Mortality and Longevity

2022 Cause of Death Report - Addendum

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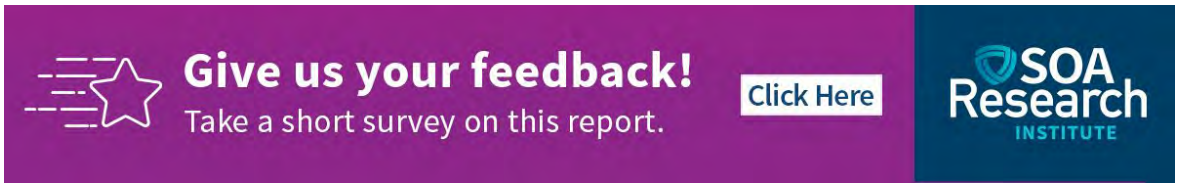

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Addendum: Potential Method of Translating COVID Deaths to All-Cause Excess Deaths

Not surprisingly, COVID deaths have had more impact on all-cause deaths than any other cause since the pandemic began. But determining excess deaths has not been a simple matter of adding COVID deaths to a non-COVID projection of all-cause deaths. Section 4 of the 2022 Cause of Death Report[1] analyzed excess deaths both due to COVID-19 and other causes. It is important to understand the relationship between COVID-19 deaths and all excess deaths as all-cause excess deaths are ultimately the most useful numbers for life insurance companies. A model that projects only COVID deaths would be missing a key relationship regarding a better approximation of overall excess deaths.

This section describes a method to convert projected COVID deaths by age in the insured population into an estimate of all-cause excess deaths. This is a critical consideration for translating a purely COVID-based excess death model into all-cause results. A suggested approach broadly involves two steps, each explained more thoroughly later:

1. Baseline factor: Develop an age-dependent set of multipliers for converting COVID deaths to all-cause excess deaths.
2. Displaced Death factor: Develop an additional set of multipliers to account for displaced deaths at older ages.

Baseline Factor

As discussed in the main report, the overall excess death total has been higher than just COVID deaths at younger ages, and excess deaths have been a bit lower than COVID deaths at older ages. To develop an age-dependent set of multipliers, a general age curve was developed using the data from the periods where lower COVID deaths occurred in this study – specifically, periods where COVID ASMRs (age-and-sex-standardized mortality rates per 1000) were 2%-3% of non-COVID expected ASMRs. This baseline should come from periods of low COVID deaths to avoid confounding displaced deaths at older ages. Table A1 shows the age groups, weighted age of each group, and the multiple representing the ratio of overall excess ASMR to COVID ASMR for each point.

Table A1
REPRESENTATIVE VALUES OF AGE MULTIPLIERS IN A LOWER COVID ENVIRONMENT (2%-3% COVID DEATHS TO ALL DEATHS)

Age Group	Weighted Age	Excess ASMR divided by COVID ASMR
5-34	27.66	274.6%
35-44	39.51	165.0%
45-54	47.45	122.0%
55-64	59.26	107.8%
65-74	68.85	107.1%
75-79	76.89	104.8%
80-84	81.90	92.7%
85-89	86.78	82.6%
90-94	91.58	81.0%

[1] https://www.soa.org/globalassets/assets/files/resources/research-report/2022/2022-cause-death-report.pdf

These values can be used to fit a trend line (a third-degree polynomial fits with an R^2 of 0.994), which could then be applied to integer age estimates of COVID deaths to convert them into all-cause excess death estimates by age.

Displaced Death Factors

One of the complications of modeling the excess deaths at older ages is that there are a number of COVID deaths that otherwise would have occurred in the near-term in the absence of COVID. Essentially, some COVID deaths were just an acceleration of deaths that would have occurred otherwise. We refer to these as "displaced deaths."

These displaced deaths vary by the intensity of the COVID wave. As projected COVID deaths increase against a non-COVID expectation, the total excess at older ages needs to be adjusted downward to account for deaths due to COVID which otherwise would have occurred in the near-term. In general, the more COVID deaths projected at older ages (coming from higher intensity "waves" of COVID), the more the total all-cause excess drops due to increased displaced deaths.

