Comparing all-cause mortality between European countries and regions methodology

Quality, methodology and comparability information for data used to calculate excess all-cause mortality for the UK, its constituent countries and European countries and their regions as reported in Comparisons of all-cause mortality between European countries and regions. Includes methodology for calculating measures of excess mortality, quality of the data sources, comparability of the measures and how to interpret the data.

Contact:
Heidi Wilson
health.data@ons.gov.uk
+44 1329 444110

Release date:
20 December 2022

Next release:
To be announced

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1 . Data sources and quality

Weekly all-cause death registration data published by Eurostat from contributing countries of the European Union and European Free Trade Association are used in our Comparisons of all-cause mortality between European countries and regions article. There are clear criteria set out by Eurostat for data to be submitted to their database , based on official recording of deaths occurring in all settings, to enable comparability.

All data analysed in this article for countries outside of the United Kingdom (UK) are publicly available on the Eurostat website (European Union Statistics Office). We previously submitted weekly counts of death registrations on behalf of the UK up until the end of 2020. Following the departure of the UK from the European Union on 31 January 2021, Eurostat were unable to publish new or ongoing UK statistical releases. For the UK, we use Office for National Statistics (ONS) data for England and Wales, National Records Scotland (NRS) data for Scotland and Northern Ireland Statistics and Research Agency (NISRA) data for Northern Ireland.

The metadata for the weekly mortality data for each country within the European Union can be found on the Eurostat website. Each national statistical institute in the European Union has been requested to provide mortality counts by week, sex, five-year age group and a geographical breakdown to nomenclature of territorial units for statistics level 3 (NUTS3 level). NUTS3 level is broadly equivalent to local authority level; you can find out more about the NUTS classification on the Eurostat website. Where these breakdowns were not possible, broader age groups or geographical areas were accepted by Eurostat.

Readily available international comparisons of coronavirus (COVID-19) mortality are of limited quality because of different reporting systems and definitions. National differences in testing and diagnosis make comparisons especially difficult, along with hospital versus non-hospital coverage. The distinction between numbers based on death certification and those depending on test results is reflected in the international differences in data availability and quality. Excess all-cause mortality is, therefore, the most robust international comparator for the COVID-19 pandemic.

For the weekly mortality data made available by Eurostat, a back series of five years of weekly deaths (2015 to 2019 inclusive) at the national and sub-national levels enable the calculating of average deaths per week. These are an essential part of the calculation of excess mortality and cumulative excess mortality during the coronavirus pandemic.

Timeliness

The timeliness of the analysis possible is limited by the availability of data on the Eurostat website. For the UK, data up until the latest weekly reporting are readily available. However, some countries update their submission of weekly deaths data to Eurostat on an infrequent basis and are not able to report data as timely as the UK, because of variations in civil registration systems and reporting practices.

In our article, we report up until the latest week available on the Eurostat website at the time of data download for all countries that have submitted data in the format required to calculate age-standardised mortality rates (disaggregated into five-year age bands and back series data available for 2015 to 2019).

Data coverage

The data coverage of our Comparisons of all-cause mortality between European countries and regions article is dependent on data submitted to and published on the Eurostat website.

As the article uses age-standardised mortality rate-based measures for comparisons of excess mortality between countries and regions, only countries and regions where deaths and populations are available by five-year age groups can be included in our analyses. We are reliant on these data being available for the comparison period of 2015 to 2019, as well as the observed period (2020 to mid-2022).

Therefore, we cannot include statistics for Albania, Germany, the Republic of Ireland, Liechtenstein, Montenegro, and Serbia as data are not available in the format required. However, figures for Germany have been included in our analysis of proportional scores (which do not require five-year age groups) and are available in the article reference tables.

NUTS geography

Eurostat introduced an update to their NUTS boundaries in 2021. Deaths on their weekly mortality database are reported by these boundaries from week 52 2020 onwards, whereas corresponding population estimates and projections published on their website are still reported by the preceding 2016 boundaries. As we require both deaths and populations to calculate age-standardised mortality rates and our measures of excess mortality, from week 52 2020 onwards we have only been able to include those areas where boundaries have not changed from 2016 to 2021. This affects 35 NUTS3 areas across Belgium, Estonia, Greece, Croatia, Italy, UK and Norway, constituting 3.7% of the (NUTS2016) NUTS3 areas.

