Excess Deaths Associated with COVID-19

Estimates of excess deaths can provide information about the burden of mortality potentially related to COVID-19, beyond the number of deaths that are directly attributed to COVID-19. Excess deaths are typically defined as the difference between observed numbers of deaths and expected numbers. This visualization provides weekly data on excess deaths by jurisdiction of occurrence. Counts of deaths in more recent weeks are compared with historical trends to determine whether the number of deaths is significantly higher than expected.

Estimates of excess deaths can be calculated in a variety of ways, and will vary depending on the methodology and assumptions about how many deaths are expected to occur. Estimates of excess deaths presented in this webpage were calculated using Farrington surveillance algorithms (1). For each jurisdiction, a model is used to generate a set of expected counts, and the upper bound of the 95% Confidence Intervals (95% CI) of these expected counts is used as a threshold to estimate excess deaths. Observed counts are compared to these upper bound estimates to determine whether a significant increase in deaths has occurred. Provisional counts are weighted to account for potential underreporting in the most recent weeks. However, data for the most recent week(s) are still likely to be incomplete. Only about 60% of deaths are reported within 10 days of the date of death, and there is considerable variation by jurisdiction. More detail about the methods, weighting, data, and limitations can be found in the Technical Notes.

This visualization includes several different estimates:

- **Number of excess deaths:** The number of excess deaths was calculated as the difference between the observed count and the threshold, by week and jurisdiction. Negative values, where the observed count fell below the threshold, were set to zero.
- **Percent excess:** The percent excess was defined as the number of excess deaths divided by the threshold.
- **Total number of excess deaths:** The total number of excess deaths in each jurisdiction was calculated by summing the excess deaths in each week, from January 1, 2020 to present. Similarly, the total number of excess deaths for the US overall was computed as a sum of jurisdiction-specific numbers of excess deaths (with negative values set to zero), and not directly estimated using the Farrington surveillance algorithms.

Weekly counts of deaths from all causes were examined, including deaths due to COVID-19. As many deaths due to COVID-19 may be assigned to other causes of deaths (for example, if COVID-19 was not mentioned on the death certificate as a suspected cause of death), tracking all-cause mortality can provide information about whether an excess number of deaths is observed, even when COVID-19 mortality may be undercounted. Additionally, deaths from all causes *excluding COVID-19* were also estimated. Comparing these two sets of estimates — excess deaths with and without COVID-19 — can provide insight about how many excess deaths are identified as due to COVID-19, and how many excess deaths are reported as due to other causes of death. These deaths could represent misclassified COVID-19 deaths, or potentially could be indirectly related to COVID-19 (e.g., deaths from other causes occurring in the context of health care shortages or overburdened health care systems).

Estimates presented here will be updated periodically, and additional information by cause of death will be added in future releases.

Select a dashboard from the drop-down menu, then click on “Update Dashboard” to navigate through different graphics.

- The first dashboard shows the weekly predicted counts of deaths from all causes, and the threshold for the expected number of deaths. Select a jurisdiction from the drop-down menu to show data for that jurisdiction.
- The second dashboard shows the weekly predicted counts of deaths from *all causes* and the weekly count of deaths from *all causes excluding COVID-19*. Select a jurisdiction from the drop-down menu to show data for that jurisdiction.

- The third dashboard shows the weekly counts of deaths from all causes. Predicted counts (weighted) are shown, along with reported (unweighted) counts, to illustrate the impact of underreporting. Select a jurisdiction from the drop-down menu to show data for that jurisdiction.
- The fourth dashboard shows the total number of excess deaths in 2020. Jurisdictions with one or more excess deaths are shown. Use the radio button to select all-cause mortality, or all-cause excluding COVID-19. Use the drop-down menu to select certain jurisdictions.
- The fifth dashboard shows the percent by which the observed counts exceed the threshold (i.e. percent excess) by week and jurisdiction. Use the radio button to select all-cause mortality, or all-cause excluding COVID-19. Use the drop-down menu to select certain jurisdictions.

Download datasets in CSV format by clicking on the link for the desired dataset under “CSV Format” link. Additional file formats are available for download for each dataset at Data.CDC.Gov.

