Mortality and Longevity

U.S. Individual Life COVID-19 Experience – Cause of Death Analysis

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U.S. Individual Life COVID-19 Experience

Cause of Death Analysis

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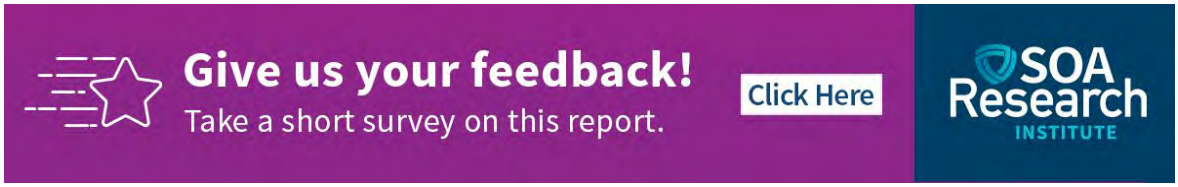

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U.S. Individual Life COVID-19 Experience

Cause of Death Analysis

Section 1: Introduction

Starting in 2021, LIMRA, Reinsurance Group of America (RGA), the Society of Actuaries (SOA) Research Institute, and TAI teamed up to gather individual life experience from a large pool of participating companies during the COVID-19 pandemic and develop insights useful to the industry. To that end, a number of reports and presentations have been created and delivered covering the experience of the insured population, the relationship of that experience to the overall population, reported claims analyses, and cause of death analyses. This report will look into 16 causes of death and how their age-standardized mortality rates changed in the insured population over the study period of 2015 through the first half of 2022, along with comparisons to the overall U.S. population.

If a model specifically projected COVID-19 death rates in the U.S. by age and sex for the next 10 years and applied them to a corresponding table of business-as-usual population mortality over that time period, that overall composition of expected mortality would likely be wrong in critical ways. The impact from COVID-19 on mortality experience stretches well beyond deaths directly added from that disease. Behaviors related to preventative health care and even driving habits changed during the pandemic, and death rates to related causes changed with them. Post-COVID sequelae increased rates of death in other causes. There was evidence of displacement of some causes due to deaths from COVID-19.

This report will showcase some of the more impactful changes to cause of death patterns and compare the overall and insured populations. Understanding the persistence of non-COVID excess requires an understanding of where the excess is coming from and why. We focus on eight cohorts (males and females, ages under 45, 45-64, 65-84, and 85 plus) and 16 causes of death. Those cohorts generally have different cause of death profiles, and these profiles were impacted uniquely during the pandemic.

This report is in conjunction with the publicly available Tableau dashboard (https://www.limra.com/en/research/dashboards/cause-of-death-2023/). As such, this report will not explore every cause/cohort relationship as the data is available in the dashboard. Instead, the focus will be on concepts and illustrative examples.

Section 2: Executive Summary

The impact of COVID-19 extended far beyond direct COVID deaths, and those ancillary impacts hit males and females differently and varied by attained age. Understanding the drivers of the non-COVID excess, whether positive or negative, is an important step in creating a reasonable view of future mortality.

The relationship between the insured age-standardized mortality rate (ASMR) and the corresponding United States (U.S.) population ASMR changed during the pandemic. The insured group improved versus U.S. population mortality across all ages. It is unclear how long this shift in the ratio of ASMRs will continue. What is clear is that not every cause contributes to this effect in the same way.

People under age 65 in the U.S. population experienced significant increases in ASMRs from most non-medical causes during the pandemic. The only exception was suicide ASMRs, which were noticeably down. The corresponding insured population differed between males and females. Insured male non-medical ASMRs were in line with pre-pandemic trends – though a hefty decrease in suicide rates offset rises in homicides, drug overdoses and motor vehicle accidents. For female insureds under age 65, the increase in non-medical ASMRs during the pandemic was due to a broader composition of contributors, though the increase in homicides and drug overdoses was most noticeable. For those over age 65, in both the U.S. population and the insured population, non-medical causes did not have the same kind of impact on overall mortality.

The differences between the U.S. and insured population ASMRs for non-communicable causes of death (cancers, cardiovascular disease, etc.) during the pandemic are striking. The U.S. population had clear evidence of increases over the pre-pandemic trends in every cohort throughout the pandemic. The insured population was much closer to pre-pandemic trends throughout the study period in all cohorts. A deeper dive into the insured results revealed some consistent offsets within this cause group that made the overall non-communicable ASMRs come in near trend. For example, males aged 85 and older had significant and consistent increases in ASMRs from nervous system deaths (mostly Alzheimer's) during the pandemic, but that increase was largely offset by a significant and consistent decrease in ASMRs from hypertension.

Communicable death rates (apart from COVID) became less seasonal during the pandemic. Those rates typically increased, often substantially for both the U.S. and insured populations.

This flattening of seasonality did not stop at communicable causes; non-communicable causes that had shown clear seasonal patterns prior to the pandemic had far less seasonality during the pandemic. This could have a broader implication in evaluating how much influence seasonality may have on some causes where we do not always emphasize it, such as kidney disease. Understanding the added burden that infections such as COVID, influenza and RSV may contribute to other causes could improve predictions around future mortality and improvement assumptions.

Accelerated and displaced deaths have a unique relationship with improvement. Accelerated deaths are deaths that occurred sooner than anticipated – in this case due to the pandemic. Displaced deaths are defined in this document as deaths from a cause that did not happen because COVID ended that life instead of another cause. Like all-cause mortality, age, gender, and underlying health conditions are key risk factors associated with COVID-19 mortality. If a person was going to die from cancer in the same year that they died from COVID, that cancer death was displaced by COVID. The people who survived COVID may be reasonably expected to have better improvement in the near term. How much better depends on how much the proportion of unhealthy to healthy lives shifted due to displacement.

Section 3: What Changed in the U.S. Population

All-cause mortality markedly increased during the pandemic, but the increases clearly were influenced by more than direct COVID deaths. In the charts and tables in this report, red numbers indicate a significantly adverse impact on all-cause mortality compared to pre-pandemic trends and green numbers indicate a significantly favorable impact on all-cause mortality compared to pre-pandemic trends (see Methodology for details and data sources).

Table 1

EXCESS PERCENT OF ALL-CAUSE MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	14%	24%	26%	43%	20%
	45-64	10%	22%	20%	36%	13%
	65-84	12%	27%	16%	25%	14%
	85+	21%	34%	19%	26%	23%
Females	Under 45	12%	22%	24%	46%	20%
	45-64	10%	23%	19%	40%	16%
	65-84	11%	25%	14%	26%	14%
	85+	13%	21%	7%	12%	11%

Table 2

EXCESS PERCENT OF COVID-INVOLVED MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	6%	7%	10%	21%	7%
	45-64	10%	15%	18%	25%	12%
	65-84	12%	20%	19%	16%	14%
	85+	12%	20%	17%	10%	14%
Females	Under 45	5%	8%	12%	26%	10%
	45-64	8%	14%	17%	27%	13%
	65-84	11%	17%	17%	16%	12%
	85+	12%	15%	13%	7%	9%

Table 3

EXCESS PERCENT OF NON-COVID MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	8%	17%	16%	22%	13%
	45-64	0%	7%	2%	10%	1%
	65-84	0%	7%	-3%	9%	0%
	85+	8%	14%	2%	15%	9%
Females	Under 45	7%	14%	12%	21%	10%
	45-64	2%	10%	2%	13%	3%
	65-84	1%	8%	-2%	10%	2%
	85+	1%	6%	-6%	5%	2%

