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No gold standard for calculating excess mortality

PERSPECTIVES

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When observed mortality is higher than expected mortality, it is referred to as excess mortality. While observed mortality is easy to quantify, calculating expected mortality is challenging. Using different methods can sometimes lead to major differences in excess mortality estimates.

Following a continuous decline in mortality and an increasing life expectancy since World War II, the COVID-19 pandemic struck Norway in March 2020. The pandemic represents a global health crisis that has led to changes in

mortality beyond cases where COVID-19 is an underlying cause of death or a contributing factor (1). Calculations of excess mortality are therefore an important measure of the public health burden of the pandemic.

During the pandemic, various estimates of excess mortality in Norway and other countries were published. Comparisons showed considerable variations in these estimates due to the absence of a standardised approach to calculating excess mortality (2, 3). In June 2023, the Norwegian Institute of Public Health published its estimates of mortality and excess mortality for the pandemic years 2020–22 (4). In this article, we explain the choices underlying the calculations of these estimates and demonstrate how certain approaches to calculating excess mortality can give an inaccurate picture of mortality trends during the pandemic.

How is expected mortality calculated?

The major challenge in calculating excess mortality during the pandemic lies in providing a reliable estimate of *expected mortality*, i.e. what the mortality rate in Norway would have been in the years 2020–22 if there had been no pandemic. Mortality has been declining for several decades, but the population of Norway is continually growing, and in around 2020 the large post-war generation reached an age where mortality increases considerably. There is also a strong indication that the dramatic decline in mortality from cardiovascular diseases is now starting to level off. Projections from the Global Burden of Disease project, based on data up to 2019, estimated that the mortality trend in Norway would start to reverse around 2020 (5). It is therefore not certain that, without the pandemic, we would have observed the same downward trend in mortality in 2020–22 as in previous years.

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Various methods with varying degrees of complexity are used to calculate expected mortality, and the choice of method can significantly impact the estimate. The simplest approach, which is also the most intuitive, is to only compare mortality in the period of interest with the average mortality in a reference period. However, such calculations do not take into account mortality trends. To factor this into the calculation, a comparison could be made of, for example, the mortality in the year of interest with the linear trend in mortality in the reference period. However, research shows that mortality varies throughout the year, even in a 'normal' year, with the highest mortality during the winter months (Figure 1). This means that a linear model cannot shed light on excess mortality over shorter periods of time, such as per week or month. In situations where mortality can change rapidly, such as during a pandemic, it is important to monitor excess mortality in shorter time intervals.

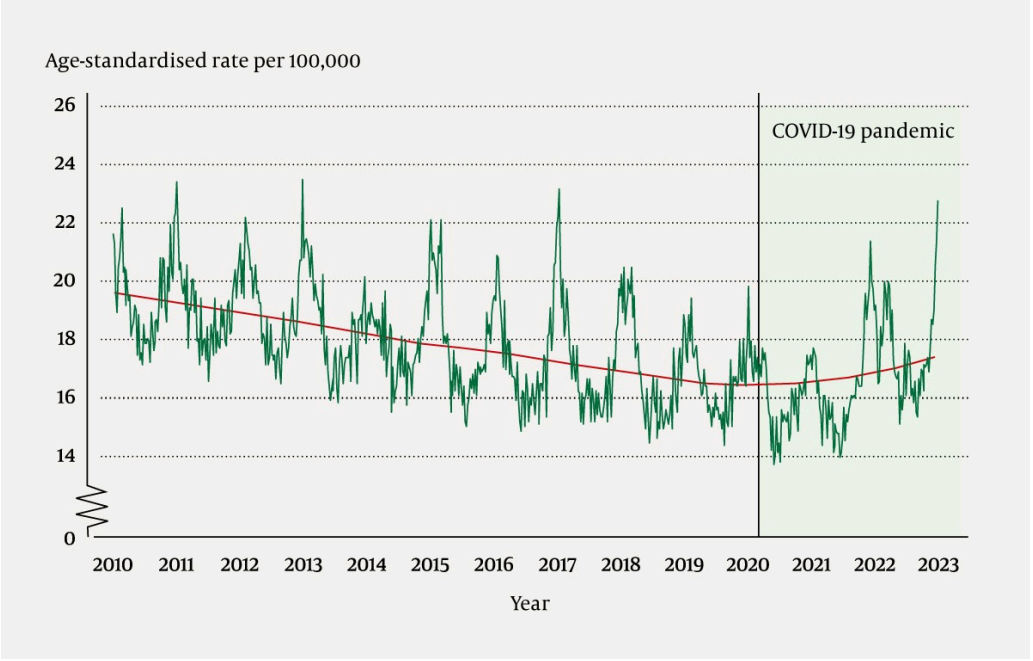

Figure 1 Age-standardised mortality rate per 100,000 over calendar weeks for each year in the period 2010–22 (smoothed over a four-week period). Age standardisation was performed using the European Standard Population, 2013 (Eurostat), to offset differences in age distribution between years. The trend line is shown in red.