Options

Select a dashboard:

Weekly Excess Deaths

Update Dashboard

CSV Format:

- National and State Estimates

Data.CDC.gov[?]:

- National and State Estimates

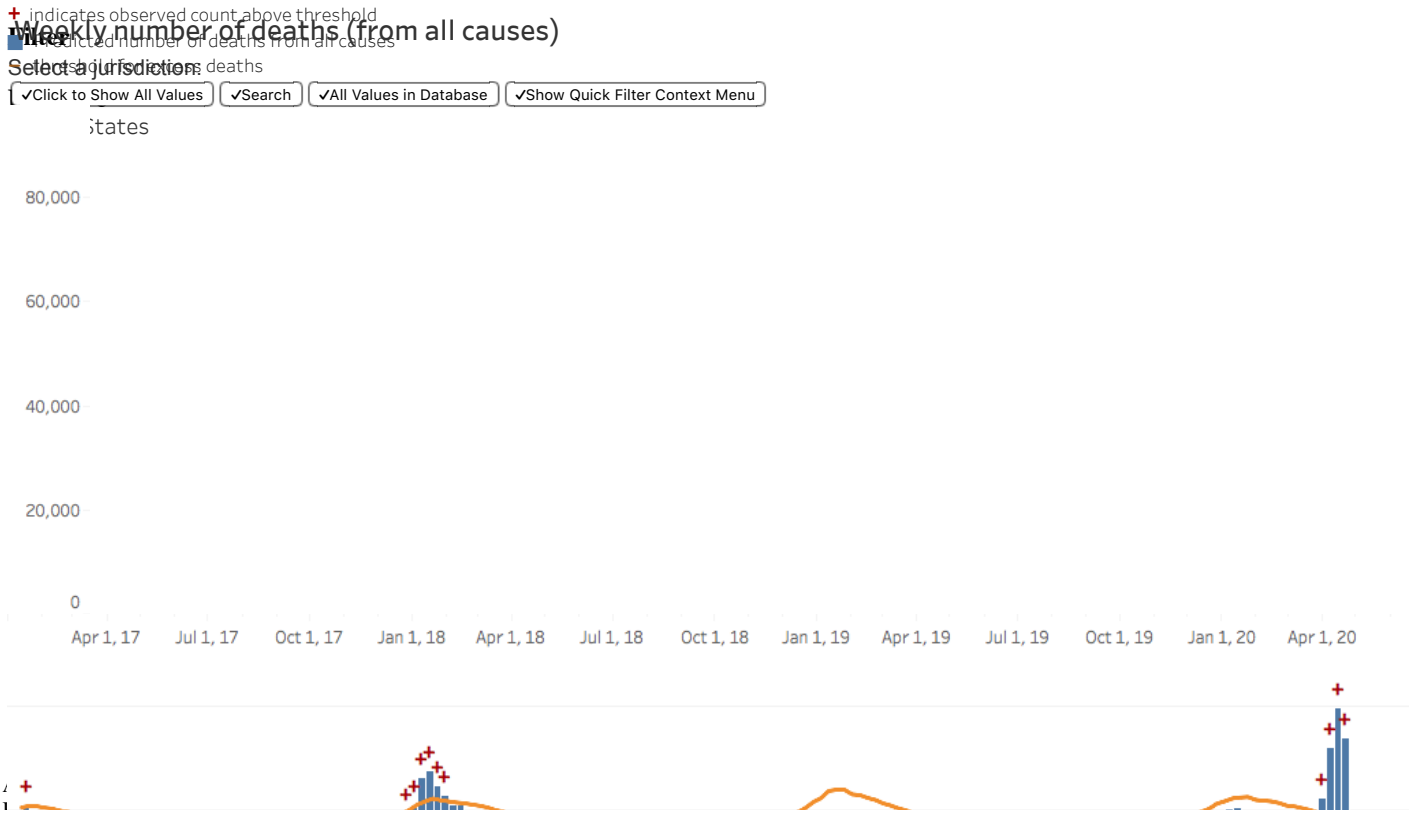

FIGURE NOTES:

Number of deaths reported on this page are the total number of deaths received and coded as of the date of analysis and do not represent all deaths that occurred in that period. Data are incomplete because of the lag in time between when the death occurred and when the death certificate is completed, submitted to NCHS and processed for reporting purposes. This delay can range from 1 week to 8 weeks or more, depending on the jurisdiction and cause of death. See https://www.cdc.gov/nchs/nvss/vsrr/COVID19/index.htm for more information. Data for New York excludes New York City. Data on all deaths excluding COVID-19 exclude deaths with an underlying cause of U07.1. Deaths with a multiple or contributing cause of U07.1 are included; therefore counts may not match the numbers of COVID-19 deaths reported elsewhere that include deaths with a multiple cause of death code of U07.1. Death counts were derived from the National Vital Statistics System database that provides the timeliest access to the data and may differ slightly from other sources due to differences in completeness, COVID-19 case definitions used, data processing, and imputation of missing dates.