Figure 1
ALL-CAUSE ASMR'S. U.S. MALE POPULATION UNDER AGE 45

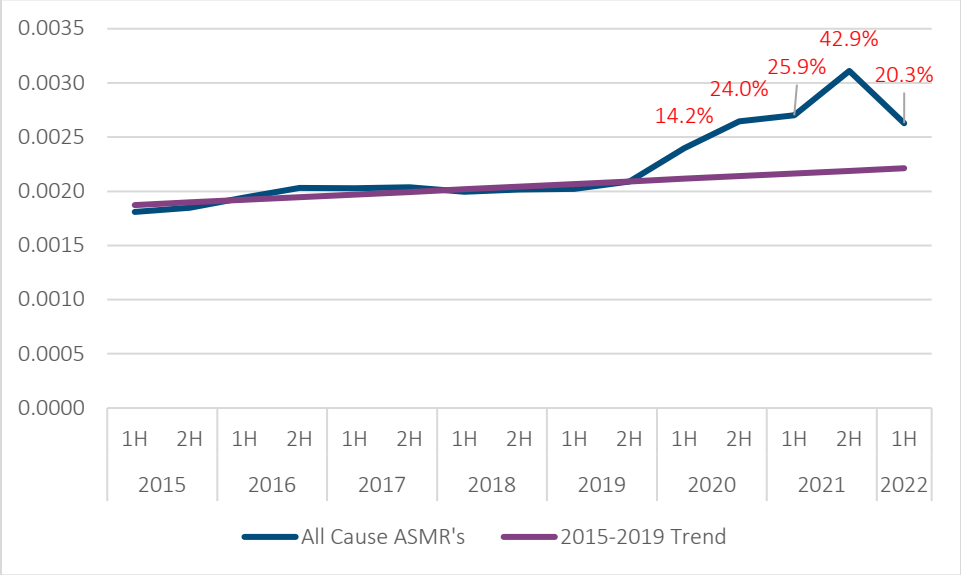
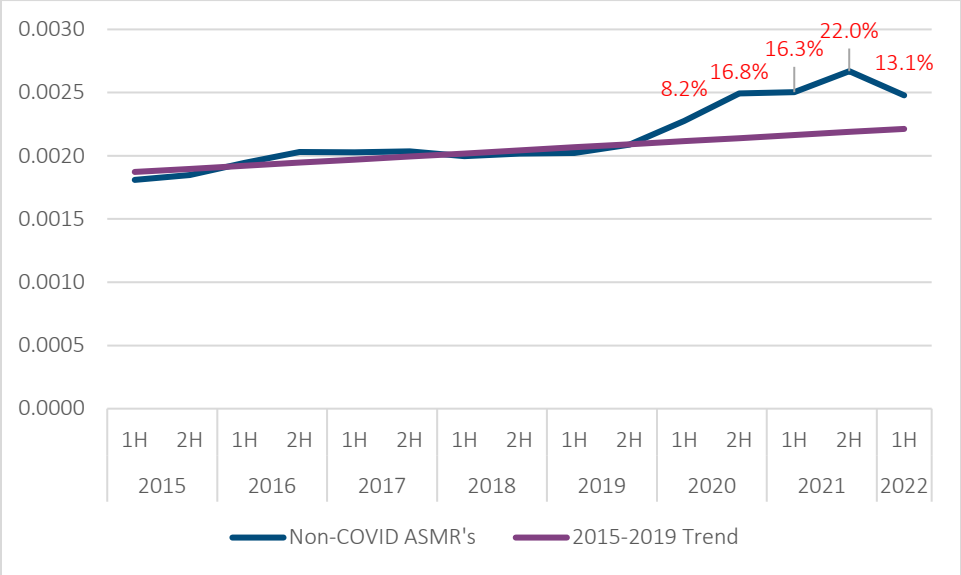


Figure 2
NON-COVID ASMR'S. U.S. MALE POPULATION UNDER AGE 45



Younger people, in particular, had very elevated non-COVID death rates in the pandemic period that far outpaced the pre-pandemic trends and, in every half-year period in this report, had a significant impact to the excess deaths of males under age 45 and females under age 45. (Please see the Methodology section "Assessing Significance" for details.) In fact, in the male under age 45 and female under age 45 cohorts, the non-COVID excess surpassed the excess from COVID in all but females in the second half of 2021.

The six cohorts ages 45 and older in the population experienced 15 of 30 half years with significant impact from non-COVID causes. However, in these cohorts, excess deaths from COVID outpaced non-COVID excess in 29 of the 30 half years in the study period, a reversal of excess contributions in the under 45 cohorts.

The cause groups impacting the population differed across cohorts. We will look at a few examples in the next subsections from the broader categories of non-medical deaths, non-communicable deaths, and communicable deaths.

3.1 POPULATION NON-MEDICAL DEATHS

In the U.S. population, increases in non-medical deaths contributed a large proportion of the excess to the four cohorts under age 65 in the study. They contributed no significant impact on the four older cohorts.