2 . Methodology

In our Comparisons of all-cause mortality between European countries and regions article, three measures for evaluating levels of mortality have been calculated (age-standardised mortality rates, relative age-standardised mortality rates and relative cumulative age-standardised mortality rates). We have also calculated proportional scores (P-scores), a further measure of evaluating deviations from expected levels of mortality that users may wish to use.

Analysis of all-cause mortality allows us to examine the impact of the coronavirus (COVID-19) pandemic not only from deaths due to COVID-19, but also excess deaths that may have occurred indirectly as a result of the wider impacts of the virus, such as on healthcare systems and society. Given the differing practices in recording and reporting deaths relating to COVID-19, it is not possible at this time to conduct accurate international comparisons of deaths involving COVID-19 specifically.

Our Comparisons of all-cause mortality between European countries and regions article examines mortality patterns from 2020 onwards, set against patterns observed during a comparative five years (2015 to 2019). The average for 2015 to 2019 provides a comparison of the number of deaths expected in a usual (non-pandemic) year and is used for comparison against 2020, 2021 and 2022. This differs from other Office for National Statistics (ONS) mortality publications, which compare deaths in 2022 against an average for the years 2016 to 2019, and 2021. This approach has not been adopted for international comparisons of mortality because of international temporal differences in COVID-19 waves. The difference between the current period and a past average is often referred to as "excess mortality". Therefore, the article is not a direct comparison of COVID-19 deaths or epidemic curves.

We focus on two main measures of excess mortality. These are:

- relative age-standardised mortality rates (rASMRs)
- relative cumulative age-standardised mortality rates (rcASMRs)

Each measure has strengths and limitations when comparing mortality between geographical areas. Broadly, these measures aim to control for non-modifiable population characteristics, such as the age structure and size of differing populations, so that like-for-like comparisons can be made between countries and regions.

For assessing weekly measures of excess mortality, rASMRs show where weekly mortality rates were above or below average, expressed as a percentage. These examine whether the rate of mortality within that individual week were proportionally higher or lower than its respective week in the five-year average and allows for identification of peaks in excess mortality.

For assessing the total weekly excess mortality over a longer period, rcASMRs indicate whether the accumulated excess mortality was above or below average, expressed as a percentage. Weekly mortality rates are calculated and aggregated over the selected period and expressed as the percentage change from the average for a comparative period. The rcASMRs value for a given week indicates how much above or below the five-year average the mortality rate is for the whole period, from the start of 2020 up to that week.

3 . Population denominator estimation

In order to create the age-standardised mortality rates (ASMRs), relative age-standardised mortality rates (rASMRs) and relative cumulative age-standardised mortality rates (rcASMRs), two data sources are required. These are:

- deaths by five-year age group and sex for each week of the study period
- corresponding population denominators for each week of the study period

The method of population estimation differs for UK areas and areas outside the UK. This is because the UK has been unable to supply weekly population and death registration figures to Eurostat since 1 January 2021, following the country's departure from the European Union.

Areas outside of the UK

For areas outside of the UK, population estimates for each five-year age group and sex were sourced at nomenclature of territorial units for statistics (NUTS) 2016 hierarchies from the Eurostat website for week one of each year in the study period: 2015, 2016, 2017, 2018, 2019. Projected population estimates for week one of 2020, 2021, 2022 and 2023 have also been sourced from Eurostat for NUTS 2016 levels 0 and 3.

Eurostat populations are an estimate or projection of the population as of 1 January of the selected year for the selected area. Our analysis operates on the assumption that 1 January falls within week one of the calendar year. However, this is not the case for 2016 and 2021, where 1 January falls within week 53 of the previous year.

