Statistics and Research

Excess mortality during the Coronavirus pandemic (COVID-19)

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 Cite this research

Excess mortality during COVID-19

IN THIS SECTION

What is ‘excess mortality’?

Excess mortality is a term used in epidemiology and public health that refers to the number of deaths *from all causes* during a crisis above and beyond what we would have expected to see under ‘normal’ conditions.[1] In this case, we’re interested in how the number of deaths during the COVID-19 pandemic compares to the deaths we would have expected had the pandemic not occurred — a crucial quantity that cannot be known but can be estimated in several ways.

Excess mortality is a more comprehensive measure of the *total* impact of the pandemic on deaths than the confirmed COVID-19 death count alone. It captures not only the confirmed deaths, but also COVID-19 deaths that were not correctly diagnosed and reported[2] as well as deaths from other causes that are attributable to the overall crisis conditions.[3]

We further discuss the relationship between confirmed COVID-19 deaths and excess mortality in the section 'Excess mortality during COVID-19: background.'

How is excess mortality measured?

Excess mortality is measured as the difference between the reported number of deaths in a given week or month (depending on the country) in 2020–2021 and an estimate of the expected number of deaths for that period had the COVID-19 pandemic not occurred.

$$Excess\ Deaths = Reported\ Deaths - Expected\ Deaths$$

The baseline of expected deaths can be estimated in several different ways.

As of 20 September 2021, we use an estimate produced by Ariel Karlinsky and Dmitry Kobak as part of their World Mortality Dataset (WMD). To produce this estimate, they first fit a regression model for each region using historical deaths data from 2015–2019;[4] they then use the model to project the number of deaths we might normally have expected in 2020.[5] Their model can capture both seasonal variation and year-to-year trends in mortality.

For more details on this method, see the article Karlinsky and Kobak (2021) Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset.[6]

Before 20 September 2021, we used a different expected deaths baseline: the average number of deaths over the years 2015–2019.[7] We made this change because using the five-year average has an important limitation — it does not account for year-to-year trends in mortality and thus can misestimate excess mortality.[8] The WMD projection, on the other hand, does not suffer from this limitation because it accounts for these year-to-year trends. Our charts using the five-year average are still accessible in links in the sections below.

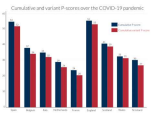
For reported deaths, we source our data from both WMD and the Human Mortality Database.

The P-score: a measure of excess mortality that is more comparable across countries

The raw number of excess deaths gives us a sense of scale, but it is less comparable across countries due to large differences in population. To better enable comparisons across countries, we measure excess mortality as the *percentage difference* between the reported and projected number of deaths. This metric is called the P-score and we calculate it as:[9]

$$P\text{-}score = \frac{Reported\ Deaths - Projected\ Deaths}{Projected\ Deaths} * 100$$

For example, if a country had a P-score of 100% in a given week in 2020, that would mean the death count for that week was 100% higher than — that is, double — the projected death count for that week.



Learn more about measures of excess mortality in our work with John Muellbauer and Janine Aron.
A pandemic primer on excess mortality statistics and their comparability across countries →

Excess mortality P-scores

The chart here shows excess mortality during the pandemic for all ages using the P-score. To see the P-scores for other countries click **Add country** on the chart.

Important points about excess mortality figures to keep in mind

The reported number of deaths might not count all deaths that occurred. This is the case for two reasons:

- First, not all countries have the infrastructure and capacity to register and report all deaths. In richer countries with high-quality mortality reporting systems, nearly 100% of deaths are registered. But in many low- and middle-income countries, undercounting of mortality is a serious issue. The UN estimates that, in "normal" times, only two-thirds of countries register at least 90% of all deaths that occur, and some countries register less than 50% — or even under 10% — of deaths. During the pandemic the actual coverage might be even lower.[10]
- Second, there are delays in death reporting that make mortality data provisional and incomplete in the weeks, months, and even years after a death occurs — even in richer countries with high-quality mortality reporting systems.[11] The extent of the delay varies by country. For some, the most recent data points are clearly very incomplete and therefore inaccurate — we *do not show* these clearly incomplete data points.[12]

The date associated with a death might refer to when the death *occurred* or to when it was *registered.* This varies by country. Death counts by date of registration can vary significantly irrespectively of any actual variation in deaths, such as from registration delays or the closure of registration offices on weekends and holidays. It can also happen that deaths are registered, but the date of death is unknown — this is the case for Sweden.[13]