Figure 3

NON-MEDICAL ASMR'S. U.S. MALE POPULATION UNDER AGE 45

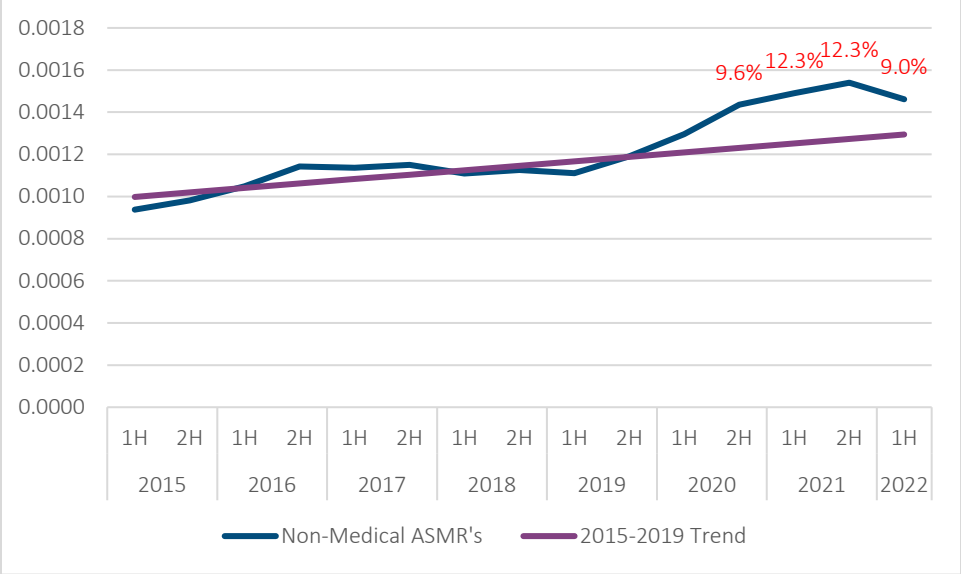


Figure 4

NON-MEDICAL ASMR'S. U.S. FEMALE POPULATION UNDER AGE 45

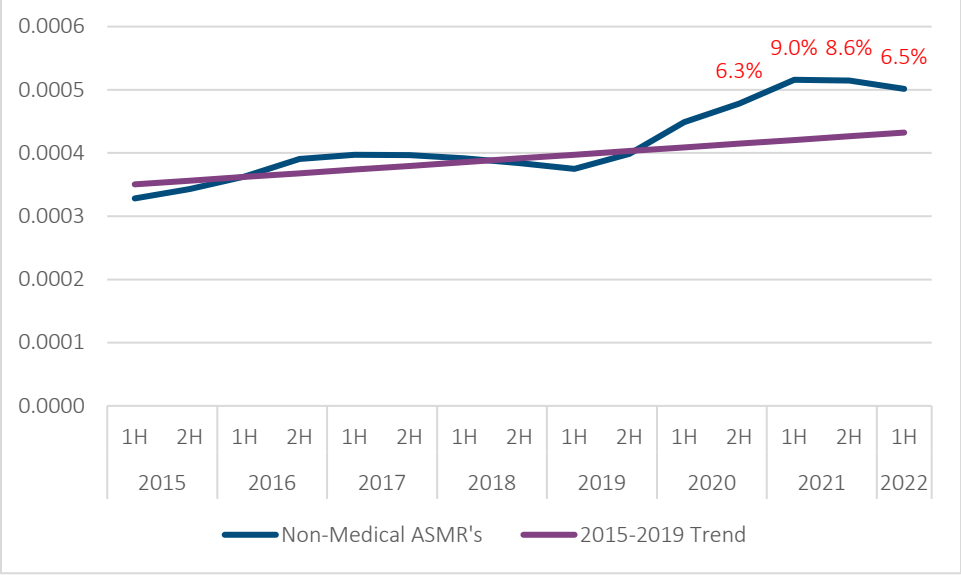


Figure 5

NON-MEDICAL ASMR'S. U.S. MALE POPULATION AGES 45-64

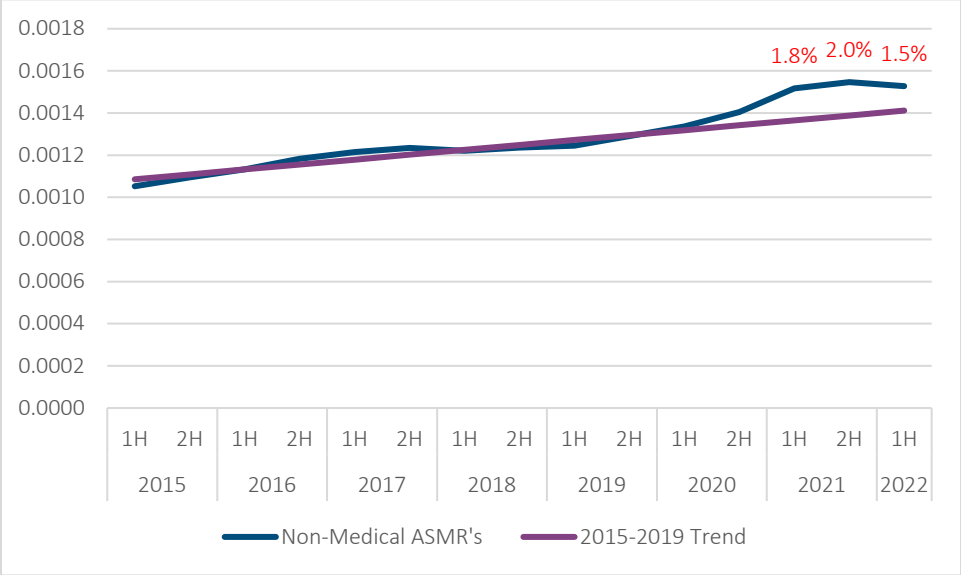
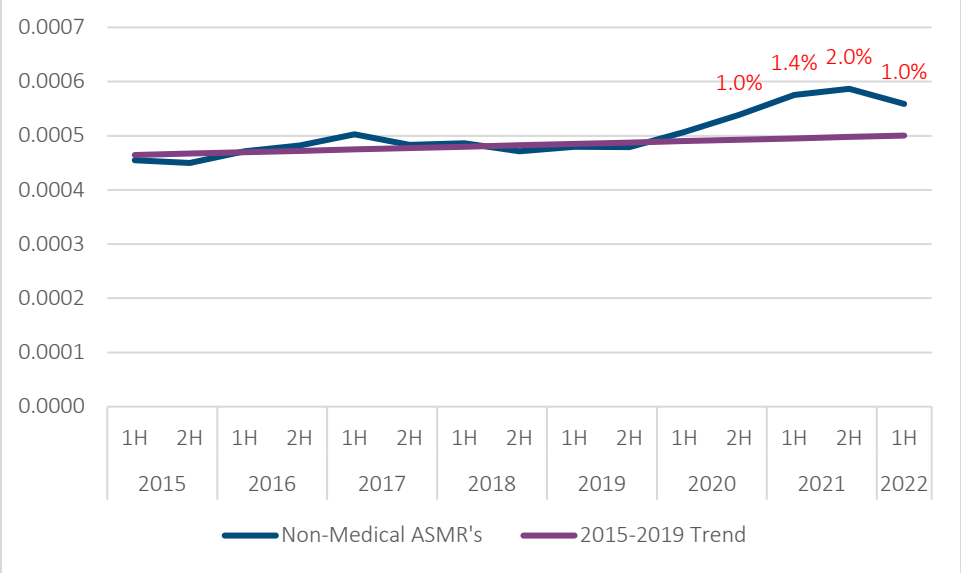


Figure 6

NON-MEDICAL ASMR'S. U.S. FEMALE POPULATION AGES 45-64



The common denominator contributing excess in all four of these cohorts was "other accidents." At these ages, that category is largely comprised of accidental drug overdoses. In the under age 45 cohorts, motor vehicle accidents and "other non-medical" also contributed heavily to the excess.

Table 4
EXCESS DEATHS IN THE U.S. POPULATION FROM NON-MEDICAL CAUSES DURING THE PANDEMIC

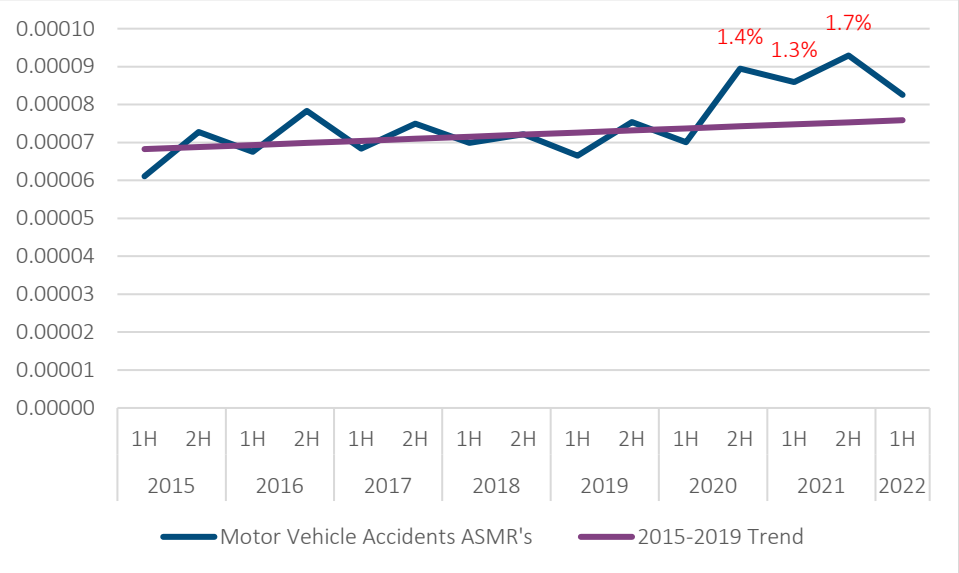
Sex	Age Group	Cause	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	Motor Vehicle Accidents	0%	2%	2%	3%	2%
		Other Non-Medical	1%	3%	2%	3%	1%
		Suicide	-1%	-1%	0%	0%	0%
		Other Accidents	5%	5%	9%	7%	6%
	45-64	Motor Vehicle Accidents	0%	0%	0%	0%	0%
		Other Non-Medical	0%	0%	0%	0%	0%
		Suicide	0%	-1%	-1%	0%	0%
		Other Accidents	1%	1%	2%	2%	2%
Females	Under 45	Motor Vehicle Accidents	0%	1%	1%	2%	1%
		Other Non-Medical	0%	1%	1%	1%	0%
		Suicide	-1%	0%	0%	0%	0%
		Other Accidents	4%	4%	7%	6%	5%
	45-64	Motor Vehicle Accidents	0%	0%	0%	0%	0%
		Other Non-Medical	0%	0%	0%	0%	0%
		Suicide	0%	0%	0%	0%	0%
		Other Accidents	1%	1%	2%	2%	1%

Notice that suicide deaths had no worse than a neutral impact on all-cause excess in these age groups for the population.

3.1.1 MOTOR VEHICLE ACCIDENTS

The overall number of car accidents decreased during the pandemic, but the number of traffic fatalities went up. The excess fatalities mostly afflicted younger cohorts and followed the typical seasonal patterns seen in the pre-pandemic lead-in period.

Figure 7
MOTOR VEHICLE ACCIDENT ASMR'S. U.S. FEMALE POPULATION UNDER AGE 45

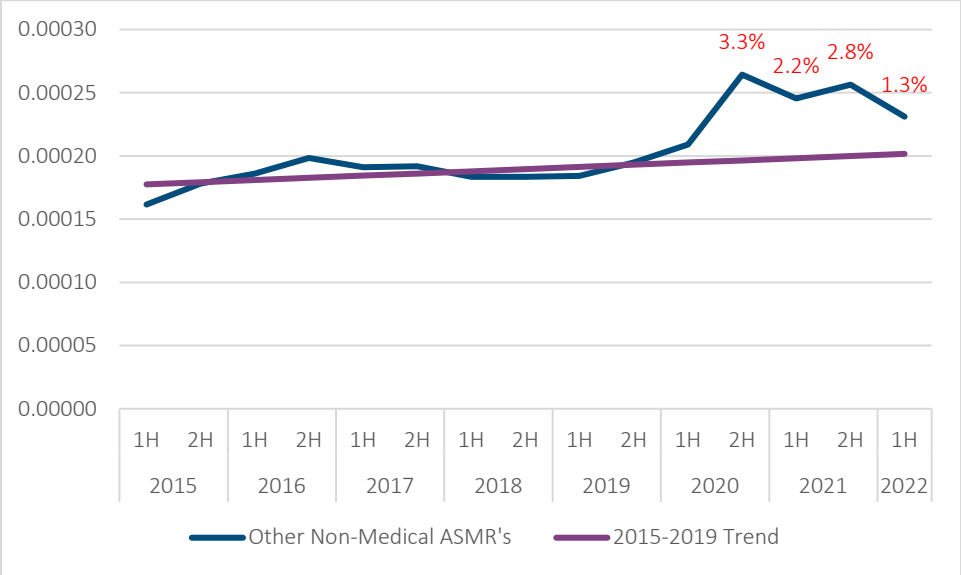


3.1.2 OTHER NON-MEDICAL DEATHS

The category "other non-medical deaths" is dominated by homicides. Like motor vehicle accident deaths, this cause only significantly changed for the youngest cohort in the population.

Figure 8

"OTHER NON-MEDICAL" ASMR'S. U.S. MALE POPULATION UNDER AGE 45



Rates of death by homicide for both males and females under age 45 increased by about 25% during the pandemic compared to 2015-2019 rates.

3.2 POPULATION NON-COMMUNICABLE DEATHS

Non-communicable deaths often stem from longer-term disease states such as cardiovascular disease. The long-term nature of these causes means they will have more impact at older ages. However, during the pandemic, the population showed very obvious increases in death rates from non-communicable causes in every cohort.