To determine the relationship of COVID deaths to excess ASMR at different magnitudes of COVID, we took advantage of some unique characteristics that we built into the study. The study was developed by month and by ten regions. Because COVID struck regions at different ferocities at different times, we were able to pull data across all levels of high to low COVID deaths and examine the experience that followed in terms of final excess deaths.

Below are the definitions of the two key ratios used in this analysis:

COVID Excess: $\frac{COVID\ ASMR + All-Cause\ Expected\ ASMR}{All-Cause\ Expected\ ASMR}$

Final Excess (all-cause): $\frac{(All-Cause\ Excess\ ASMR + All-Cause\ Expected\ ASMR)}{All-Cause\ Expected\ ASMR}$

The highest percentage of COVID Excess deaths in any region-month set in the study was around 145%. There were many examples of region-months for that highest point in the older age groups, and the sample availability increased as the percentage threshold decreased. We captured the aftermath of overall excess deaths all the way down to the "low," or baseline, COVID periods (around 2% to 3% COVID to expected).

The relationship of COVID Excess deaths to Final Excess deaths is linear with an R^2 of 0.971.

Table A2 shows the COVID excess deaths and final excess deaths observed for older age groups. The table shows nine representative values for each age group, reflecting the various excess percentages that exist in the data.

Table A2

COVID EXCESS DEATHS VS FINAL EXCESS DEATHS AT OLDER AGES AT VARIOUS COVID MAGNITUDES

Age Group	COVID Excess	Final Excess
80-84	141.5%	133.0%
	136.9%	130.0%
	132.5%	125.6%
	127.6%	121.1%
	122.5%	119.8%
	117.4%	116.6%
	112.8%	113.4%
	107.4%	109.2%
	103.2%	102.2%
85-89	143.4%	134.4%
	136.7%	129.0%
	132.8%	127.5%
	127.4%	124.0%
	122.6%	118.1%
	117.4%	115.7%
	112.1%	109.9%
	107.5%	108.7%
	103.0%	100.2%
90-94	141.5%	134.1%
	137.1%	128.4%
	132.2%	124.0%
	127.1%	122.8%
	122.8%	115.0%
	117.5%	114.5%
	112.3%	109.4%
	107.3%	109.1%
	102.8%	100.8%

There are not enough samples available at the younger ages to test for the displaced death relationships - that is, periods where COVID deaths reached 40% of expected deaths (or even 25%) at ages under 50 were not available. There is no solid evidence to support use of this displaced deaths function under age 50. A recommendation, which we implemented in the following test case, was to keep the maximal impact through age 80, but then reduce the displaced death impact to zero by age 50. We applied a hyperbolic tangent function to capture the steep grade off.

