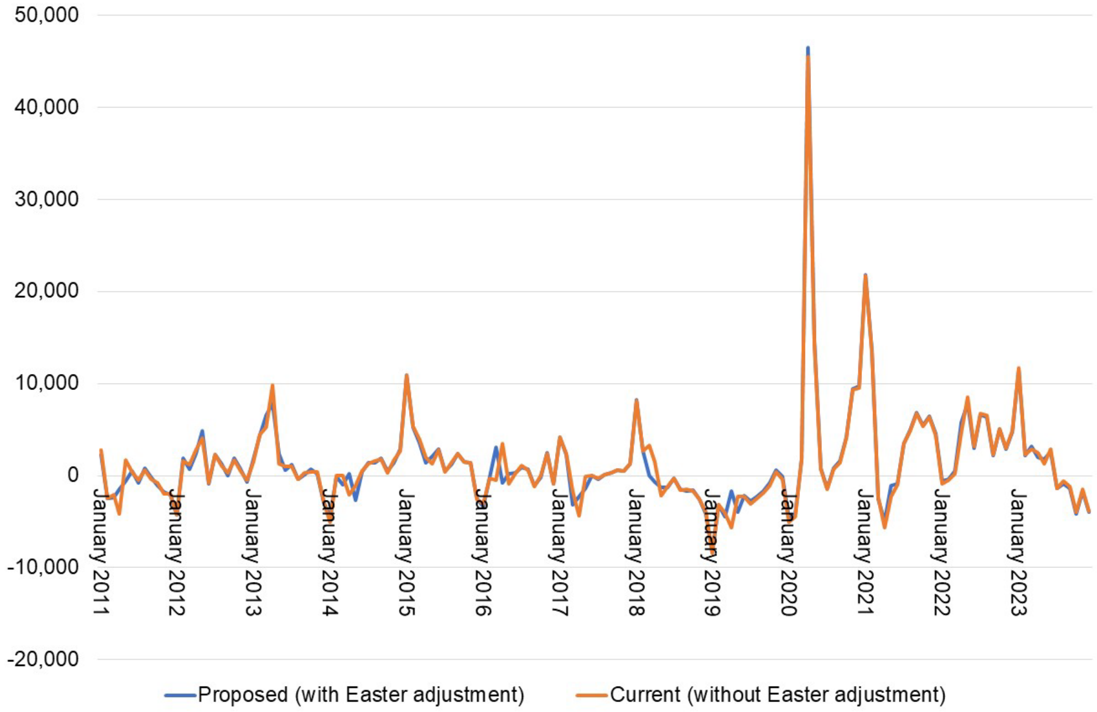
It should be remembered that public holiday effects are an artefact of compiling mortality statistics based on date of death registration rather than date of death. Therefore, in the longer term, we will consider if and how to implement mortality outputs (not just excess deaths) based on death occurrences rather than, or in addition to, death registrations.

Impact

Figure 9 shows that, as expected, the largest monthly differences in excess deaths estimated from the proposed approach (accounting for an Easter effect with a three-week catch-up period) and the current approach (no Easter adjustment) are observed in the months directly affected by the Easter adjustment: March, April and May. The periods with the biggest absolute differences between the estimates are April 2016 (proposed = 53,466, current = 49,166), April 2019 (proposed = 51,859, current = 55,814), and March 2016 (proposed = 52,128 current = 55,739).

As can be seen from Supplementary Table 6, the impact of adjusting for Easter effects on annual estimates of excess mortality is generally quite small. This is to be expected, given that the adjustment effectively "moves" some of the expected deaths (and thus excess deaths) from one month into a neighbouring month. However, there are notable changes to the estimates for 2018 (from +522 to -3,904) and 2019 (from -34,408 to -30,771).

Figure 9. Monthly estimates of excess deaths obtained by using the current (no Easter adjustment) and proposed (accounting for an Easter effect with a three-week catch-up period) model specifications, UK, January 2011 to December 2023



Questions for the MARP

Question 6: Does the Panel agree that we should implement an adjustment for public holidays in our models (subject to further impact assessment on the weekly data and for holidays other than Easter)?

Question 7: If the Panel does agree that we should implement an adjustment for public holidays, does it have any suggestions for alternative approaches for how this could be done?