Table 5

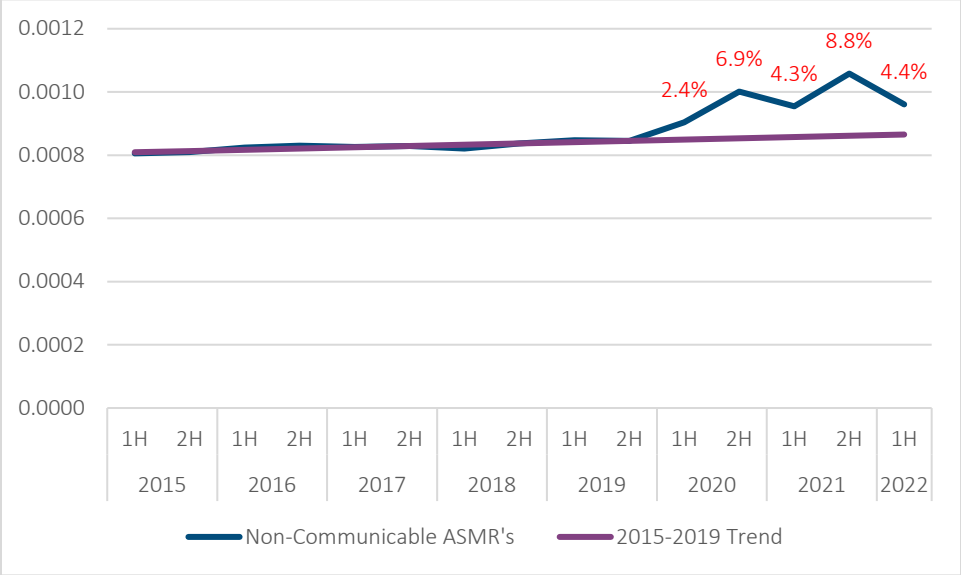
EXCESS DEATHS IN THE U.S. POPULATION FROM NON-COMMUNICABLE CAUSES DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	2%	7%	4%	9%	4%
	45-64	-1%	6%	0%	7%	0%
	65-84	0%	6%	-3%	7%	0%
	85+	8%	13%	2%	14%	9%
Females	Under 45	2%	8%	4%	11%	4%
	45-64	1%	8%	1%	10%	2%
	65-84	1%	7%	-2%	9%	3%
	85+	1%	6%	-5%	4%	2%

The increase was especially striking at the younger ages, as seen in the pattern of non-communicable deaths for males under age 45.

Figure 9

NON-COMMUNICABLE ASMR'S. U.S. MALE POPULATION UNDER AGE 45



The smooth pre-pandemic trend changed significantly and began contributing far more than the expected rate of death. Recall that, if COVID appears anywhere on the death certificate in the population numbers, we count it as a COVID death, so these increases are all independent of that cause being recorded. It is possible that some of the excess shown is from unreported COVID, but there is no way to determine that.

3.2.1 CANCER

Cancer screenings were down during the pandemic, which logically should lead to an increase in undiagnosed cancer, in turn leading to an increase in cancer deaths for some period following the drop in diagnoses. We typically have heard a message that these deaths are not yet evident but, in some cohorts, it does appear that an increase is underway.

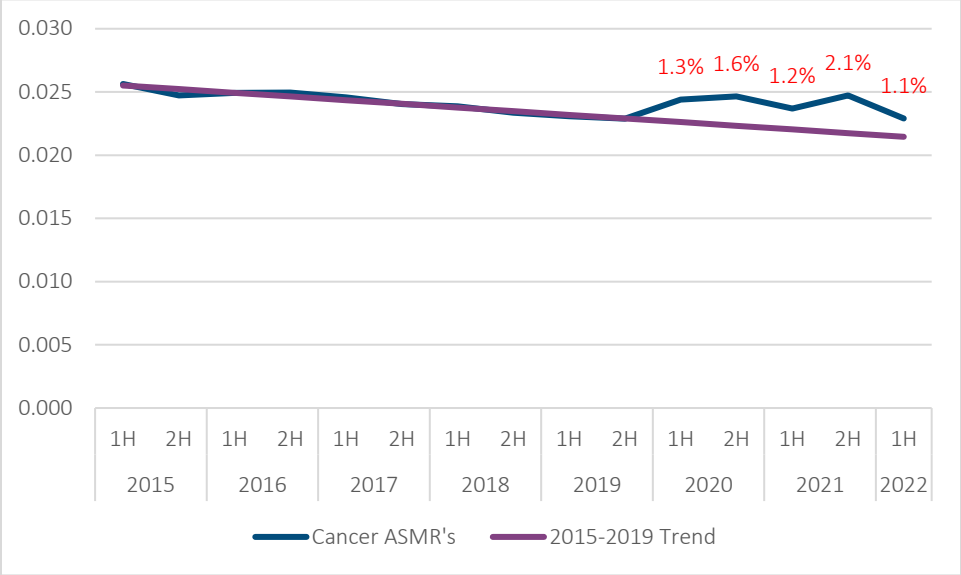
Table 6

EXCESS PERCENT OF CANCER MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	0%	0%	0%	0%
	45-64	-1%	0%	0%	0%	-1%
	65-84	0%	1%	0%	**1%**	0%
	85+	**1%**	**2%**	**1%**	**2%**	**1%**
Females	Under 45	0%	0%	0%	**1%**	-1%
	45-64	0%	0%	0%	1%	-1%
	65-84	1%	1%	0%	**1%**	0%
	85+	0%	0%	0%	0%	0%

Figure 10

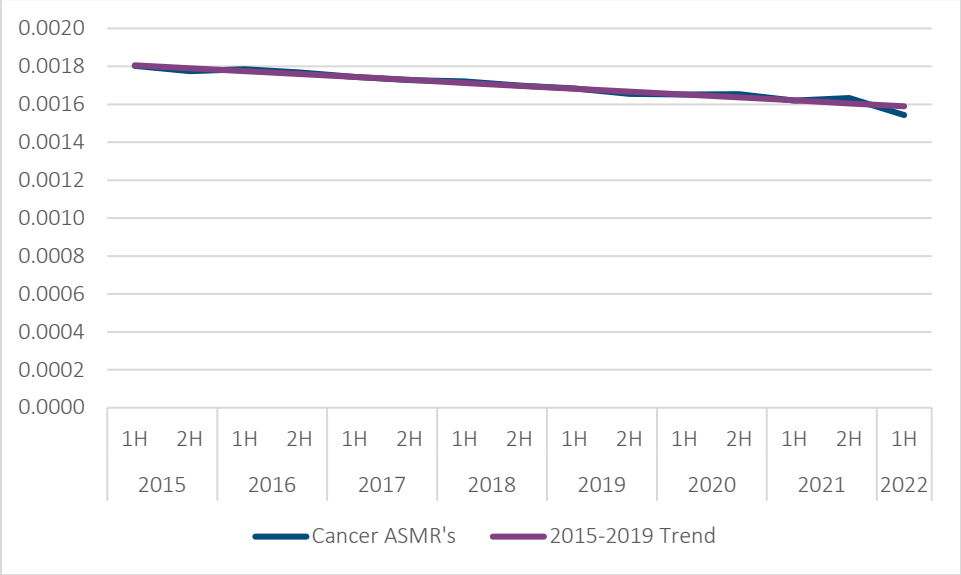
CANCER ASMR'S. U.S. MALE POPULATION AGES 85 AND OLDER



It is plausible that, even if a cohort does not deviate significantly from the pre-pandemic trend, it is a bad sign for cancer deaths. For example, in female ages 45 to 64, cancer is the leading cause of death in this study, but the pandemic ASMRs come out roughly where the trend was headed.

Figure 11

CANCER ASMR'S. U.S. FEMALE POPULATION AGES 45-64



Looking back at the table of all-cause mortality increases, this cohort averaged 22% excess deaths over the five semi-annual periods of the pandemic in this study and, yet cancer – the leading cause of death – never had more than a 1% deviation from trend. Considering cancer should be a prime candidate for displacement by COVID, it is conceivable that cancer death rates coming in on trend is a bad result.

3.2.2 CARDIOVASCULAR DEATHS OTHER THAN HYPERTENSION

The cause of death that significantly impacted the most cohorts, other than hypertension, was cardiovascular deaths. In our eight age/sex cohorts, this cause of death both deviated significantly from pre-pandemic trends and added at least 1% overall excess in most semi-annual periods in the study.