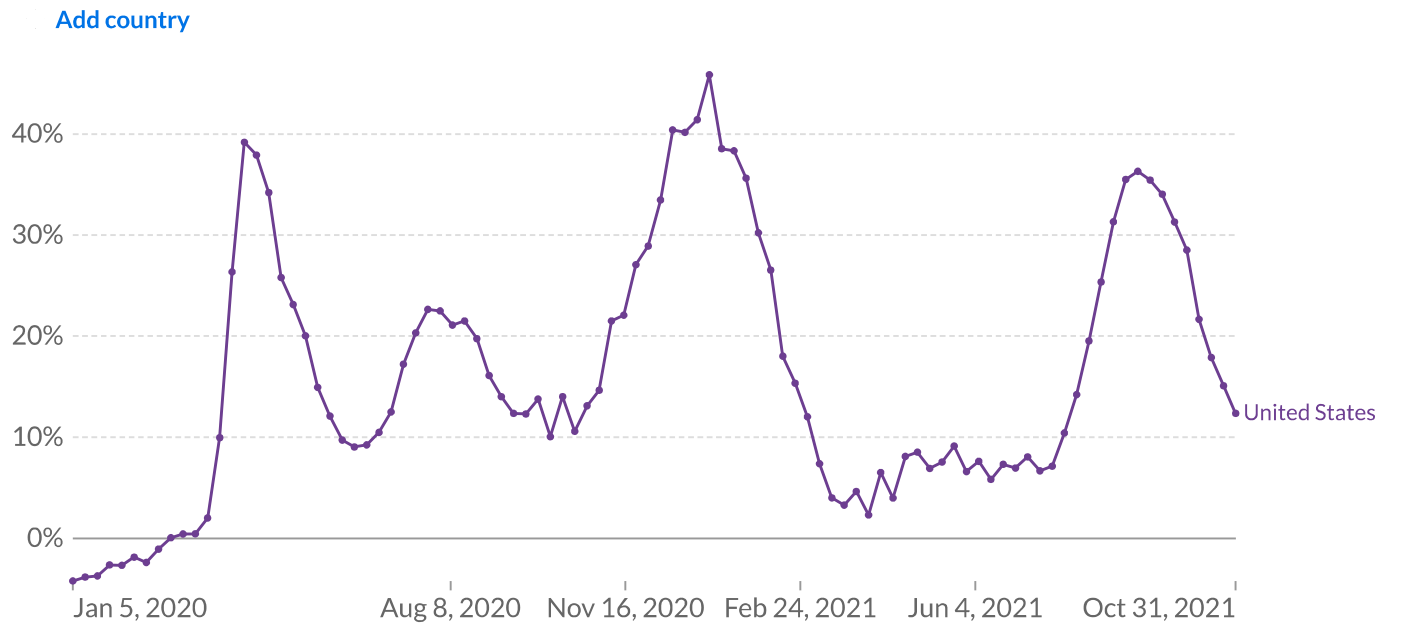
The dates of any particular reporting week might differ slightly between countries. This is because countries that report weekly data define the start and end days of the week differently. Most follow international standard ISO 8601, which defines the week as from Monday to Sunday, but not all countries follow this standard.[14] In the charts on this page we use the ISO 8601 week end dates from 2020–2021.[15]

Deaths reported weekly might not be directly comparable to deaths reported monthly. For instance, because excess mortality calculated from monthly data tends to be lower than the excess calculated from weekly data.[16]

For more discussion and detail on these points, see our article with John Muellbauer and Janine Aron as well as the metadata from the Human Mortality Database and World Mortality Dataset.

Excess mortality: Deaths from all causes compared to projection based on previous years

The percentage difference between the reported number of weekly or monthly deaths in 2020–2021 and the projected number of deaths for the same period based on previous years. The reported number might not count all deaths that occurred due to incomplete coverage and delays in reporting.



Source: Human Mortality Database (2021), World Mortality Dataset (2021) OurWorldInData.org/coronavirus • CC I
Note: Comparisons across countries are affected by differences in the completeness of death reporting. Details can be found at our Excess Mortality page.

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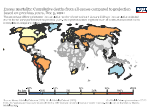