To interpolate the weekly populations, the calculated change in population between week one of the selected year and week one of the following year was divided by the number of statistical weeks for that year. As a result of leap years, some years require a 53rd week to be added. This was the case for 2015 and 2020, which contained 53 weeks, whereas 2016 to 2019, 2021 and 2022 contained 52 weeks. The calculated change was then added to the yearly population (week one) and accumulated over the weeks to create a linearly interpolated population denominators for each week of the year. The formula can be expressed as the following:

$$E\left(x,\ s,\ w,\ y\right) = \ P\left(x,\ s,\ y\right) + \ \left(\frac{P\left(x,\ s, y+1\right) - P\left(x,\ s,\ y\right)}{l}\left(w-1\right)\right)$$

Where:

- P is annual population
- x is age group
- s is sex
- y is year
- w is week
- l is the maximum number of weeks in the year

Areas within the UK

For areas within the UK, the following population sources were used to estimate weekly populations:

- mid-year population estimates (MYE) for 2014 to 2020 by single year of age, sex and local authority in the UK, England, Wales, Scotland, and Northern Ireland
- 2018-based national population projections (NPPs) for 2021 to 2023 by single year of age and sex in the UK, England, Wales, Scotland, and Northern Ireland
- 2018-based sub-national population projections (SNPPs) for 2021 to 2023, by single year of age, sex and local authority in England, Wales, Scotland, and Northern Ireland, which were adjusted to the most recent 2020-based NPPs

For both country and NUTS3 level weekly interpolated estimates, the populations by single year of age and sex were aggregated into five-year age bands.

MYE for 2014 to 2020 were used for both national and sub-national populations.

For 2021 to 2023 country-level populations, 2018-based NPPs were used for the weekly interpolation estimation of the population. This ensures consistency with other mortality publications, which use 2018-based projections at country level.

For NUTS3 level populations, scaling factors were calculated for the years 2021 to 2023, for each country's age and sex, by dividing the 2020-based NPP by the 2018-based NPP. This scaling factor was then applied to the 2018-based SNPPs for 2021 to 2023 projections to bring them more in line with the updated 2020-based projections. The SNPPs were then aggregated into NUTS3 level areas. Because this article is the only mortality publication produced by the Office for National Statistics (ONS), which looks at NUTS3 geography, the adjustment allows us to make use of the most up-to-date data without conflicting with published figures. This means the underlying SNPPs are still comparable to our other releases, while being in line with and benefiting from assumptions set on more recent changes to the population, such as from the early months of the coronavirus (COVID-19) pandemic.

The method for estimating the population for each week using linear interpolation for areas within the UK differs slightly from that used for areas outside of the UK. This is because of the use of MYE, NPPs and SNPPs for UK areas. Population estimates and projections relate to the usually resident population on 30 June of each year. Therefore, weekly populations are interpolated between two mid-year populations. The two annual populations used to estimate a weekly population is determined by where the week falls in relation to the week containing the mid-year (30 June).

The formula used for estimating populations for weeks before the week of the mid-year is:

$$E\left(x,\ s,\ w,\ y\right) = \ P\left(x,\ s,\ y\right) + \ \left(\frac{P\left(x,\ s,y\right) - P\left(x,s,y-1\right)}{52\ \times 7}m_{y\ -\ 1}\right)$$

Where:

- P is annual population
- x is age group
- s is sex
- y is year
- w is week
- m is number of days from 30 June of y-1 (the mid-year) to the week end date

The formula used for estimating populations for the week of and following the mid-year is:

$$E\left(x,\ s,\ w,\ y\right) = \ P\left(x,\ s,\ y\right) + \ \left(\frac{P\left(x,\ s,y\right) - P\left(x,s,y-1\right)}{52\ \times 7}m_{y}\right)$$

Where:

- P is annual population
- x is age group
- s is sex
- y is year
- w is week
- m is number of days from 30 June of y (the mid-year) to the week end date

Notes on methodology change

In the previous editions of this analysis, the estimated weekly populations were calculated using populations from Eurostat provided by the ONS.

Weekly populations were interpolated between the annual populations for years 2015 through 2020 using the same method as other countries in this analysis. Week one 2020 estimates produced by the ONS were then extrapolated through to week one 2021 using the calculated rate of change from week one 2019 to week one 2020. Because of the lack of an estimate of UK NUTS populations at week one 2021, we continued the weekly linear extrapolation up to the latest week of analysis.

The weekly population estimates became less representative of the population as time progressed further from the years from which the difference was calculated (2019 and 2020). We decided to move to using the ONS mid-year estimates and projections. This ensures the exposure estimations used in the rate calculations are up-to-date and is consistent with other mortality publications within the ONS mortality publications.