Table 7

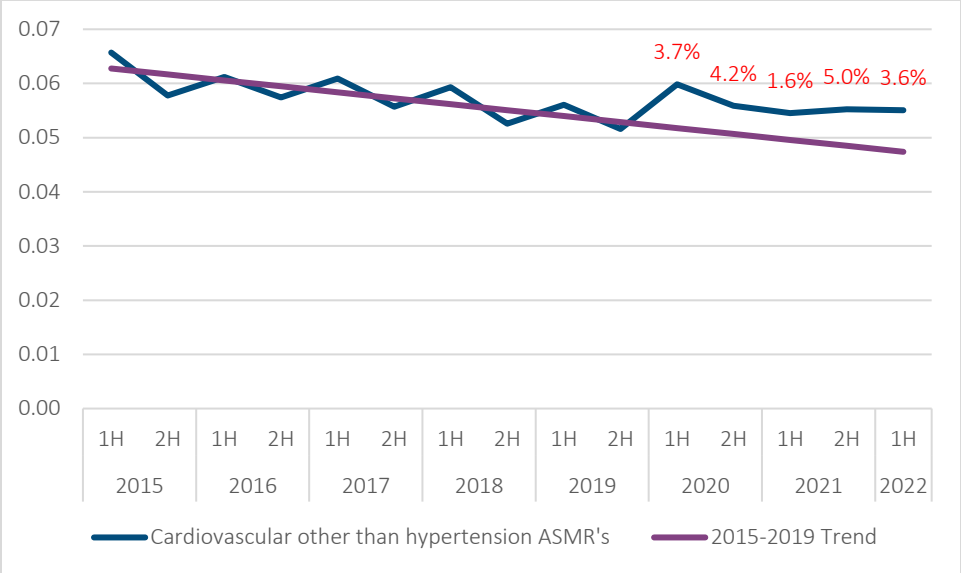
EXCESS PERCENT OF CARDIOVASCULAR (EXCLUDING HYPERTENSION) MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	1%	**2%**	**1%**	**2%**	1%
	45-64	0%	**2%**	1%	**2%**	0%
	65-84	1%	**2%**	0%	**2%**	1%
	85+	**4%**	**4%**	2%	**5%**	**4%**
Females	Under 45	1%	**2%**	**1%**	**2%**	1%
	45-64	1%	**2%**	1%	**2%**	**1%**
	65-84	1%	**2%**	0%	**3%**	**1%**
	85+	1%	1%	-1%	**1%**	1%

The oldest male cohort experienced the worst impact.

Figure 12

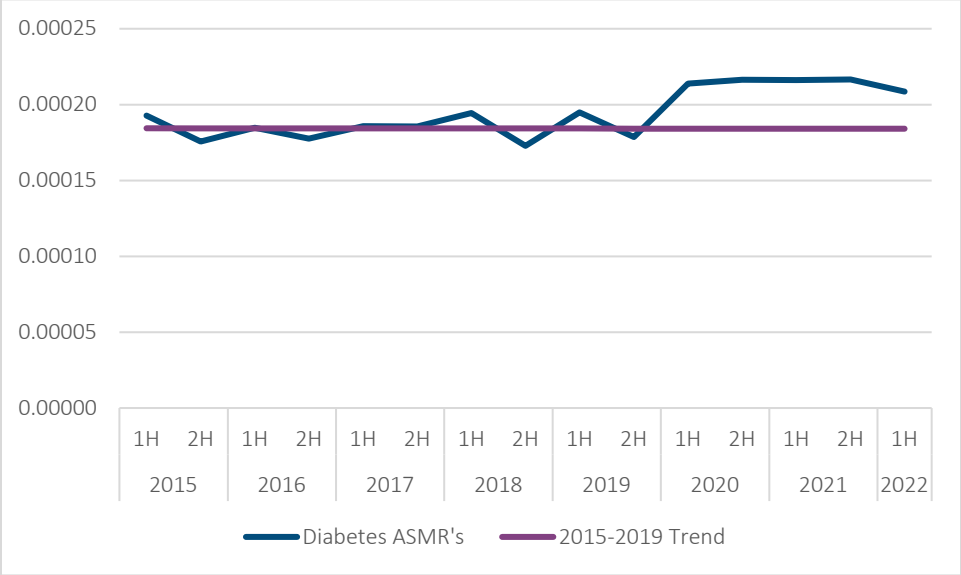
CARDIOVASCULAR (OTHER THAN HYPERTENSION) ASMR'S. U.S. MALE POPULATION AGES 85 AND OLDER



3.2.3 DIABETES

Diabetes deaths did not meet both conditions in the population data that would specifically call them out as significantly impactful in this study. That is not to say that they were not impacted. They increased almost universally beyond pre-pandemic trends, but the excess in relation to all-cause mortality never crossed the 1% threshold. The most excess was to females in the age 45-64 cohort, at 0.82% in the second half of 2020, but the pattern relative to trend in that cohort was similar to the other cohorts and something to track.

Figure 13
DIABETES ASMR'S. U.S. FEMALE POPULATION AGES 45-64



Diabetes, similar to cancer, is a prime target for displacement since the people with that underlying condition are at elevated risk of dying from COVID. Therefore, a clearly higher set of ASMRs during the pandemic may be a particularly poor outcome.

3.2.4 DIGESTIVE

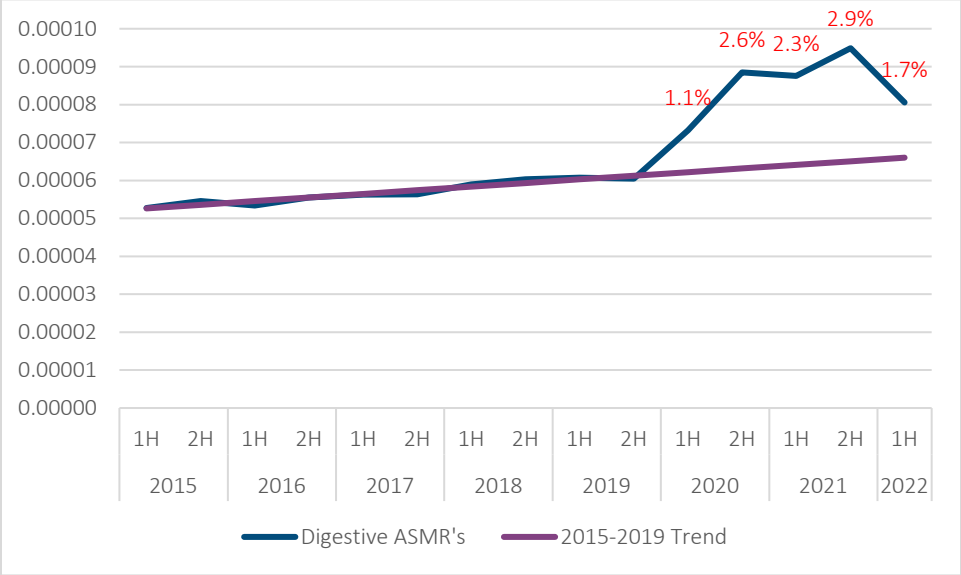
The deaths in this category are largely related to liver disease. Importantly, at younger ages, these liver-related deaths are more often linked to alcohol use. And it is the younger cohorts that saw the significant impacts in their all-cause ASMRs due to this cause.

Table 8
EXCESS PERCENT OF DIGESTIVE MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	1%	**2%**	**2%**	**2%**	**2%**
	45-64	0%	**1%**	**1%**	**2%**	1%
	65-84	0%	0%	0%	0%	0%
	85+	0%	0%	0%	0%	0%
Females	Under 45	**1%**	**3%**	**2%**	**3%**	**2%**
	45-64	0%	**1%**	**1%**	**2%**	**1%**
	65-84	0%	0%	0%	1%	0%
	85+	0%	0%	0%	0%	0%

Looking at females under age 45, the pre-pandemic trend was steady, and the post-pandemic shift was enormous.

Figure 14
DIGESTIVE DISEASE ASMR'S. U.S. FEMALE POPULATION UNDER AGE 45



The second half of 2021 shows almost a 50% increase in this cause of death, amounting to nearly a 3% increase to all-cause mortality for this cohort.

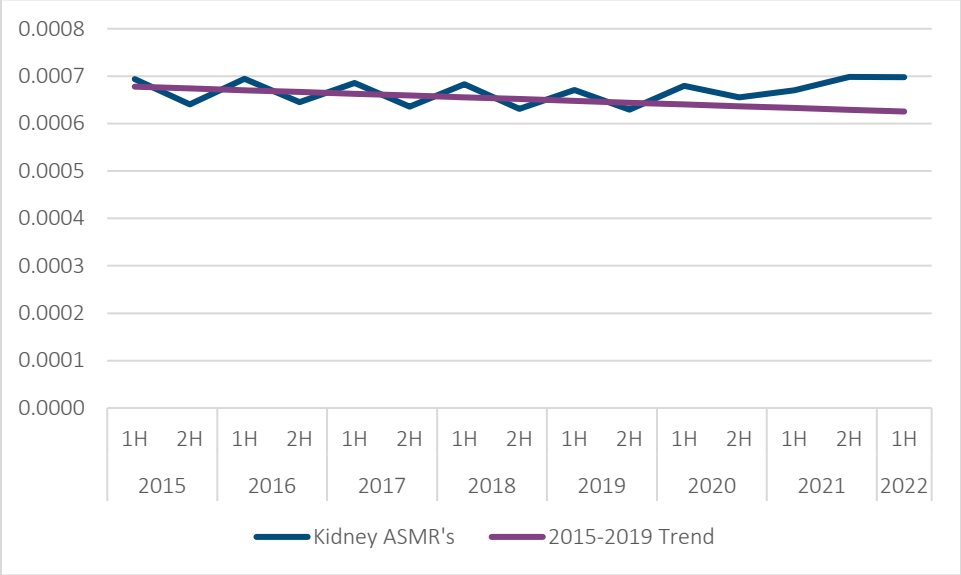
3.2.5 HYPERTENSION

In the U.S. population, deaths related to hypertension had no significant impact on overall excess mortality. In the section on insured lives, we show that, in the insured population, these ASMRs were either within pre-pandemic expectations or, when not, they came in better than expected.