7. Longer-term considerations

The following longer-term developments are not expected to be considered in the next round of published improvements to the methodology and are recorded here for completeness.

- Local authority breakdowns for England and sub-national breakdowns for Wales, Scotland and Northern Ireland (monthly estimates only)
- Breakdowns by area deprivation decile group (monthly estimates only)
- Models for cause- and place-specific estimates (monthly estimates only)
- Explore deprivation breakdowns (either in the main models or separately)
- Estimates based on date of occurrence rather than registration (this is a broader consideration for mortality reporting more generally, not just excess deaths)

As some of these features are already being produced for England by OHID (e.g. local authority and deprivation breakdowns, and cause-specific estimates), ONS and OHID will need agree a long-term production and publishing strategy to avoid duplication and proliferation of outputs.

References

1. Office for National Statistics. Estimating excess deaths in the UK, methodology changes: February 2024. 2024. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/articles/estimatingexcessdeathsintheukmethodologychanges/february2024

2. Office for Statistical Regulation. Official Statistics in Development. 2024. Available at: https://osr.statisticsauthority.gov.uk/policies/official-statistics-policies/official-statistics-in-development/

3. Office for Health Improvement and Disparities. Excess mortality within England: post-pandemic method: Methodology. 2024. Available at: https://fingertips.phe.org.uk/documents/excess-mortality-within-england-post-pandemic-method.htm

Appendix 1: Supplementary tables

Supplementary Table 1. Annual estimates of excess deaths obtained by using different approaches to estimating expected deaths, UK, 2011 to 2023

Year	Projected trend	Projected level
2011	-8,827	-21,414
2012	10,020	-3,549
2013	22,206	7,595
2014	1,587	-8,567
2015	30,858	22,369
2016	941	-1,564
2017	2,925	957
2018	522	-1,000
2019	-34,408	-31,155
2020	76,412	68,693
2021	55,079	48,009
2022	43,456	34,525
2023	10,994	9,762

Supplementary Table 2. Annual estimates of excess deaths obtained by using different baseline period lengths, UK, 2011 to 2023

Year	Baseline period length				
	3 years	4 years	5 years	6 years	7 years
2011	-607	-8,070	-8,827	N/A	N/A
2012	22,576	15,878	10,020	9,012	N/A
2013	13,149	25,411	22,206	18,391	17,769
2014	-15,895	-12,126	1,587	2,489	1,666
2015	30,673	31,949	30,858	39,947	40,293
2016	-5,055	-6,319	941	4,245	15,042
2017	-10,104	5,329	2,925	7,657	10,281
2018	5,486	-10,035	522	-873	3,556
2019	-36,709	-24,176	-34,408	-26,065	-26,522
2020	89,945	74,676	76,412	63,884	67,364
2021	75,741	66,462	55,079	57,564	45,314
2022	23,806	46,662	43,456	37,921	39,680
2023	-17,932	-11,386	10,994	15,417	14,880

Supplementary Table 3. BIC values from monthly models using different thresholds at which five-year age bands begin in the specification of the coarse age group variable, England and Wales, reference months January 2011 to December 2023