Cumulative P-scores using projected baseline →

P-scores using five-year average baseline →

Excess mortality P-scores by age group

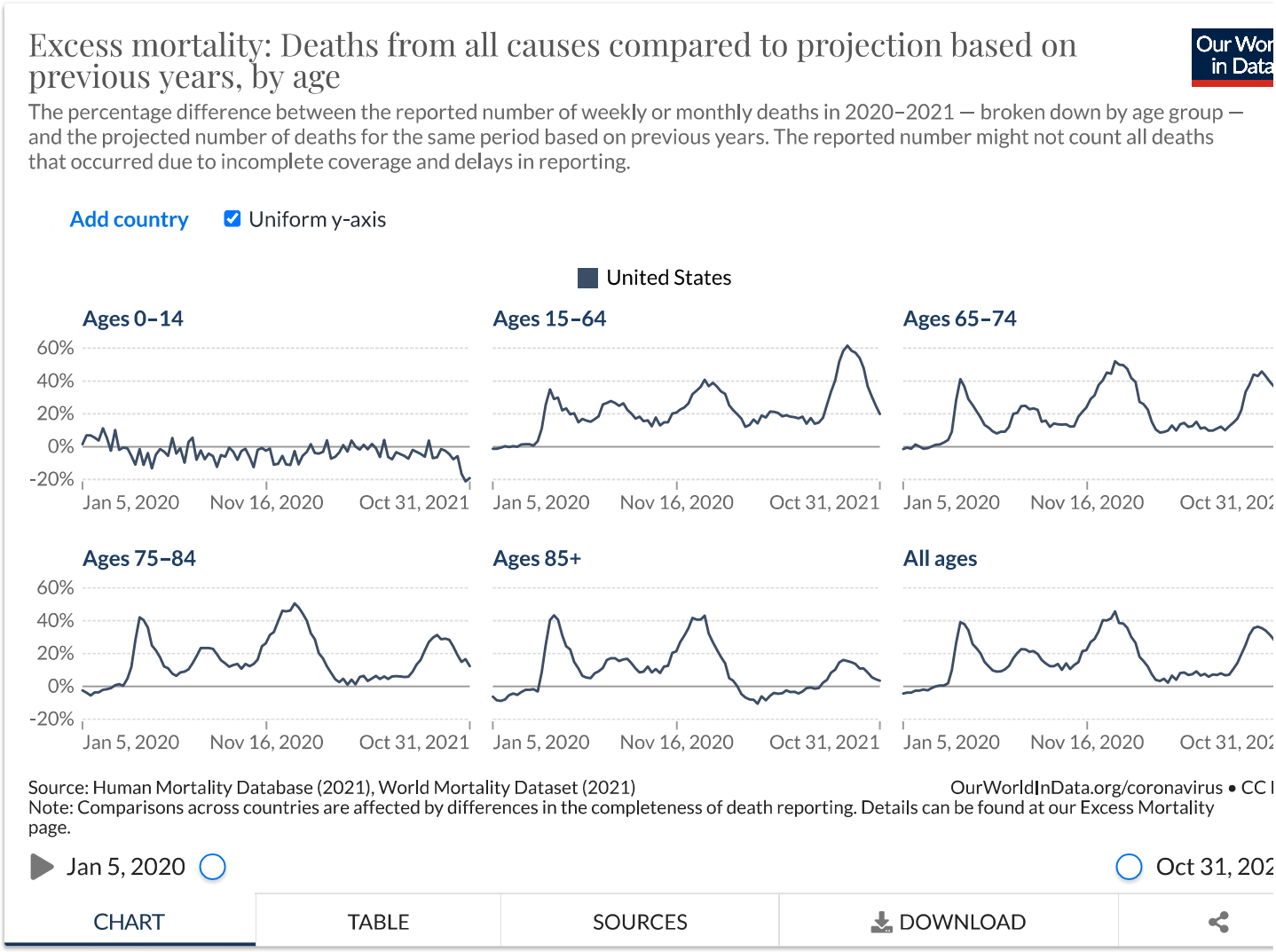
The chart here shows P-scores broken down by age groups: ages 0–14, 15–64, 65–74, 75–84, and 85+. The mortality risk from COVID-19 increases with age.[17]

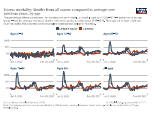
Countries for which the reported deaths data is sourced from the World Mortality Dataset are not included in this chart because the data is not broken down by age. Though WMD does provide the projected baselines used for

calculating P-scores by age in this chart.[18]

Why is it informative to look at P-scores for different age groups?

The chart in the previous section showed P-scores for *all ages* — these are impacted by differences in both mortality risk by age and countries' age distributions. For example, countries with older populations — which have a higher mortality risk, including from COVID-19 — will tend to have higher all-age P-scores by default. Looking at the P-scores for *different age groups* is therefore informative when comparing countries.