3.2.6 KIDNEY

Kidney-related mortality behaved very similar to the diabetes-related mortality discussed earlier. That is, it was consistently noticeably worse throughout the pandemic in almost every cohort and semi-annual period, but did not add enough overall excess to be flagged as significantly impactful in this report. A representative example is female ages 65 to 84.

Figure 15
KIDNEY-RELATED ASMR'S. U.S. FEMALE POPULATION AGES 65-84



3.2.7 NERVOUS SYSTEM

Nervous system deaths are dominated by Alzheimer's disease and their impact is more commonly seen at the oldest ages.

Table 9
EXCESS PERCENT OF NERVOUS SYSTEM MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	0%	0%	0%	0%
	45-64	0%	0%	0%	0%	0%
	65-84	0%	0%	0%	0%	0%
	85+	1%	2%	0%	1%	0%
Females	Under 45	0%	0%	0%	0%	0%
	45-64	0%	0%	0%	0%	0%
	65-84	0%	1%	0%	0%	0%
	85+	1%	2%	-1%	0%	-1%

There was some concern about miscoding COVID deaths as Alzheimer's early in the pandemic. In the population numbers, that explanation makes some sense as the most negatively impactful results were all in 2020.

3.2.8 RESPIRATORY

Respiratory deaths, such as COPD, appear to have been the most likely target for displacement by COVID. Nowhere in the population were respiratory deaths significantly bad during the pandemic and, in several instances, they were significantly better than the pre-pandemic trend.

Table 10

EXCESS PERCENT OF RESPIRATORY MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	0%	0%	0%	0%
	45-64	0%	0%	-1%	0%	-1%
	65-84	0%	0%	-1%	0%	-1%
	85+	0%	0%	-1%	0%	0%
Females	Under 45	0%	0%	0%	0%	0%
	45-64	0%	0%	-1%	0%	-1%
	65-84	0%	0%	-2%	0%	-1%
	85+	0%	-1%	-2%	0%	-1%

3.2.9 OTHER NON-COMMUNICABLE DEATHS

This catch-all category has the most inexplicable results. There have been no changes in coding that would affect this cause, but it is the pandemic-era volatility that is most strange. Typically, the other causes are much more likely to be either up or down versus pre-pandemic trend. And typically, other causes tend to behave at a similar magnitude. That was not the case with this cause set, which is heavily influenced by "mental and behavioral disorders due to psychoactive substance abuse" at younger ages and "unspecified dementia" at older ages.

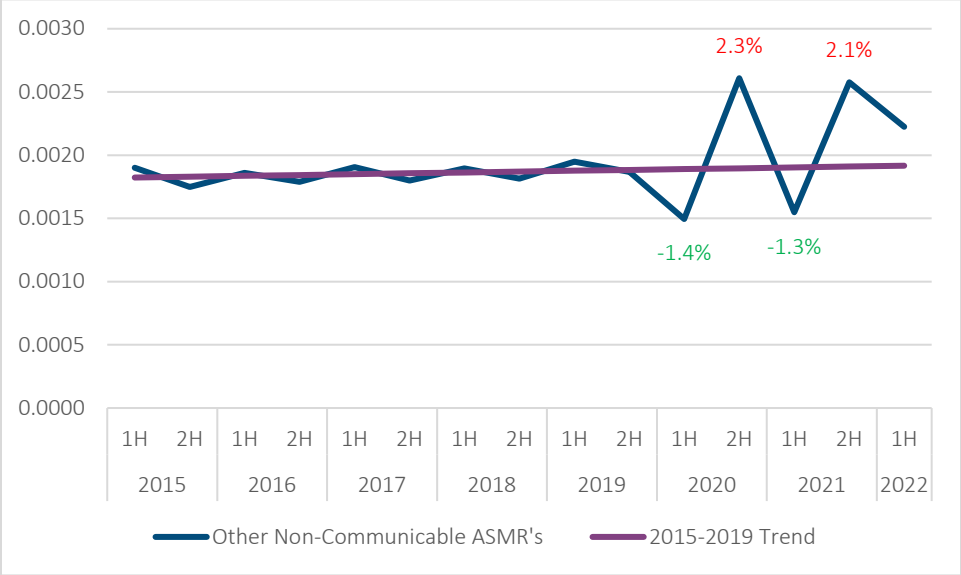
Table 11

EXCESS PERCENT OF "OTHER NON-COMMUNICABLE" MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	2%	0%	3%	2%
	45-64	-1%	2%	-1%	3%	1%
	65-84	-1%	2%	-1%	2%	1%
	85+	0%	4%	-1%	3%	2%
Females	Under 45	0%	2%	-1%	5%	2%
	45-64	-1%	2%	-1%	3%	1%
	65-84	-1%	3%	-1%	2%	1%
	85+	-1%	4%	-1%	2%	2%

For an example of how strangely these results came in relative to trend, look at male ages 65 to 84.

Figure 16
"OTHER NON-COMMUNICABLE" ASMR'S. U.S. MALE POPULATION AGES 65-84



Notice that there was some seasonality prior to the pandemic and, at first, it may appear the pandemic exacerbated that seasonality. Looking closer, the seasonal pattern (worse in the first half, better in the second half) actually flipped in addition to the increased magnitude in swings. Again, nothing about how causes in this group were recorded should have changed during the pandemic.

3.3 POPULATION COMMUNICABLE DEATHS

Death rates in the U.S. population from communicable causes appeared less impacted than many other causes. Here, those causes are split into (1) influenza and pneumonia deaths and (2) all other non-COVID communicable causes of death.

Table 12

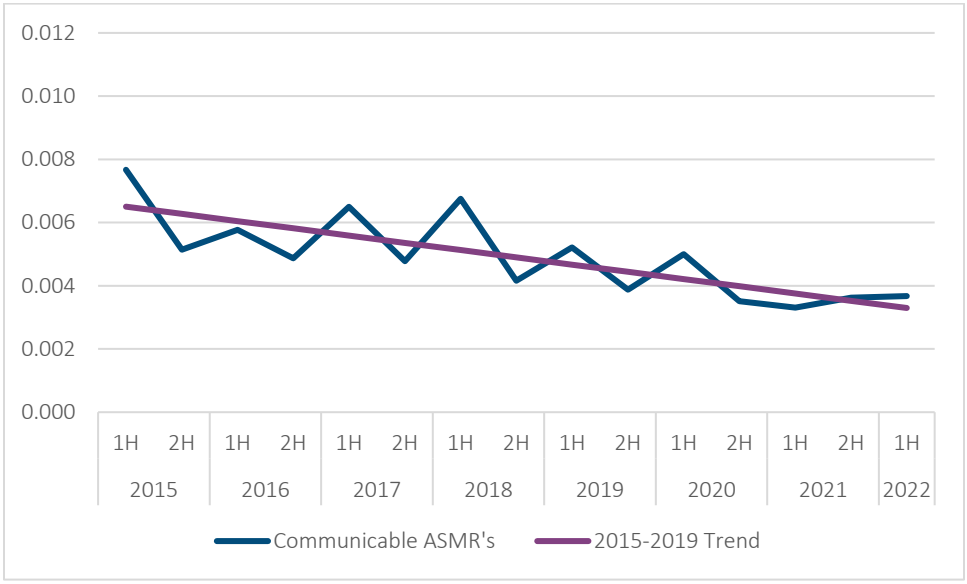
EXCESS PERCENT OF COMMUNICABLE DISEASE (EXCLUDING COVID) MORTALITY IN THE U.S. POPULATION DURING THE PANDEMIC

Sex	Age Group	Cause	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	Influenza & Pneumonia	0%	0%	0%	0%	0%
		Other Communicable	0%	0%	0%	1%	0%
	45-64	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	0%	0%	1%	0%
	65-84	Influenza & Pneumonia	0%	0%	-1%	0%	0%
		Other Communicable	0%	0%	0%	1%	0%
	85+	Influenza & Pneumonia	0%	0%	-1%	0%	0%
		Other Communicable	0%	0%	0%	0%	0%
Females	Under 45	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	0%	0%	1%	0%
	45-64	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	1%	0%	1%	0%
	65-84	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	0%	0%	0%	0%
	85+	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	0%	0%	0%	0%

There is a bit of evidence of displacement to influenza and pneumonia from COVID, but it is not overwhelming. More interesting may be the impact on seasonality. Communicable causes of death always show a seasonal pattern when splitting the year into a first and second half, where the first half death rates are worse than the second half, followed by an increase in the subsequent first half. COVID flattened and sometimes reversed that seasonality.