> Weekly excess deaths

Technical Notes

Methods

Counts of deaths in the most recent weeks were compared with historical trends (from 2013 to present) to determine whether the number of deaths in recent weeks was significantly higher than expected, using Farrington surveillance algorithms (1). The 'surveillance' package in R (2) was used to implement the Farrington algorithms, which use overdispersed Poisson generalized linear models with spline terms to model trends in counts, accounting for seasonality. For each jurisdiction, a model is used to generate a set of expected counts, and the upper bound of the 95% Confidence Intervals of these expected counts is used as a threshold to estimate excess deaths. Observed counts are compared to these upper bound estimates to determine whether a significant increase in deaths has occurred. Reported counts were weighted to account for potential underreporting in the most recent weeks.

This method is useful in detecting when jurisdictions may have *higher* than expected numbers of deaths, but cannot be used to determine whether a given jurisdiction has fewer deaths than expected. This method relies on the upper bound of the 95% CI of expected counts based on historical trends, thus most of the observed weeks should fall below this threshold. Additionally, provisional counts of deaths are incomplete, and the degree of underreporting varies considerably by jurisdiction. This underreporting of deaths in recent weeks can contribute to observed counts below the threshold. Thus, the estimates of excess deaths – the numbers of deaths falling above the threshold – may be underestimated. While reported counts are weighted to account for potential underreporting in the most recent weeks, the true magnitude of underreporting is unknown. Therefore, weighted counts of deaths may over- or underestimate the true number of deaths in a given jurisdiction.

The number of excess deaths was calculated as the difference between the observed count and the threshold, by week and jurisdiction. Negative values, where the observed count fell below the threshold, were set to zero. The percent excess was defined as the number of excess deaths divided by the threshold. The total number of excess deaths in each state was calculated by summing the excess deaths in each week, from January 1, 2020 to present. Similarly, the total number of excess deaths in the US was calculated by summing the total numbers of excess deaths across the jurisdictions.

Estimates of excess deaths for the US overall were computed as a sum of jurisdiction-specific numbers of excess deaths (with negative values set to zero), and not directly estimated using the Farrington surveillance algorithms. This was done to account for the possibility that if several jurisdictions report fewer than expected deaths while other jurisdictions report many more deaths than expected, these negative and positive values will cancel each other out when estimating excess deaths for the US directly using the Farrington surveillance algorithms. Until data are finalized (typically 12 months after the close of the data year), it is not possible to determine whether observed decreases in mortality using provisional data are due to true declines or to underreporting. Thus, when computing excess deaths directly for the US, negative values due to underreporting in some jurisdictions will offset excess deaths observed in other jurisdictions. For example, the total number of excess deaths in the US computed directly for the US using the Farrington algorithms was approximately 25% lower than the number calculated by summing across the jurisdictions with excess deaths. This difference is likely due to several jurisdictions reporting lower than expected numbers of deaths – which could be a function of underreporting, true declines in mortality in certain areas, or a combination of these factors. Different estimated thresholds for the expected number of deaths in the US and across the jurisdictions could also contribute to potential discrepancies between the number of excess deaths in the US when estimated directly compared with the sum of jurisdiction-specific estimates.

Other definitions of excess deaths would result in different estimates. For example, defining excess deaths as the difference between the observed counts and the expected (not the upper bound of the 95% CI) would result in larger estimates of excess deaths. The upper bound of the 95% CI was used in this release as it more readily identifies areas experiencing *statistically significantly* higher than normal mortality. Using the expected count, by contrast, would indicate which areas are experiencing higher than average mortality.

Finally, the estimates of excess deaths reported here may not be due to COVID-19, either directly or indirectly. Upward trends in other causes of death (e.g., suicide, drug overdose, heart disease) may contribute to excess deaths in some jurisdictions. Future analyses of cause-specific excess mortality may provide additional information about these patterns.