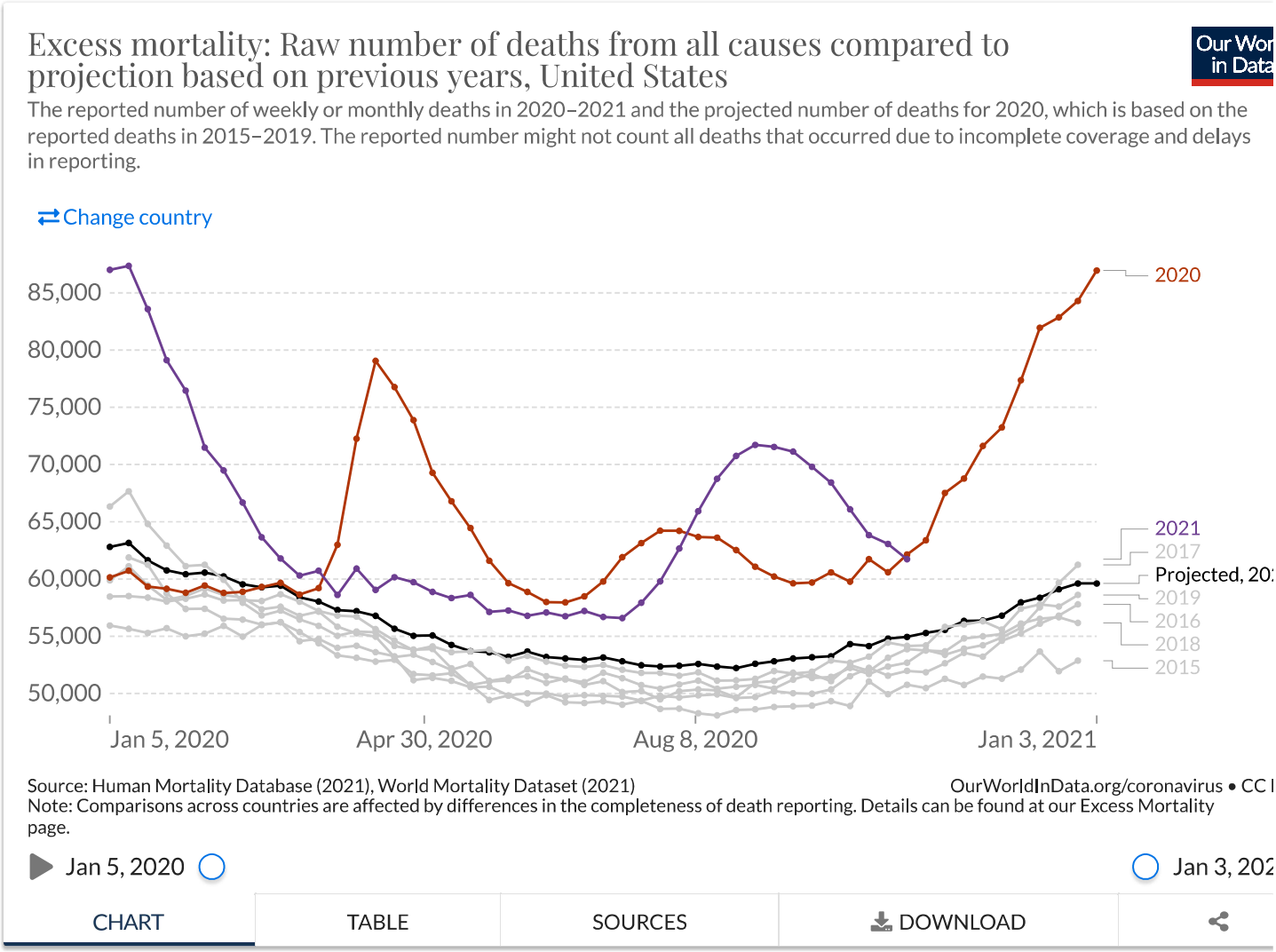


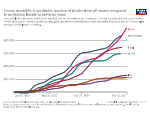
P-scores by age group using five-year average baseline →

Excess mortality using raw death counts

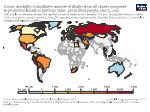
Besides visualizing excess mortality as a percentage difference as we have with the P-scores, we can also look at the raw death count as shown in the chart here. The raw death count gives us a sense of scale: for example, the US suffered roughly 470,000 excess deaths in 2020, compared to 352,000 confirmed COVID-19 deaths during that year.

However, this measure is less comparable across countries due to large differences in populations. You can still see the death counts for other countries by clicking "Change country" on the chart.





Cumulative excess deaths during COVID-19 →



Cumulative excess deaths during COVID-19 per million people →

Estimated excess mortality from *The Economist*

Many countries have not reported any data on all-cause mortality during the pandemic. If we want to understand the total impact of the pandemic on deaths in those countries, as well as globally, we must find a way to estimate this death toll.

The Economist built a machine-learning model to estimate the number of excess deaths during the pandemic for 223 countries & regions.[19] From these country-level estimates they calculate a global figure.

Globally, the model estimates that the total number of excess deaths is **two to four times higher** than the reported number of confirmed deaths due to COVID-19. You can explore the data for any country or region by clicking "Change country" on the chart.

How should we think about these estimates?