Figure 17

COMMUNICABLE DISEASE ASMR'S. U.S. FEMALE POPULATION AGES 85 AND OLDER



The first half of 2021 deaths rates were lower than the second half of 2020 death rates. The second half of 2021 death rates were then higher than the first half of 2021. The first half of 2022 was very similar to the second half of 2021.

As with COVID, it is probably better to think about the all-in burden on mortality from these other communicable causes rather than the direct deaths in isolation. Going forward, bad flu seasons and waning COVID immunity could lead to not only rises in direct deaths from those causes, but an increase in deaths for at-risk people from other causes as well. Refer to the section on seasonality for examples.

Section 4: What Changed in the Fully Underwritten Insured Population

All-cause mortality in the insured population went up, but not as much as the overall U.S. population. The contribution of excess from non-COVID-involved deaths was very different for the insured versus U.S. results. As before in the charts and tables, red numbers indicate a significantly adverse impact on all-cause mortality compared to pre-pandemic trends and green numbers indicate a significantly favorable impact on all-cause mortality compared to pre-pandemic trends.

Table 13

EXCESS PERCENT OF ALL-CAUSE MORTALITY IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	12%	18%	13%	31%	15%
	45-64	11%	14%	21%	33%	11%
	65-84	7%	18%	9%	14%	5%
	85+	6%	18%	2%	6%	2%
Females	Under 45	8%	11%	14%	20%	14%
	45-64	9%	9%	16%	21%	9%
	65-84	8%	17%	8%	15%	4%
	85+	8%	14%	3%	5%	1%

Table 14

EXCESS PERCENT OF COVID-INVOLVED MORTALITY IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	5%	5%	7%	19%	6%
	45-64	8%	14%	17%	28%	11%
	65-84	7%	16%	13%	12%	9%
	85+	8%	15%	10%	7%	8%
Females	Under 45	5%	6%	5%	20%	8%
	45-64	7%	10%	13%	19%	8%
	65-84	7%	13%	11%	11%	7%
	85+	8%	13%	9%	6%	6%

Table 15

EXCESS PERCENT OF NON-COVID MORTALITY IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	7%	13%	6%	12%	9%
	45-64	4%	0%	4%	5%	1%
	65-84	-1%	2%	-4%	2%	-4%
	85+	-2%	2%	-8%	-1%	-6%
Females	Under 45	3%	6%	9%	0%	6%
	45-64	2%	-1%	3%	2%	1%
	65-84	1%	4%	-2%	4%	-3%
	85+	1%	1%	-6%	0%	-5%

4.1 INSURED NON-MEDICAL DEATHS

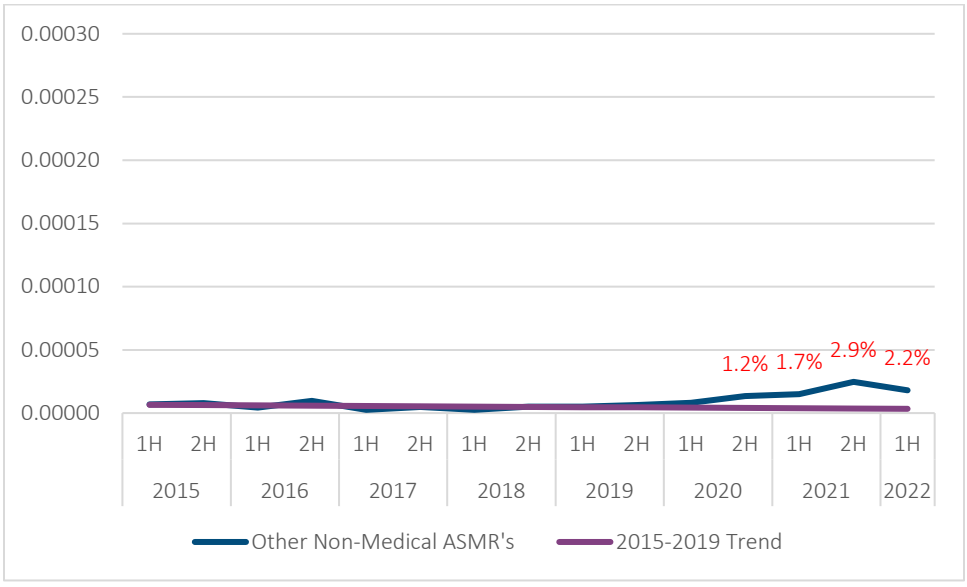
Non-medical death rates generally increased in the insured population, but not nearly as much as they increased in the U.S. population. The deviations from trend were only significant in the four youngest cohorts.

Table 16
EXCESS PERCENT OF NON-MEDICAL DEATHS IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	Cause	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	Motor Vehicle Accidents	-1%	1%	4%	2%	3%
		Other Non-Medical	1%	1%	2%	3%	2%
		Suicide	-4%	0%	-6%	-1%	-5%
		Other Accidents	5%	8%	-1%	2%	0%
	45-64	Motor Vehicle Accidents	0%	0%	0%	0%	0%
		Other Non-Medical	0%	0%	1%	0%	1%
		Suicide	-1%	-1%	-1%	-1%	-1%
		Other Accidents	0%	-1%	1%	0%	0%
Females	Under 45	Motor Vehicle Accidents	1%	2%	5%	-1%	2%
		Other Non-Medical	1%	2%	1%	2%	1%
		Suicide	3%	-4%	0%	-3%	3%
		Other Accidents	5%	2%	9%	0%	3%
	45-64	Motor Vehicle Accidents	0%	0%	0%	0%	0%
		Other Non-Medical	0%	1%	1%	1%	1%
		Suicide	0%	-1%	0%	0%	0%
		Other Accidents	0%	0%	1%	0%	1%

One cause to draw more attention to out of this set is “other non-medical,” which is largely composed of homicides. Homicides are going up in the overall population but, during the pandemic, the fully underwritten insured population was significantly impacted by homicides, especially at the younger ages.

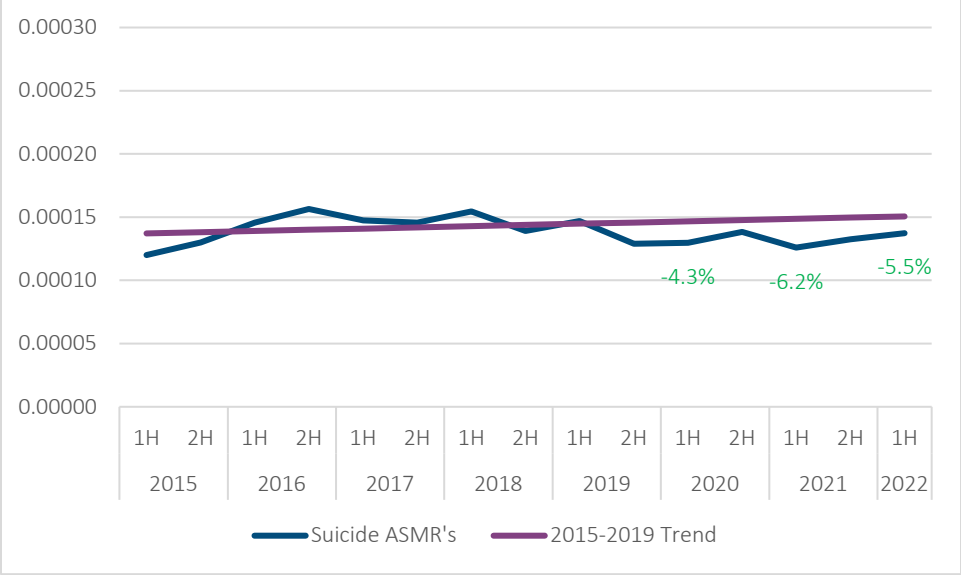
Figure 18
"OTHER NON-MEDICAL" ASMR'S. FULLY UNDERWRITTEN INSURED MALES UNDER AGE 45



This had been an almost negligible cause of death, but the rates more than doubled during the pandemic compared to the pre-pandemic period and the excess from homicides became an important contributor of non-COVID excess at the younger ages.

Will suicide death rates remain lower than pre-pandemic? If they stay where they are, or if they improve further, it will do a lot to keep non-medical mortality rates down. If they revert, it could be a major cause for concern considering the rise in other non-medical causes.

Figure 19
SUICIDE ASMR'S. FULLY UNDERWRITTEN INSURED MALES UNDER AGE 45



4.2 INSURED NON-COMMUNICABLE DEATHS

The insured population had very mixed experience with non-communicable deaths compared to pre-pandemic trends.