Testing Model Fit

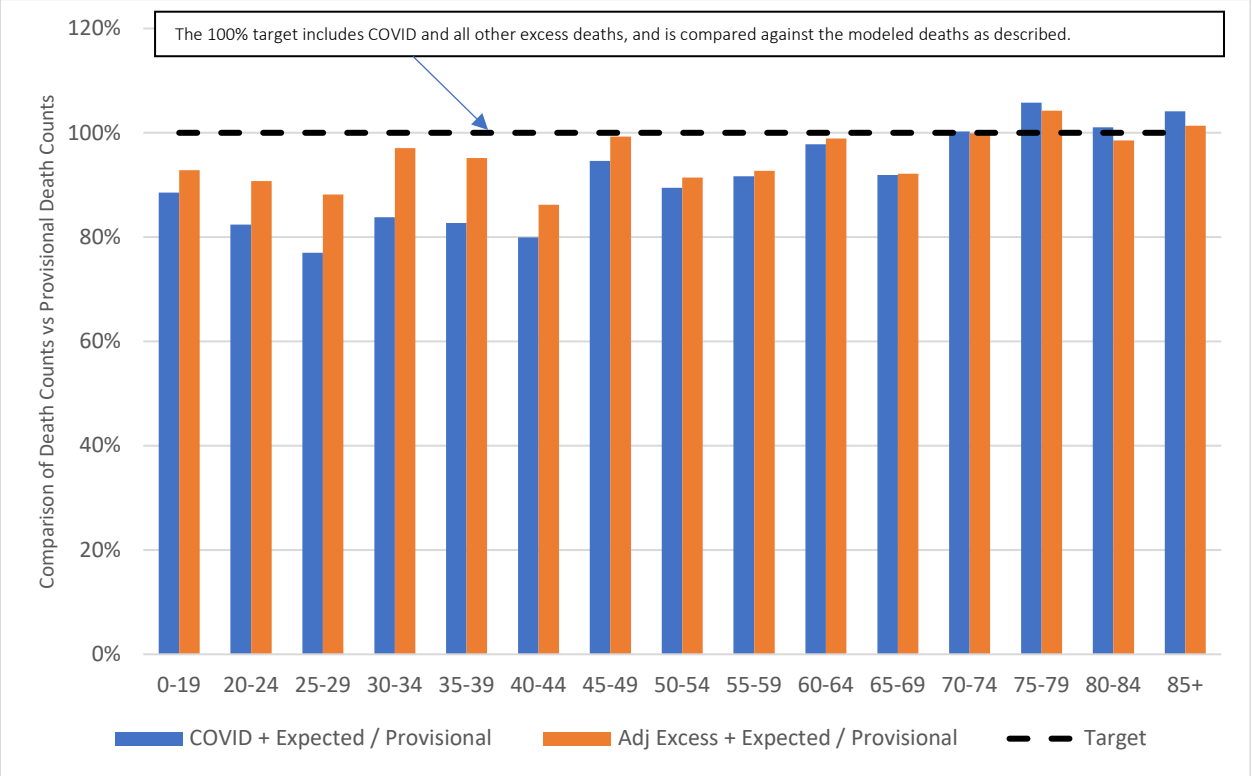
We wanted to test these estimation methods against real data. A forward-looking model test opportunity is available using data beyond the "March 31, 2021" date that marked the end of this iteration of the study. The CDC releases provisional deaths by age group that includes a breakout of COVID deaths. Additionally, a 2019 U.S. population table by age was advanced through 2021 by applying a 1% mortality improvement per year estimate from 2019 into 2021, giving a reasonable count of expected deaths had COVID not occurred. Following the two-step modeling process outlined in the introduction to this addendum, with these tools we may:

1. Directly apply the methods described above (the baseline factor by age and the displaced death factor) to the provisional reported 2021 COVID estimates at each age to develop a new adjusted excess count
2. Within age groups, add:
    a. Expected deaths and COVID deaths
    b. Expected deaths and Adjusted Excess deaths developed in (1) above
3. Compare (2a) and (2b) against published total provisional deaths

What we hope to find is that 2b is closer to the provisional deaths across most age groups than 2a. For all ages combined, the adjusted excess deaths (2b) ended with roughly the same total deaths as the listed provisional COVID deaths (2a) – both came in at about 98.5% of provisional deaths. However, the *allocation* of deaths by age varied substantially. Figure A1 shows that the adjusted excess (2b) significantly outperformed the unadjusted COVID addition (2a) at younger ages and was closer to the 100% target of provisional deaths than unadjusted deaths in 14 of the 15 age groups.

Figure A1

COMPARISON OF COVID AS THE ONLY EXCESS VS ADJUSTED EXCESS (AS DESCRIBED) *



* The target shown is the provisional deaths within each age band.

The only age group where just adding COVID to expected was closer to the provisional deaths was the 80-84 age group. The unadjusted total was 1.1% over the provisional target, while the adjusted excess was 1.5% under the provisional target in that age group.

COVID deaths are challenging enough to model, but as this real-life test case shows, if no further adjustments are made to represent how other causes develop in conjunction with COVID by age, even a model that perfectly predicts COVID deaths would often still miss the mark on true excess mortality, sometimes substantially.