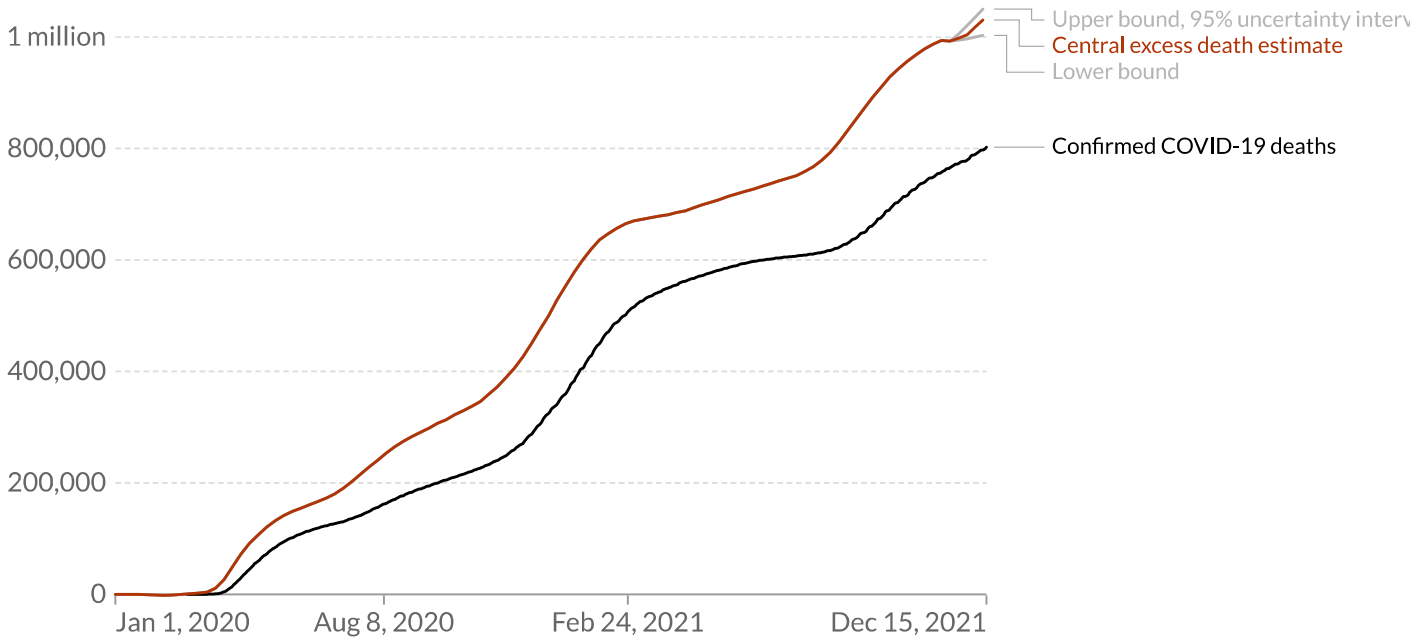
This work by *The Economist* is currently the most comprehensive and rigorous attempt to understand how mortality has changed during the pandemic at the global level. But these estimates come with a great deal of uncertainty given the large amount of data that is missing *and* the known shortcomings even for data that is available.

We can think of them as our best, educated — but still ballpark — estimates. Some of the specific figures are highly uncertain, as the large uncertainty intervals show. But the overall conclusion remains clear: in many countries and globally, the number of confirmed deaths from COVID-19 is far below the pandemic's full death toll.

Estimated cumulative excess deaths during COVID-19, United States

For countries that have not reported all-cause mortality data for a given week, an estimate is shown, with uncertainty interval. If reported data is available, that value only is shown. For comparison, cumulative confirmed COVID-19 deaths are shown.

Change country



Source: The Economist (2021), Johns Hopkins University (2021)

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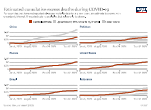
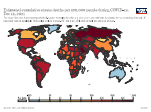


Estimated cumulative excess deaths during COVID-19: multiple-country view →



Estimated cumulative excess deaths during COVID-19 per 100k people →

Excess mortality: our data sources

Our World in Data relies on data from the Human Mortality Database, the World Mortality Dataset, and *The Economist*

In our presentation of excess mortality figures we rely on the reported all-cause mortality data from the Human Mortality Database (HMD) and the World Mortality Dataset (WMD). We also present model estimates of excess deaths published by *The Economist*. We make all of the data used in our charts downloadable as complete and structured .csv files here on our GitHub site.

We have calculated P-scores from the reported death data provided by HMD and WMD, and from the projections provided by WMD.

Human Mortality Database

The Human Mortality Database is maintained by a team of researchers based at the University of California, Berkeley, USA and the Max Planck Institute for Demographic Research in Rostock, Germany. HMD has been publishing updates on all-cause mortality for currently 38 countries as part of its Short-term Mortality Fluctuations (STMF) project since May 2020.[20]

HMD updates its data weekly. The data is sourced from Eurostat and national statistical agencies — a full list of sources and detailed information for each country's data series can be found in the HMD metadata file. HMD was our sole source of data until 20 February 2021.

You can read more about HMD's STMF project in the article by Németh, Jdanov, and Shkolnikov (2021) An open-sourced, web-based application to analyze weekly excess mortality based on the Short-term Mortality Fluctuations data series.[21]

World Mortality Dataset

The World Mortality Dataset is maintained by the researchers Ariel Karlinsky and Dmitry Kobak. WMD has been publishing updates on all-cause mortality for currently 112 countries and regions since January 2021. We do not use the data from some of these countries because they fail to meet the following quality criteria: 1) at least three years of historical data;[22] and 2) data published either weekly or monthly.[23] The data is not broken down by age so we only include it in our all-age charts.[24]

As of 20 September 2021, we use WMD's projected deaths for 2020 as our baseline for the expected deaths had the COVID-19 pandemic not occurred. We use this baseline for all countries and regions, including for deaths broken down by age group.

