

Calculating the excess mortality baseline

Sarah Crofts, Sarah Caul, Alexander Cooke, Georgia Brett

Purpose

This paper discusses the issues to consider when estimating the number of expected deaths (or 'baseline') in a given period, and possible methods being explored by a cross-UK and cross-organisation baseline working group. Estimating the number of expected deaths is a key step in calculating the number of excess deaths. The outcome of the working group will be to provide a recommendation paper on the most appropriate method and bring it to MARP for further assurance. Therefore, this paper is intended to provide MARP with the background of this project and a chance to provide advice at an early stage.

Key asks of MARP

We would welcome feedback on the methods discussed and the proposed criteria for determining which methodology to take forward.

- Are there other methods we should be investigating?
- Are there other elements we should consider when looking at results?

1. Background information

Excess mortality is the difference between the actual number of deaths observed and the number that were expected. Across the UK we are aware of the number of deaths observed (although there is more than one measure of this – registrations, occurrences and notifications), however there are different methods available for estimating the expected number of deaths.

The impact of the pandemic means that the question we are seeking to answer isn't as clear as it was prior to the pandemic and has now widened to 'What do we mean by expected number of deaths?'. Are we trying to calculate the number of deaths had there not been a pandemic, i.e. the impact of the pandemic on mortality? Or are we trying to calculate the number of deaths given there is a pandemic, i.e. to inform us about what is happening now? Or could there be a different question we need to answer? The baseline working group have decided the question we should be answering is "*Do the latest reported data on deaths, in isolation or cumulatively, indicate a rise, or fall, in mortality compared with previously observed mortality?*"

The Office for Statistics Regulation have been involved in discussions around this work. In February 2023 the [OSR released a report with recommendations](#) around ONS' excess deaths reporting. We continue to liaise with OSR, and use their recommendations as part of the working group. There were six recommendations that came from this report:

- Be open and proactively engage with a wide range of users about the development work it is undertaking and its decision making throughout this process.
- Improve how its data are presented and how any uncertainty in the data is explained to users. While there isn't one definitive right answer on what the expected number of deaths should be, users should be supported in understanding this.
- Review its understanding of users' needs, as different users may have different uses of these data and therefore different methodologies may be suitable in different circumstances. This means reviewing, considering and explaining what it means by 'expected deaths' when calculating excess mortality.
- Provide users with clear, accessible information on:
 - the methods and the reasons why the group has chosen to apply those methods

- the differences in approach taken to measuring excess mortality including signposting to the different sources of data
- how to interpret differences in the resultant published data

As well as this review, the OSR has recently carried out a data compliance check on mortality statistics (because of the increased interest in the topic) and the Methods and Quality Directorate in ONS are also doing a review. We will take the recommendations from the three areas and make sure we incorporate them in this project and the way we work moving forward.

The cross-UK excess mortality baseline group was established in February 2023 and benefits from expertise spanning many organisations and fields. As well as representatives from different areas of ONS (mortality experts, methodologists and demographers), the group has representation from Cabinet Office, Office for Health Improvements and Disparities (OHID) within the Department of Health and Social Care (DHSC), UK Health Security Agency (UKHSA), Public Health Wales, Welsh Government, National Records of Scotland, Northern Ireland Statistics and Research Agency, Department of Health Northern Ireland, and the actuarial profession (Lane Clark & Peacock LLP and the Continuous Mortality Investigation (CMI)).

The group will bring its recommendations to MARP at a later date for consideration before presenting to the National Statistician to make the final decision. This methodology will then be adopted across organisations as the standard methodology to calculate excess deaths with only a few exceptions to this rule. A paper will be published at the end of the project looking at the results of each option and why the final method was chosen. As part of this paper we will discuss the exceptions to this and when they should apply.

2. Terms and outcomes of the group

The resulting methodology will need to provide measures of excess deaths across a range of geographies (UK, England, Wales, Scotland, Northern Ireland, Local Authorities) and time periods (Weekly, Monthly, Annual). The group will also take in to account the possibility of providing further disaggregation such as by cause of death and socio-demographic characteristics such as age, sex and possibly ethnicity.