Reference period	50+	55+	60+	65+	70+	Minimum
Jan-11	27,278	27,319	27,274	27,299	27,280	60+
Feb-11	27,297	27,344	27,303	27,330	27,311	50+
Mar-11	27,177	27,227	27,186	27,200	27,176	70+
Apr-11	27,272	27,322	27,280	27,296	27,273	50+
May-11	27,267	27,318	27,273	27,284	27,265	70+
Jun-11	27,279	27,324	27,272	27,279	27,259	70+
Jul-11	27,277	27,328	27,274	27,277	27,265	70+
Aug-11	27,241	27,291	27,238	27,245	27,233	70+
Sep-11	27,213	27,275	27,220	27,231	27,211	70+
Oct-11	27,195	27,263	27,208	27,214	27,203	50+
Nov-11	27,166	27,236	27,177	27,185	27,170	50+
Dec-11	27,136	27,199	27,134	27,134	27,116	70+
Jan-12	27,094	27,153	27,087	27,065	27,054	70+
Feb-12	27,185	27,247	27,181	27,159	27,149	70+
Mar-12	27,068	27,127	27,060	27,037	27,031	70+
Apr-12	27,267	27,322	27,252	27,230	27,218	70+
May-12	27,285	27,349	27,280	27,255	27,242	70+
Jun-12	27,285	27,351	27,281	27,256	27,249	70+
Jul-12	27,142	27,211	27,139	27,109	27,095	70+
Aug-12	27,120	27,188	27,117	27,088	27,088	65+
Sep-12	27,067	27,130	27,057	27,030	27,036	65+
Oct-12	27,081	27,147	27,072	27,035	27,049	65+
Nov-12	27,079	27,143	27,070	27,036	27,048	65+
Dec-12	26,599	26,657	26,585	26,550	26,552	65+
Jan-13	26,264	26,329	26,261	26,221	26,207	70+
Feb-13	26,289	26,363	26,294	26,256	26,231	70+
Mar-13	26,376	26,450	26,382	26,342	26,313	70+
Apr-13	26,537	26,608	26,542	26,502	26,469	70+
May-13	26,761	26,831	26,769	26,730	26,692	70+
Jun-13	26,784	26,856	26,795	26,755	26,712	70+
Jul-13	26,877	26,952	26,893	26,851	26,805	70+
Aug-13	26,936	26,999	26,938	26,892	26,839	70+
Sep-13	26,906	26,973	26,915	26,868	26,818	70+
Oct-13	26,948	27,015	26,959	26,912	26,858	70+
Nov-13	26,913	26,977	26,927	26,888	26,833	70+
Dec-13	26,896	26,964	26,912	26,875	26,819	70+
Jan-14	26,737	26,799	26,757	26,716	26,653	70+
Feb-14	26,877	26,929	26,885	26,847	26,784	70+
Mar-14	27,324	27,375	27,331	27,295	27,230	70+
Apr-14	28,244	28,293	28,247	28,218	28,148	70+
May-14	28,234	28,290	28,247	28,219	28,150	70+

Reference period	50+	55+	60+	65+	70+	Minimum
Jun-14	28,214	28,270	28,227	28,194	28,124	70+
Jul-14	28,155	28,205	28,167	28,137	28,069	70+
Aug-14	28,112	28,162	28,124	28,091	28,026	70+
Sep-14	28,070	28,119	28,080	28,045	27,980	70+
Oct-14	28,016	28,068	28,027	27,984	27,922	70+
Nov-14	27,864	27,920	27,884	27,840	27,780	70+
Dec-14	26,854	26,910	26,873	26,833	26,770	70+
Jan-15	26,538	26,599	26,557	26,519	26,445	70+
Feb-15	26,610	26,677	26,634	26,598	26,526	70+
Mar-15	26,734	26,808	26,764	26,726	26,660	70+
Apr-15	26,762	26,829	26,789	26,751	26,685	70+
May-15	26,709	26,769	26,725	26,687	26,619	70+
Jun-15	26,682	26,740	26,697	26,659	26,590	70+
Jul-15	26,684	26,741	26,701	26,655	26,588	70+
Aug-15	26,700	26,754	26,715	26,665	26,609	70+
Sep-15	26,727	26,776	26,738	26,686	26,629	70+
Oct-15	26,665	26,711	26,672	26,612	26,553	70+
Nov-15	26,624	26,672	26,629	26,562	26,507	70+
Dec-15	26,702	26,754	26,711	26,642	26,583	70+
Jan-16	28,548	28,605	28,557	28,493	28,432	70+
Feb-16	28,773	28,827	28,778	28,715	28,653	70+
Mar-16	28,880	28,931	28,882	28,821	28,758	70+
Apr-16	28,821	28,866	28,814	28,755	28,692	70+
May-16	28,808	28,863	28,811	28,756	28,692	70+
Jun-16	28,738	28,790	28,736	28,681	28,615	70+
Jul-16	28,739	28,786	28,739	28,680	28,615	70+
Aug-16	28,716	28,768	28,724	28,660	28,599	70+
Sep-16	28,658	28,704	28,664	28,595	28,533	70+
Oct-16	28,585	28,630	28,592	28,521	28,459	70+
Nov-16	28,543	28,582	28,543	28,471	28,413	70+
Dec-16	28,507	28,546	28,513	28,441	28,388	70+
Jan-17	28,552	28,588	28,564	28,493	28,449	70+
Feb-17	28,515	28,542	28,522	28,451	28,409	70+
Mar-17	28,455	28,489	28,464	28,393	28,351	70+
Apr-17	28,156	28,185	28,167	28,099	28,056	70+
May-17	28,110	28,133	28,124	28,055	28,012	70+
Jun-17	28,096	28,115	28,107	28,038	27,997	70+
Jul-17	28,118	28,138	28,132	28,064	28,024	70+
Aug-17	28,121	28,149	28,147	28,080	28,027	70+
Sep-17	28,149	28,178	28,172	28,100	28,048	70+
Oct-17	28,163	28,189	28,182	28,110	28,057	70+
Nov-17	28,264	28,295	28,290	28,218	28,163	70+
Dec-17	28,270	28,305	28,300	28,227	28,174	70+
Jan-18	28,380	28,417	28,402	28,331	28,290	70+