WMD updates its data weekly. The data is sourced from the Human Mortality Database — we use the reported deaths data directly from HMD and not WMD — Eurostat, and national statistical agencies. A full list of sources and information for each country's data series can be found on WMD's GitHub site.

You can read more about WMD in the article by Karlinsky and Kobak (2021) Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset.[25]

The Economist

The Economist built a machine-learning model to estimate the number of excess deaths during the pandemic for 223 countries & regions. From these country-level estimates they calculate a global figure.

The Economist presents the model estimates and details their sources in the article "The pandemic's true death toll." They describe their model methodology in the article "How we estimated the true death toll of the pandemic."

Source information country by country

Location	Source
Albania	World Mortality Dataset
Andorra	World Mortality Dataset
Antigua and Barbuda	World Mortality Dataset
Argentina	World Mortality Dataset
Armenia	World Mortality Dataset
Aruba	World Mortality Dataset
Australia	Human Mortality Database
Austria	Human Mortality Database
Azerbaijan	World Mortality Dataset
Belarus	World Mortality Dataset
Belgium	Human Mortality Database
Belize	World Mortality Dataset
Bermuda	World Mortality Dataset
Bolivia	World Mortality Dataset
Bosnia and Herzegovina	World Mortality Dataset
Brazil	World Mortality Dataset
Brunei	World Mortality Dataset
Bulgaria	Human Mortality Database
Canada	Human Mortality Database
Chile	Human Mortality Database
Colombia	World Mortality Dataset
Costa Rica	World Mortality Dataset
Croatia	Human Mortality Database
Cuba	World Mortality Dataset
Cyprus	World Mortality Dataset
Czechia	Human Mortality Database
Denmark	Human Mortality Database
Dominican Republic	World Mortality Dataset
Ecuador	World Mortality Dataset
Egypt	World Mortality Dataset

El Salvador	World Mortality Dataset
England & Wales	Human Mortality Database
Estonia	Human Mortality Database
Faeroe Islands	World Mortality Dataset
Finland	Human Mortality Database
France	Human Mortality Database
French Guiana	World Mortality Dataset
French Polynesia	World Mortality Dataset
Georgia	World Mortality Dataset
Germany	Human Mortality Database
Gibraltar	World Mortality Dataset
Greece	Human Mortality Database
Greenland	World Mortality Dataset
Guadeloupe	World Mortality Dataset
Guatemala	World Mortality Dataset
Hong Kong	World Mortality Dataset
Hungary	Human Mortality Database
Iceland	Human Mortality Database
Iran	World Mortality Dataset
Ireland	World Mortality Dataset
Israel	Human Mortality Database
Italy	Human Mortality Database
Jamaica	World Mortality Dataset
Japan	World Mortality Dataset
Kazakhstan	World Mortality Dataset
Kosovo	World Mortality Dataset
Kuwait	World Mortality Dataset
Kyrgyzstan	World Mortality Dataset
Latvia	Human Mortality Database
Lebanon	World Mortality Dataset
Liechtenstein	World Mortality Dataset
Lithuania	Human Mortality Database
Luxembourg	Human Mortality Database
Macao	World Mortality Dataset

Malaysia	World Mortality Dataset
Malta	World Mortality Dataset
Martinique	World Mortality Dataset
Mauritius	World Mortality Dataset
Mayotte	World Mortality Dataset
Mexico	World Mortality Dataset
Moldova	World Mortality Dataset
Monaco	World Mortality Dataset
Mongolia	World Mortality Dataset
Montenegro	World Mortality Dataset
Netherlands	Human Mortality Database
New Caledonia	World Mortality Dataset
New Zealand	Human Mortality Database
Nicaragua	World Mortality Dataset
North Macedonia	World Mortality Dataset
Northern Ireland	Human Mortality Database
Norway	Human Mortality Database
Oman	World Mortality Dataset
Panama	World Mortality Dataset
Paraguay	World Mortality Dataset
Peru	World Mortality Dataset
Philippines	World Mortality Dataset
Poland	Human Mortality Database
Portugal	Human Mortality Database
Puerto Rico	World Mortality Dataset
Qatar	World Mortality Dataset
Reunion	World Mortality Dataset
Romania	World Mortality Dataset
Russia	World Mortality Dataset
San Marino	World Mortality Dataset
Scotland	Human Mortality Database
Serbia	World Mortality Dataset
Seychelles	World Mortality Dataset
Singapore	World Mortality Dataset