4 . Mortality rates and P-scores

Age-standardised mortality rates (ASMRs)

Age-standardised mortality rates (ASMRs) are used to allow comparisons between populations that may contain different overall population sizes and proportions of people of different ages. The 2013 European Standard Population, as seen on the National Archives website is used to standardise age-specific rates to a consistent population. The formula used is:

$$ASMR\left(per100,000\right)_{(G,i)} = \frac{100,000}{\sum_{(x)\in G} ESP\left(x\right)} \sum_{(x,s)\in G} \frac{D\left(x,s,i\right)}{E\left(x,s,i\right)} ESP\left(x\right)$$

Where:

- G is the group (defined by some combination of age and sex) for which we calculate the ASMR
- i is the time interval for which we calculate the ASMR
- x is age
- s is sex
- ESP(x) is the standard population for age x
- D (x,s,i) is the number of deaths for age x and sex s in time interval i
- E (x,s,i) is a measure of the exposure for age x and sex s in time interval i

Weekly estimates of person-years exposed has been calculated using linear interpolation of population estimates and projections. For further information, please see Section 3: Population denominator estimation.

Relative age-standardised mortality rates (rASMRs)

Relative age-standardised mortality rates (rASMRs) are weekly measures of excess mortality using ASMRs that are standardised to the 2013 European standard population.

Excess mortality for a particular week is defined as the difference between the ASMR for that week, and average ASMR for that week in the five years from 2015 to 2019 inclusive. For the years that do not have 53 weeks (2016 to 2019), we have used the mid-point between week 52 and week 1 of the following year for the calculation of the ASMR. This excess mortality is then expressed as a proportion of the five-year average ASMR.

The following formula is used:

$$rASMR\left(G,w,y\right) \;=\; \frac{ASMR\left(G,w,y\right) \;-\; \overline{ASMR}\left(G,w,2015-19\right)}{\overline{ASMR}\left(G,w,2015-19\right)}$$

Where:

- rASMR(G,w,y) is relative age-standardised mortality rate in week w and year y
- ASMR(G,w,y) is age-standardised mortality rate in week w and year y, as defined in "Age-standardised mortality rates" section
- $\overline{ASMR}(G,w,2015-19)$ is mean age-standardised mortality in week w, averaged over years 2015 to 2019

Notes on methodology change

In previous versions of this analysis, the rASMR calculation expressed the excess mortality in a given week (the difference between the observed and average rate for that week) as a proportion of the average of all weeks across the entire year. Instead, the current methodology expresses the excess mortality as a proportion of the average rate for that specific week. This allows aspects such as seasonal variability to be taken into account when calculating how proportional an excess rate is.

The previous formula was as follows:

$$rASMR\left(G,w,y\right) \;=\; \frac{ASMR\left(G,w,y\right) \;-\; \overline{ASMR}\left(G,\;w,\;2015-2019\right)}{\frac{\overline{cASMR}(G,\;w,\;2015-19)}{52}}$$

For information on cumulative age-standardised rates (cASMRs), please see the Relative cumulative age-standardised mortality rates (rcASMRs) section.

Relative cumulative age-standardised mortality rates (rcASMRs)

Rather than absolute values of death counts, relative cumulative age-standardised mortality rates (rcASMRs) sum all age-standardised mortality rates between two time points. In this article, rcASMRs are calculated cumulatively from week 1 2020 until the latest week available. The 2015 to 2019 average cumulative age-standardised mortality rate for that time period is used as a comparator. Where the time period extends beyond one year, this is treated as an extension of the number of weeks in the year, for example week one 2021 is effectively week 54 in the period of interest. For the five-year average, week one onwards of the 2015 to 2019 average is used in the calculation of the cumulative age-standardised mortality rates (cASMR).

We define cASMR, the cumulative ASMR, which is used in calculating relative cASMRs, as the sum of weekly ASMRs up to that point in the year.