Reference period	50+	55+	60+	65+	70+	Minimum
Feb-18	28,504	28,540	28,520	28,452	28,413	70+
Mar-18	28,562	28,595	28,577	28,508	28,467	70+
Apr-18	28,953	28,988	28,964	28,896	28,855	70+
May-18	28,795	28,827	28,802	28,735	28,695	70+
Jun-18	28,761	28,791	28,769	28,708	28,671	70+
Jul-18	28,699	28,725	28,708	28,652	28,624	70+
Aug-18	28,676	28,712	28,696	28,642	28,620	70+
Sep-18	28,691	28,731	28,708	28,656	28,632	70+
Oct-18	28,643	28,683	28,658	28,606	28,585	70+
Nov-18	28,647	28,694	28,669	28,624	28,608	70+
Dec-18	28,641	28,675	28,651	28,606	28,596	70+
Jan-19	29,064	29,101	29,073	29,034	29,032	70+
Feb-19	29,142	29,180	29,153	29,115	29,114	70+
Mar-19	29,012	29,049	29,019	28,981	28,984	65+
Apr-19	27,911	27,950	27,922	27,879	27,881	65+
May-19	28,024	28,054	28,020	27,980	27,972	70+
Jun-19	28,155	28,182	28,152	28,117	28,107	70+
Jul-19	28,183	28,213	28,182	28,155	28,145	70+
Aug-19	28,339	28,367	28,343	28,324	28,314	70+
Sep-19	28,468	28,494	28,473	28,465	28,457	70+
Oct-19	28,612	28,631	28,616	28,617	28,605	70+
Nov-19	28,777	28,796	28,783	28,790	28,775	70+
Dec-19	29,110	29,125	29,112	29,125	29,110	70+
Jan-20	28,944	28,955	28,935	28,949	28,937	60+
Feb-20	28,580	28,589	28,569	28,584	28,571	60+
Mar-20	28,354	28,360	28,342	28,366	28,348	60+
Apr-20	28,063	28,072	28,053	28,084	28,066	60+
May-20	28,022	28,030	28,017	28,054	28,035	60+
Jun-20	28,009	28,024	28,013	28,052	28,035	50+
Jul-20	27,959	27,969	27,960	28,005	27,982	50+
Aug-20	27,956	27,962	27,952	28,000	27,972	60+
Sep-20	27,983	27,988	27,977	28,028	28,003	60+
Oct-20	28,020	28,027	28,025	28,079	28,054	50+
Nov-20	28,146	28,148	28,148	28,198	28,172	50+
Dec-20	28,092	28,091	28,086	28,132	28,100	60+
Jan-21	27,327	27,318	27,304	27,343	27,310	60+
Feb-21	27,495	27,486	27,477	27,511	27,476	70+
Mar-21	27,538	27,527	27,522	27,551	27,516	70+
Apr-21	27,166	27,155	27,148	27,168	27,133	70+
May-21	26,793	26,781	26,774	26,792	26,758	70+
Jun-21	26,797	26,787	26,780	26,802	26,768	70+
Jul-21	26,887	26,878	26,872	26,908	26,879	60+
Aug-21	26,880	26,867	26,865	26,908	26,879	60+
Sep-21	26,918	26,901	26,903	26,955	26,929	55+