Slovakia	Human Mortality Database
Slovenia	Human Mortality Database
South Africa	World Mortality Dataset
South Korea	Human Mortality Database
Spain	Human Mortality Database
Sweden[26]	World Mortality Dataset
Switzerland	Human Mortality Database
Taiwan	World Mortality Dataset
Thailand	World Mortality Dataset
Transnistria	World Mortality Dataset
Tunisia	World Mortality Dataset
Ukraine	World Mortality Dataset
United Kingdom	Human Mortality Database
United States	Human Mortality Database
Uruguay	World Mortality Dataset
Uzbekistan	World Mortality Dataset

Other publicly available data on excess mortality

International organizations are not publishing an international database on excess mortality

Unlike statistics on confirmed COVID-19 deaths — for which several organizations such as the WHO, ECDC, and Johns Hopkins University are collating data for all countries — there is no single source of data on excess mortality. And no data source will have data for all countries, because excess mortality statistics will only be available for a minority of countries.

This is a major problem for policymakers, researchers, and the general public that have a need to understand the ongoing pandemic.

Several media publications and regional data sources are publishing public databases

In addition to the Human Mortality Database and the World Mortality Dataset, several media publications and regional data sources have been publishing excess death data for some countries.

- *The Economist* published the first database on excess mortality on GitHub. Its reporting on the topic can be found here. We show their global estimates of excess mortality in the section here.
- *The New York Times* publishes its dataset on excess mortality on GitHub. Its reporting on the topic can be found here.

- *The Financial Times* publishes its dataset on excess mortality on GitHub. Its reporting on the topic can be found here.
- *The Washington Post* publishes its dataset on excess mortality in the US on GitHub. The GitHub page also contains links to the Post's reporting on the topic.
- *Eurostat* publishes downloadable data for European countries on its website.

Excess mortality during COVID-19: background

What is the relationship between confirmed COVID-19 deaths and excess mortality?

In our work on the Coronavirus pandemic we visualize the data on the confirmed number of deaths from COVID-19 for all countries. We update this data daily based on figures published by Johns Hopkins University (JHU).

But these confirmed deaths figures may differ from the excess mortality figures, which better capture the *total* impact of the pandemic on deaths, for several reasons:

- Some (but not all) countries only report COVID-19 deaths that occur in hospitals — people that die from the disease at home may not be recorded;
- Some countries only report deaths for which a COVID-19 test has confirmed that a patient was infected with the virus — untested individuals may not be included;
- Death reporting systems may be insufficient to accurately measure mortality — this is particularly true in poorer countries;
- The pandemic may result in increased deaths from other causes for a number of reasons including weakened healthcare systems; fewer people seeking treatment for other health risks; or less available funding and treatment for other diseases (e.g. HIV/AIDS, malaria, tuberculosis);
- The pandemic may also result in *fewer* deaths from other causes. For example, the mobility restrictions during the pandemic might lead to fewer deaths from road accidents. Or there might be fewer deaths from the flu because of interventions to stop the spread of COVID-19, or because COVID-19 now causes deaths that would have otherwise been caused by the flu.

Because COVID-19 "competes" with other causes of death like the flu, this means that COVID-19 deaths are not by default excess deaths. It is possible for there to be more confirmed COVID-19 deaths than excess deaths, and in fact for there to be confirmed COVID-19 deaths without *any* excess deaths.

This all makes clear that the two statistics — confirmed deaths due to COVID-19 and excess mortality — can be related in ways that are not straightforward. This is because they are giving a perspective on different questions:

- The confirmed deaths often undercount the total impact of the pandemic on deaths, but in contrast to excess mortality they contain information about the *cause of death*.
- The excess mortality includes not only those who have died from COVID-19, but also those from all other causes — and these numbers may also be changing due to the overall pandemic conditions.

This means both metrics are needed to understand the total impact of the pandemic on deaths.

Excess mortality statistics will only be available for a minority of countries

Excess mortality data is unfortunately not available for many countries, and because the required data from previous years is lacking this will continue to be the case. When the goal is to monitor a global pandemic, this is a major limitation of this metric.

Excess mortality can only be calculated on the basis of accurate, high-frequency data on mortality from previous years. But few countries have statistical agencies with the capacity and infrastructure to report the number of people that died in a given month, week or even day-to-day. For most low- and middle-income countries, such data is not available for previous years.

As we saw from the available excess mortality estimates discussed previously, this data is most often only available for richer countries that can afford high-quality data reporting systems.

Researchers can draw on some other sources to estimate excess mortality — such as funeral or burial records — or on data from subnational regions of poorer countries (often the capital). But in many cases no information at all can be obtained.