The group outcomes are:

1. To provide clarity on the question(s) we are seeking to answer (e.g. 'How many excess deaths are there?')
2. To evidence the most appropriate method to be used to answer this/these question(s) and calculate excess deaths
3. Make sure that user needs are at the heart of evidencing 1 and 2, and that the resulting publication clarifies the excess mortality landscape

An options paper with a recommendation will be sent to the National Statistician who will make the final decision on the most appropriate method

The fundamental question that the group will focus on is *“Do the latest reported data on deaths, in isolation or cumulatively, indicate a rise, or fall, in mortality compared with previously observed mortality?”*

We will prioritise and test available methods against data from at least 2015 using the following criteria when calculating the expected number of deaths. The method needs to:

- account for the context that the pandemic has occurred

- account for demographic change, mainly age distribution
- account for the seasonal variation seen in mortality
- be appropriate for all lengths of periods – Weekly, monthly and annual
- be suitable to run at the UK, England, Wales, Scotland and Northern Ireland levels when broken down by sex
- provide an interval estimate around the point estimate (confidence intervals)
- be understandable to users. A simpler method is preferable to a more complex method if the methods work as well as each other
- be relatively unbiased across a range of scenarios

The analysis will be carried out by the ONS mortality team and other member organisations, dependent upon available resources.

As well as meeting the above criteria we will test using statistics such as the mean absolute percentage error (MAPE) across the non-pandemic years to see how well the methods would have predicted previously observed death rates. We will also look to see if we see deviation from predicted values where expected. For example, we would expect to see excess in 2015 and negative excess in 2019 due to the differences in flu prevalence in those years particularly.

Methodology already available and methodology being investigated

There are multiple measures for the number of expected deaths used to measure excess deaths. These different measures produce different excess deaths figures. They include:

- five-year averages (number of deaths and age-standardised mortality rates)
- [relative age-standardised mortality rates](#)
- [segmented regression analysis](#)
- [the Continuous Mortality Investigation \(CMI\) mortality projections](#)
- [CMI pandemic monitor](#)
- [EuroMOMO](#)
- [UK Health Security Agency \(UKHSA\) daily mortality method](#)
- [Office for Health Improvement and Disparity's \(OHID\) excess death](#) model

Some of the commonly used methods are summarised below.

ONS uses the average of the previous five years (excluding 2020) to calculate the expected number of deaths in a given period. We use this method as it ensures comparison with a recent period which was similar in life expectancy, advances in healthcare, population size and shape. Using multiple years removes the fluctuations that can be seen year-on-year when looking at mortality. Some of the benefits of this method are that it is easy to understand and does not rely on different data breakdowns. For instance, it requires only the number of deaths for the period and the five years prior. Some of the limitations are that it does not take into account any trend in the data, nor any other variables than deaths (when looking at numbers of deaths), population, and age-structure (when looking at rates).

OHID's estimates of excess deaths are based on a method developed specifically to measure excess deaths during the coronavirus (COVID-19) pandemic. It uses a (Quasi-Poisson regression) model to estimate expected deaths each week, based on the trend in mortality rates from 2015 to 2019. OHID's model accounts for changes to the population, including ageing. The model accounts for ethnicity, sex, and levels of deprivation, so excess deaths for these factors are reported separately. OHID's complex method assumes that the trend in mortality rates before the

pandemic (from 2015 to 2019) would have continued had there been no pandemic. This trend is not completely clear, however. The long-term downward trend in mortality rates slowed in the 2010s, though there was more improvement in 2019 than in other recent years.

The Continuous Mortality Investigation (CMI) Pandemic Mortality Monitor was developed specifically to measure excess deaths during the pandemic and uses analysis based on Standardised Mortality Rates (SMRs). Provisional weekly deaths data published by the ONS is adjusted to control for changes in the size, age, and gender distribution of the population over time. Calculated SMRs are compared with SMRs from 2019, the last pre-pandemic year.

The UKHSA mortality baseline used for EuroMomo is based on modelling week of death with a Serfling wave function and linear trend or for younger ages with no seasonality, just a linear trend. Only spring and autumn weeks are used in this modelling. This is to have a function that fits well to years, with no large excesses due to flu in the winter and heatwaves in the summer. For their daily model, the baseline until November 2020 was from the same day of the year in the previous five years, plus or minus seven days, with an extrapolated time trend. The baseline from December 2020 to March 2021 only uses the same days, plus or minus seven days, from the past three low flu years with no trend. The baseline from April 2021 onwards is set to be the same as the previous year's baseline.

We will be exploring alternative methods such as Holt-Winters (a method that uses exponential smoothing to predict future values), ARIMA/SARIMA models (autoregressive integrated moving average model with or without seasonality included), Neural networks (a simplified model based on the way the human brain processes information), Farrington models (a quasi-Poisson regression-based model), and investigating the models used by WHO (more information can be found [here](#)).