Completeness

To account for potential underreporting in the most recent weeks, counts were weighted by the inverse of completeness. Completeness was estimated as follows. Using provisional data from 2018-2019, weekly provisional counts were compared to final data (with final data for 2019 approximated by the data available as of April, 9, 2020), at various lag times (e.g., 1 week following the death, 2 weeks, 3 weeks, up to 26 weeks) by reporting jurisdiction. Completeness by week, lag, and jurisdiction was modeled using hierarchical Bayesian models with spatial and temporal random effects. Temporal random effects were included for both the time trend in the provisional counts, and the lag or reporting delay. These random effects were specified using a type-I random walk distribution, where counts in a given time period depend on the value for the prior time period, plus an error term. Spatial random effects were included such that jurisdictions with small numbers 'borrow strength' from nearby jurisdictions to produce stable estimates of completeness. These models were implemented using R-INLA (3). Posterior predicted median values of completeness by jurisdiction and lag time were obtained from the models, and the weekly estimates for 2019 were averaged to provide the most recent possible estimates of completeness by jurisdiction, at given lag times. The inverse of these completeness values were applied as weights to adjust for incomplete reporting of provisional mortality data. For example, if provisional mortality data in 2019 for a given jurisdiction was 50% complete within 1 week of death and 75% complete within 2 weeks of death, then the weights for that jurisdiction would be 2 for data presented with a 1 week lag and 1.3 for data presented with a 2 week lag. Weights were truncated at 4 to avoid overinflating provisional counts of deaths for jurisdictions with very low completeness levels (e.g., completeness estimates for some jurisdictions was 0-2%). These jurisdictions included: Alaska, Connecticut, Louisiana, North Carolina, Ohio, Rhode Island, South Dakota, Virginia, and West Virginia. For these jurisdictions in particular, the weighting may be insufficient to address underreporting, particularly for data reported with shorter lag times (e.g., within 4–6 weeks).

Mortality Outcomes

Weekly counts of deaths from all causes were examined, including deaths due to COVID-19. As many deaths due to COVID-19 may be assigned to other causes of deaths (for example, if COVID-19 was not mentioned on the death certificate as a suspected cause of death), tracking all-cause mortality can provide information about whether an excess number of deaths is observed, even when COVID-19 mortality may be undercounted. These estimates can also provide information about deaths that may be indirectly related to COVID-19. For example, if deaths due to other causes may increase as a result of health care shortages due to COVID-19. Additionally, deaths from all causes ***excluding COVID-19*** were also estimated. These counts excluded deaths with an underlying cause of U07.1. Deaths with a multiple or contributing cause of U07.1 were included; therefore counts may not match counts of COVID-19 deaths reported elsewhere that include deaths with a multiple cause of death code of U07.1. Only about 5% of death records where U07.1 is present do not include it as the underlying cause of death.

Comparing these two sets of estimates—excess deaths with and without COVID-19—can provide insight about how many excess deaths are identified as due to COVID-19, and how many excess deaths are due to other causes of death. These deaths could represent misclassified COVID-19 deaths, or potentially could be indirectly related to COVID-19. Additionally, death certificates are often initially submitted without a cause of death, and then updated when cause of death information becomes available. It may be the case that some excess deaths that are not attributed directly to COVID-19 will be updated in coming weeks with cause-of-death information that includes COVID-19. These analyses will be updated periodically, and the numbers presented will change as more data are received.

Limitations

These estimates are based on provisional data, which are incomplete. The weighting method applied here may not fully account for underreporting if there are longer delays at present than in past years. Conversely, the weighting method may over-adjust for underreporting, given improvements in data timeliness in certain jurisdictions. Unweighted estimates are provided, so that users can see the impact of weighting the provisional counts. However, these unweighted counts are underestimates, and the extent to which they may underestimate the true count of deaths is unknown. Some jurisdictions exhibit recent increases in deaths when using weighted estimates, but not the unweighted. These increases may be an early indication of excess mortality related to COVID-19, but should be interpreted with caution, until confirmed by other data sources such as state or local health departments. It is possible that recent improvements in the timeliness of data could also contribute to the pattern where a jurisdiction exhibits recent increases with the weighted data, but not the unweighted. Conversely, recent increases may be missed in jurisdictions with historically low levels of completeness (e.g., Connecticut, North Carolina) either due to the lack of provisional data or insufficient weighting to address incomplete data.

References

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