For example:

$$cASMR\left(G,w,y\right)=\sum_{i=1}^{i=w}ASMR\left(G,w,y\right)$$

The following formula is used to calculate the rcASMRs:

$$rcASMR(G,w,y)\ =\frac{cASMR\left(G,w,y\right)\ -\ \overline{cASMR}\ \left(G,w,2015-19\right)}{\overline{cASMR}\ \left(G,w,2015-19\right)}$$

Where:

- cASMR(G,w,y) is cumulative standardised mortality rate in week w and year y, as defined in Age-standardised mortality rates section

  $\overline{cASMR}(G,w,2015-19)$
- is mean cumulative age-standardised mortality rate to week w, averaged over 2015-19

In order to include week 53 2020 in our calculations and extend the rcASMR beyond the end of the calendar year for 2020, we calculate a pseudo ASMR for week 53 for the years 2016, 2017, 2018 and 2019 to include in the 2015 to 2019 average. This is calculated as the mid-point between the ASMR for week 52 and week one of the following year.

Notes on methodology change

In the previous versions of this analysis, the rcASMR calculation expressed the difference between an observed rate and the expected rate (based on the average of 2015 to 2019) as a proportion of the five-year-average cASMR always for week 52, regardless of how many weeks are actually in the period of interest.

The previous formula was as follows:

$$rcASMR(G,w,y)=\frac{cASMR(G,w,y)\ -\ \overline{cASMR}(G,w,2015-19)}{\overline{cASMR}(G,52,2015-19)}$$

Where:

- cASMR(G,w,y) is cumulative standardised mortality rate in week w and year y, as defined in Age-standardised mortality rates section

$\overline{cASMR}(G, w, 2015-19)$
- is mean cumulative age-standardised mortality rate to week w, averaged over 2015 to 19

$\overline{cASMR}(G, 52, 2015-19)$
- is mean cumulative age-standardised mortality rate to week 52, averaged over 2015 to 19

Instead, this release expresses the difference in rates as a proportion of the average cASMR for the specific corresponding period of interest.

This has the advantage that the individual value for any given week gives a clearer indication of how proportionally above or below a given rate is compared with the expected rate (based on the five-year-average of a corresponding period). However, caution should be taken when comparing values between weeks, as a drop in rcASMR may not necessarily indicate a period of below-average mortality. When a new week is added, the averaging effect means that the new rcASMR value will be closer to the new added value than the previous week' s rcASMR. If a given week's value is smaller than the rcASMR for preceding weeks, the net effect will be for the rcASMR to drop slightly, even if the newest week had a positive (above-average) excess mortality rate.

Proportional-scores (P-scores)

Proportional-scores (P-scores) are weekly measures of excess mortality. In June 2020, the Our World in Data website published an article recommending the use of P-scores in evaluating excess mortality in the COVID-19 pandemic.

Excess deaths are defined as the number of deaths registered above the five-year average (2015 to 2019). To determine a P-score, the following formula is used:

$$\rho_t = \frac{D\left(G, i, y\right) - \bar{D}\left(G, i, 2015-19\right)}{\bar{D}\left(G, i, 2015-19\right)}$$

This formula is used where:

- is the P-score at time point t
- (G,i,y) is the number of deaths for group G in time interval i in the period of interest (y)

$\overline{D}\left(G, i, 2015-19\right)$
- is the mean number of deaths for group G in time interval i in years 2015 to 2019 inclusive

The formula for a P-score is similar to that for relative age-standardised mortality rate (rASMR), except that the P-score uses deaths rather than age-standardised mortality rates, so does not control for changes in the population. Furthermore, week 53 2020 is compared with the 2015 to 2019 average for week 52, not the mid-point between week 52 and week 1 of the following year, as used in the calculation of rASMRs and rcASMRs. This method is consistent with our other mortality publications, which compare the number of deaths registered weekly with a comparative average.

5 . Interpreting the data

As statistical measures, age-standardised mortality rates (ASMRs), relative ASMRs (rASMRs), and relative cumulative ASMRs (rcASMRs) all aim to reduce bias, allowing for comparisons to be made between populations in differing geographical areas of differing sizes and demographic structures. Each measure has revealed something different about the patterns of all-cause mortality from 2020 onwards. Presentation of age-standardised mortality rates shows us how these vary by seasons within countries and how they vary in size between countries.