Reference period	50+	55+	60+	65+	70+	Minimum
Oct-21	27,090	27,072	27,077	27,139	27,119	55+
Nov-21	26,630	26,612	26,617	26,680	26,657	55+
Dec-21	26,142	26,120	26,125	26,190	26,172	55+
Jan-22	25,082	25,058	25,058	25,120	25,105	60+
Feb-22	24,541	24,516	24,511	24,579	24,568	60+
Mar-22	24,653	24,623	24,612	24,693	24,696	60+
Apr-22	24,646	24,615	24,601	24,672	24,685	60+
May-22	24,690	24,655	24,642	24,727	24,748	60+
Jun-22	24,659	24,626	24,613	24,694	24,725	60+
Jul-22	24,949	24,914	24,913	25,001	25,044	60+
Aug-22	25,354	25,319	25,316	25,410	25,452	60+
Sep-22	25,907	25,875	25,876	25,987	26,031	55+
Oct-22	26,148	26,119	26,122	26,231	26,276	55+
Nov-22	26,594	26,560	26,559	26,669	26,712	60+
Dec-22	26,817	26,786	26,787	26,890	26,920	55+
Jan-23	26,709	26,674	26,675	26,752	26,757	55+
Feb-23	26,648	26,612	26,618	26,681	26,685	55+
Mar-23	26,731	26,696	26,696	26,750	26,755	60+
Apr-23	26,904	26,866	26,873	26,925	26,922	55+
May-23	27,634	27,592	27,599	27,649	27,641	55+
Jun-23	27,633	27,591	27,602	27,659	27,642	55+
Jul-23	28,026	27,985	27,995	28,057	28,045	55+
Aug-23	28,383	28,349	28,360	28,430	28,413	55+
Sep-23	28,384	28,345	28,355	28,432	28,421	55+
Oct-23	28,589	28,553	28,563	28,645	28,629	55+
Nov-23	28,582	28,546	28,554	28,642	28,631	55+
Dec-23	28,774	28,744	28,755	28,839	28,818	55+

Supplementary Table 4. Annual estimates of excess deaths obtained by using the current and proposed specifications of the coarse age group variable in the model, UK, 2011 to 2023

Year	Current	Proposed
2011	-8,827	-8,754
2012	10,020	10,147
2013	22,206	22,324
2014	1,587	1,665
2015	30,858	30,919
2016	941	968
2017	2,925	2,913
2018	522	531
2019	-34,408	-34,375
2020	76,412	76,428
2021	55,079	55,090
2022	43,456	43,187
2023	10,994	11,184

Supplementary Table 5. Number of months that each candidate model specification minimises the BIC, reference months January 2011 to December 2023

Geography	With Easter adjustment						Without Easter adjustment
	No catch-up period	1 week catch-up	2 weeks catch-up	3 weeks catch-up	4 weeks catch-up	Any adjustment	
England and Wales, including non-residents	0 (0.0%)	1 (0.6%)	39 (25.0%)	76 (48.7%)	38 (24.4%)	154 (98.7%)	2 (1.3%)
England, excluding non-residents	0 (0.0%)	0 (0.0%)	36 (23.1%)	80 (51.3%)	38 (24.4%)	154 (98.7%)	2 (1.3%)
Wales, excluding non-residents	0 (0.0%)	40 (25.6%)	14 (9.0%)	49 (31.4%)	36 (23.1%)	139 (89.1%)	17 (10.9%)
Scotland, including non-residents	12 (7.7%)	25 (16.0%)	0 (0.0%)	20 (12.8%)	71 (45.5%)	128 (82.1%)	28 (17.9%)
Northern Ireland, including non-residents	21 (13.5%)	27 (17.3%)	36 (23.1%)	47 (30.1%)	16 (10.3%)	147 (94.2%)	9 (5.8%)

Supplementary Table 6. Annual estimates of excess deaths obtained by using the current (no Easter adjustment) and proposed (accounting for an Easter effect with a three-week catch-up period) model specifications, UK, 2011 to 2023

Year	Current	Proposed
2011	-8,827	-9,451
2012	10,020	10,171
2013	22,206	22,484
2014	1,587	1,659
2015	30,858	30,703
2016	941	1,214
2017	2,925	2,180
2018	522	-3,904
2019	-34,408	-30,771
2020	76,412	79,129
2021	55,079	57,577
2022	43,456	43,870
2023	10,994	9,751