Endnotes

1. Checchi, F., & Roberts, L. (2005). Interpreting and using mortality data in humanitarian emergencies. *Humanitarian Practice Network*, *52*.
2. For example, because no COVID-19 test was conducted or a country's death reporting system failed to register the death as from COVID.
3. Conditions such as health systems being overwhelmed, resources being diverted away from other health problems, or fewer people seeking treatment for other health risks.
4. Or as many years from this period as are available.
5. They do not produce a separate estimate for 2021 to avoid further projection.
6. Karlinsky, A. and Kobak, D. (2021). Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. *eLife*, DOI: 10.7554/eLife.69336.
7. Except for a few countries for which we only have data from the years 2016 or 2017 to 2019; for details see this spreadsheet and the Human Mortality Database metadata.
8. For instance, for countries that have an increasing trend in mortality like the US and South Korea, the five-year average will *over*estimate excess deaths; while for countries that have a decreasing trend in mortality like Russia, it will *under*estimate excess deaths.
9. We calculate P-scores using the reported deaths data for 2020–2021 from HMD and WMD — see here for country by country source information — and the projected deaths for 2020 from WMD (which we use for all countries and regions, including for deaths broken down by age group).

10. See this spreadsheet for the UN-estimated death registration coverage of the countries in our dataset. Despite the estimates, the actual coverage might be lower due to the burden of the pandemic. For analysis of this under-reporting see the recent paper by Whittaker et al (2021) Under-reporting of deaths limits our understanding of true burden of covid-19.

    Also note that while Australia usually registers nearly 100% of deaths, the data series we have here is for *doctor-certified deaths only*, which account for ~85–90% of all deaths. For more details see this page of the Australian Bureau of Statistics.

11. For instance, a 2016 CDC study of the delay in the US found that after four weeks, only 54% of deaths had been registered; by eight weeks the figure was 75%, and it didn't reach 100% until almost a year after the date of death. Though the CDC does note that "Data timeliness has improved in recent years, and current timeliness is likely higher than published rates." In fact the CDC currently estimates that "63% of all U.S. deaths are reported within 10 days of the date of death, but there is significant variation between states."

12. Clearly incomplete data is marked by a large, abrupt drop in the death count — often well below the five-year average — and a pattern of substantial upward revision to the count from recent periods. For a detailed list of the data we exclude for each country see this spreadsheet.

13. In 2020, for instance, there were an estimated ~2500 such deaths; see here for details.

    Before 27 September 2021, we did not include these deaths in Sweden's data series because our source at the time, the Human Mortality Database, did not include them.

    As of 27 September 2021, however, we *do* include these deaths with unknown date — we switched sources for Sweden to the World Mortality Dataset (WMD), which does include these deaths. See here for how WMD does this: https://github.com/akarlinsky/world_mortality#sweden-weekly.

14. For instance, England & Wales define the week as from Saturday to Friday.

15. This enables easy comparisons of weekly deaths across the years in the chart, but it means we show a date that is slightly incorrect (plus or minus a few days) for the other years. This is because the same numbered week falls on slightly different dates in different years; for example, Week 1 2020 ended on 5 January 2020, while Week 1 2021 ended on 10 January 2021. For more details see this resource with ISO 8601 week dates across the years.

16. The reason for this is that the monthly data smooth the weekly fluctuations, resulting in lower estimates. Source: D. Jdanov, Human Mortality Database, personal communication, 11 February 2021.

17. For example, compared to the death rate from COVID-19 for ages 5–17, the death rate for ages 65–74 is 1100 times higher, for ages 75–84 it is 2800 times higher, and for ages 85+ it is *7900 times higher*. These estimates are based on US data from the CDC: COVID-19 Hospitalization and Death by Age.

18. These baselines are produced according to the same method described in Karlinsky and Kobak 2021.

19. To read *The Economist's* article presenting the model estimates, see: https://www.economist.com/graphic-detail/coronavirus-excess-deaths-estimates

    To read about the model methodology, see: https://www.economist.com/graphic-detail/2021/05/13/how-we-estimated-the-true-death-toll-of-the-pandemic

20. HMD only includes countries with the highest quality and most comprehensive mortality statistics, with breakdowns by age and sex and many years of historical data. Because of this, only select countries with very robust and capable statistical agencies are included.

21. Németh L., Jdanov D.A., Shkolnikov V.M. (2021) An open-sourced, web-based application to analyze weekly excess mortality based on the Short-term Mortality Fluctuations data series. PLoS ONE 16(2): e0246663. https://doi.org/10.1371/journal.pone.0246663

22. This criterion was changed from four years to three years of historical data on 30 May 2021.

23. The full list of excluded countries and reasons for exclusion can be found in this spreadsheet. It is possible we will amend this list on the basis of new information.

24. Though WMD does provide the projected baselines used for calculating P-scores in the by-age chart.

25. Karlinsky, A. and Kobak, D. (2021). Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. *eLife*, DOI: 10.7554/eLife.69336.

26. 27 September 2021: Switched source from Human Mortality Database to World Mortality Dataset to account for deaths with unknown date.

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Citation

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    title = {Coronavirus Pandemic (COVID-19)},
    journal = {Our World in Data},
    year = {2020},
    note = {https://ourworldindata.org/coronavirus}
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