It is important to keep in mind that countries and regions with smaller populations are subject to greater fluctuations and variations in relative measures of excess mortality. Small changes in the total number of deaths may be represented by large changes in relative excess mortality.

The measures we have reported on do not, however, offer conclusive explanations for the reasons behind the patterns observed. Nonetheless, our measures do offer insight into relative change in mortality levels.

We have chosen to report on age-standardised mortality rate-based measures in this report to account for differing age structures of the populations of the countries included in our analyses. In addition, we also provide reference tables for proportional scores (P-scores). We include data for Germany in the table for P-scores, but not in those for ASMRs, rASMRs and rcASMRs. Deaths data for Germany by five-year age group and by sex was not available on the Eurostat database at the time of our analyses, so it is not possible to calculate age-standardised mortality rates.

6 . Country comparability of the data

Because of the established system of reporting weekly mortality in the UK, we submitted weekly death counts to Eurostat based on date of death registration rather than actual date of death (date of occurrence). Death registration counts in any given week represent approximately 46% of deaths that occurred in that seven-day period. Our analysis, as explained in our Predicting total weekly death occurrences in England and Wales methodology, has shown that by three weeks after the week of occurrence, approximately 92% of occurrences will be registered. The remaining 8% may be delayed, with around 2% being delayed by one year or more because of the length of time before a coroner's hearing and subsequent report is finalised and the cause of death is registered.

Therefore, for us to produce relatively comprehensive counts of weekly deaths by date of occurrence on behalf of the UK, there would need to be at least a three-week delay in the reporting of total deaths. This is because of the delay between death occurrence and death registration. Please see our recent Counting deaths involving the coronavirus (COVID-19) blog and our Impact of registration delays on mortality statistics in England and Wales article about registration delays.

The following countries report to Eurostat by date of death occurrence:

- Austria
- Belgium
- Bulgaria
- Czechia
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Italy
- Latvia
- Lithuania
- Luxembourg
- Netherlands
- Poland
- Portugal
- Romania
- Slovenia
- Slovakia
- Spain
- Sweden
- Switzerland

Data referring to recent weeks may be under-reporting the actual number of deaths and they are likely to be revised. The UK reports deaths by date of registration.

We refer to weeks starting on a Saturday and ending on a Friday, as is standard for the weekly reporting of deaths for England, Wales, and Northern Ireland. Scotland, and the rest of Europe report weeks starting on Monday and ending on Sunday; therefore, these dates are a guide rather than exact for all countries. This means that any comparison of weekly deaths between England, Wales and Northern Ireland and its hierarchy of nomenclature of territorial units for statistics (NUTS) units, with Scotland and other European countries, is subject to caveats in relation to the temporal comparability for any given week. Patterns of deaths by date of registration broadly follow those of deaths by date of occurrence but are affected by public holidays when registry offices are closed.

Eurostat also assigns deaths with an unknown age to "UNK"; we exclude these deaths as we cannot know which five-year age group to assign them to when calculating an age-standardised mortality rate. This affects a range of countries, in particular, deaths reported from France from reporting year 2019 onwards. From week 1 2015 to week 26 2022, 15,723 deaths were reported as age unknown for France. The country next most affected was Spain, with 4,191 deaths of unknown age from week 1 2015 to week 26 2022. Additional countries also had deaths assigned with an unknown age, but records were much lower; data can be found on the Eurostat website.

In addition, where the NUTS3 (local authority equivalent) geography of a death is unknown, but the NUTS0 (country level) is known, we include the death in the country total but not in any further geographical breakdowns.

7 . Related links

Comparisons of all-cause mortality between European countries and regions: 28 December 2019 to week ending 1 July 2022
Article | 20 December 2022
Comparisons of all-cause excess mortality on a weekly basis since the start of the coronavirus pandemic. Measures include relative age-standardised mortality rates and relative cumulative age-standardised mortality rates.

Comparisons of all-cause mortality between European countries and regions
Dataset | 20 December 2022
All-cause mortality rates of selected European countries and regions. Breakdowns include sex and broad age group for selected countries and cities.

8 . Cite this methodology

Office for National Statistics (ONS), published 20 December 2022, ONS website, methodology, Comparing all-cause mortality between European countries and regions methodology