Reference period as a basis

An important factor when calculating expected mortality is the years that are included in the reference period. Mortality in the time period of interest is typically compared with mortality in periods as close in time as possible. This naturally entails some challenges when selecting a time period for comparison in a pandemic that spans several years and results in untypical changes in mortality. Calculating expected mortality in 2022 will yield different estimates depending on whether 2020 and 2021 are included or excluded from the reference period. Different reference periods have been used in international comparisons of excess mortality during the pandemic, ranging from one, three, five and ten years preceding the pandemic. With a shorter reference period, acute or short-term untypical changes in mortality due to, for example, severe flu seasons, heat waves or terrorist attacks, will have a more pronounced effect than for longer time periods.

Other factors that affect mortality could also be included in the calculations, such as health service capacity, the population's underlying health status and vaccine coverage. Such factors have particularly been included in excess mortality estimates in international comparisons (6, 7).

Norwegian Institute of Public Health's calculations

The COVID-19 pandemic occurred in several waves, and the authorities implemented various temporary infection control measures to combat these. To examine the impact of the waves of COVID-19 infection and the implemented measures on mortality during these periods, models are needed that can capture such time-varying effects.

> ***«To examine the impact of the waves of COVID-19 infection and the implemented measures on mortality during these periods, models are needed that can capture such time-varying effects»***

We therefore chose not to use simpler approaches such as calculating expected mortality based on an average in a reference period or using a linear model. Instead, we used what are known as time series models. These models take into account seasonal variations and trends in mortality over time by estimating expected mortality during the pandemic based on mortality trends and seasonal variations in the ten years preceding the pandemic (2010–19). We tested four different time series models by examining the accuracy in calculations of expected mortality for periods where we had observed data. Three of these yielded good results during testing, but the accuracy varied in different time periods across the models. Instead of selecting one of these models to be the guiding model for the excess mortality estimate, we therefore chose to express the final excess mortality estimate as a weighted average of the individual estimates from the three models.

How are the results presented?

Excess mortality can be presented as the number of additional deaths compared to what was expected (in absolute numbers or as a rate), or as a percentage increase in the expected number, mortality rate per 100,000, or age-standardised mortality rate per 100,000. When using the death tally alone, the population size or how it has changed over time are not factored in. Mortality rate per 100,000 takes into account the size of the population but does not reflect how the population has aged since 2010.

Previous calculations have found that excess mortality for the Nordic countries is overestimated when only changes in population size are considered and not changes in age composition, even in complex models (8). In this report, we have therefore chosen to express the estimates as age-standardised rates in order to reflect the changes in population size and age distribution over time. The age-standardised rates are then converted to the number of deaths. This gives excess mortality of 11.5 % in 2022 (measured as the deviation between the observed and expected number of deaths divided by the expected number of deaths) and 5.2 % in the pandemic period as a whole (2020–22).

«The lower the baseline mortality, the fewer deaths are needed to show a larger percentage increase in mortality. It is therefore important to know the absolute mortality rate»

How the result is presented has a considerable impact on the interpretation of excess mortality. The relative increase in mortality, i.e. expressed as a percentage, is interesting because it provides insight into how mortality has changed within different groups. In 2022, for example, we find excess mortality in all age groups except the 60–69 age group. The percentage increase in mortality was highest in the 70–79 age group.

However, the percentage increase in mortality depends on the baseline mortality: the lower this is, the fewer deaths are needed to show a larger percentage increase in mortality. It is therefore important to know the absolute mortality rate, which is much higher among those aged 90 and over (24,752 per 100,000 in 2022) than in the 70–79 age group (2,315 per 100,000 in 2022).

The media and the general population are also often concerned with the number of additional deaths, partly because it gives an indication of the increase in mortality that is intuitively easy to understand. Of these, 90 % occurred in the 70+ population, and 10 % of these were in the age group 90 years and over.

Different approaches, different estimates

In our work for this report, we tested three different approaches to calculating expected mortality, with or without accounting for changes in population size and ageing, using the preceding three, five and ten years as reference periods. Details of these tests are provided in the results section and in Appendix 2 of the report (4). A simple comparison of mortality during the pandemic with the average in the period 2010–19, without accounting for changes in age composition over time, gives an excess mortality of 4.8 % in 2022 and –0.6 % for the pandemic period (2020–22) as a whole. The notably lower estimate in this simple approach compared to our main model can be attributed to the fact that the simple approach does not reflect the declining mortality over time. Despite the high mortality in 2022, it was still lower than in the first half of the reference period.

Using a linear model that reflects changes in both the size and the age composition of the population, excess mortality is 12.9 % for 2022 and 6.0 % for the entire pandemic period. Although a linear model with age standardisation yields relatively similar results to our main model, a model of this type does not factor in seasonal trends in mortality or shed light on the status of excess mortality over shorter periods of time.

Calculating excess mortality is important for understanding the repercussions of the pandemic in Norway. However, there is no gold standard for making such calculations. In our report, our goal has been to provide a well-considered and validated estimate. Nevertheless, there may be factors we have not

included in the analyses. If we had opted for different models, they could have yielded estimates that were either higher or lower than the ones we ultimately arrived at. In order for the Norwegian Institute of Public Health to fulfil its social mission, it is important that the knowledge we generate is useful for the authorities, the health service and the population. We therefore strive for transparency in our calculations and continuously focus on quality assuring and improving our work. It is still too early to tell how the pandemic has affected mortality in Norway. Continued monitoring of total mortality and excess mortality is therefore needed.

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