Table 17
EXCESS DEATH RATES FROM NON-COMMUNICABLE CAUSES IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	6%	3%	6%	3%	7%
	45-64	4%	1%	3%	2%	0%
	65-84	-1%	1%	-3%	1%	-4%
	85+	-2%	2%	-7%	-1%	-4%
Females	Under 45	-7%	2%	-7%	-2%	-3%
	45-64	2%	-2%	2%	-3%	-2%
	65-84	0%	3%	-2%	3%	-3%
	85+	1%	0%	-5%	-1%	-4%

Note that several of the excess percentages are large (both positive and negative), but they did not deviate from the pre-pandemic trend at the $p < 0.01$ level to be flagged as significant.

4.2.1 CANCER

If cancer screenings and treatments lagged during the pandemic, there should be questions around what impact that may have on mortality and how long any mortality impact will last. The first half of 2022 saw the worst semi-annual excess from cancer for three of our insured cohorts (males and females under age 45 and female ages 45 to 64), so this bears careful monitoring.

Table 18
EXCESS PERCENT OF DEATH RATES FROM CANCER IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	3%	1%	3%	2%	5%
	45-64	2%	-2%	0%	-2%	0%
	65-84	1%	0%	0%	-1%	0%
	85+	-1%	0%	-1%	1%	-1%
Females	Under 45	-4%	-3%	-1%	-5%	6%
	45-64	2%	-1%	3%	-2%	4%
	65-84	1%	1%	1%	2%	1%
	85+	0%	0%	0%	0%	-1%

4.2.2 CARDIOVASCULAR OTHER THAN HYPERTENSION

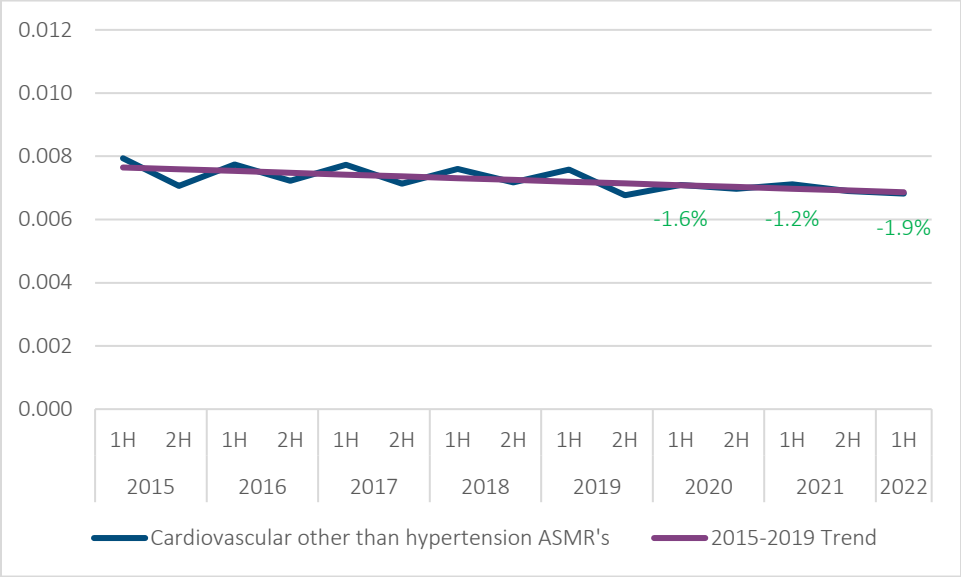
The population increases to this cause did not translate the same to the insured population. In fact, male ages 65 to 84 had three periods of significantly good results.

Table 19
EXCESS PERCENT OF DEATH RATES FROM CARDIOVASCULAR (EXCLUDING HYPERTENSION) IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	1%	3%	0%	1%
	45-64	0%	3%	2%	2%	-1%
	65-84	-2%	0%	-1%	1%	-2%
	85+	-1%	2%	-3%	0%	-2%
Females	Under 45	1%	4%	3%	0%	-1%
	45-64	0%	0%	0%	0%	-2%
	65-84	0%	1%	1%	1%	0%
	85+	0%	1%	-1%	3%	0%

The good results in the male ages 65 to 84 cohort may have been partly due to the general flattening of seasonality that occurred for this and other non-medical causes during the pandemic.

Figure 20
CARDIOVASCULAR (OTHER THAN HYPERTENSION) ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 65-84

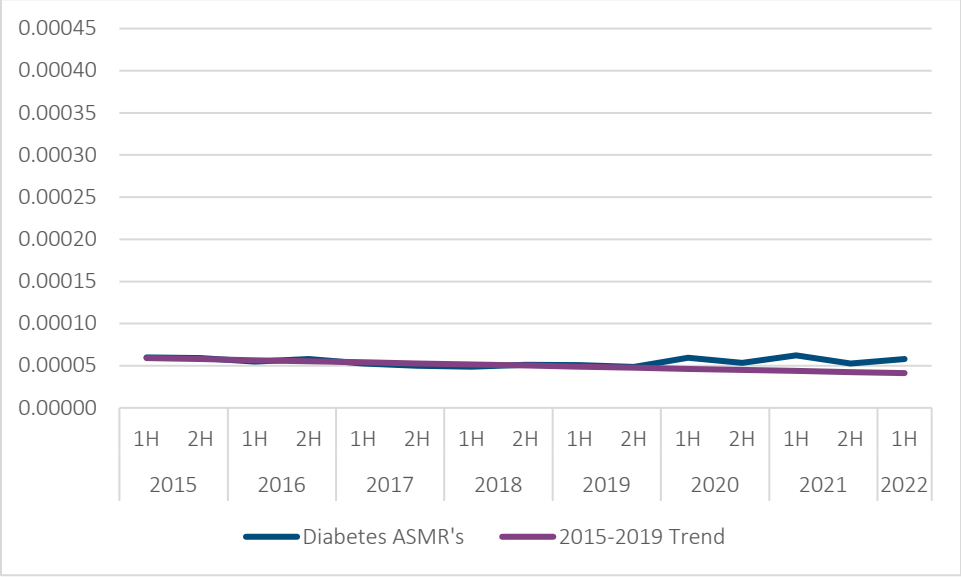


The ASMRs came in steadily during the pandemic periods, but that meant that the first half numbers were lower than the first half trends, while the second half numbers were nearly identical to trend.

4.2.3 DIABETES

Just as in the overall population, diabetes ASMRs were generally worse than trend during the pandemic, but this did not result in a large contribution to excess deaths.

Figure 21
DIABETES ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 45-64



4.2.4 DIGESTIVE

As called out in the U.S. population section, digestive deaths at the younger ages are largely made up of liver disease linked to alcohol misuse. The most impactful results from this cause group to the insured population were in the younger cohorts.

Table 20

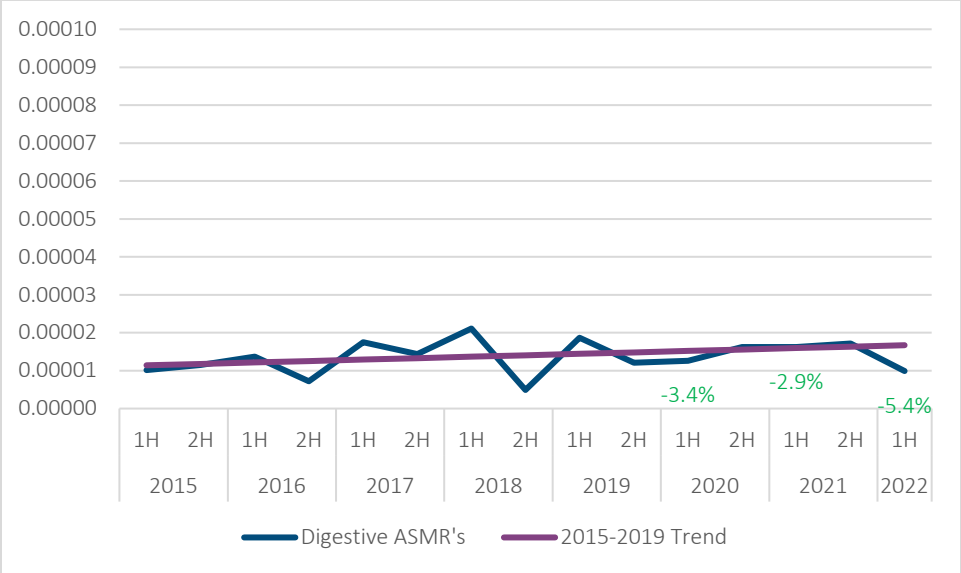
EXCESS PERCENT OF ASMR FROM DIGESTIVE DISEASE DEATHS IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	1%	1%	1%	0%	2%
	45-64	1%	0%	1%	0%	1%
	65-84	0%	0%	0%	0%	0%
	85+	0%	0%	0%	0%	0%
Females	Under 45	-3%	2%	-3%	2%	-5%
	45-64	0%	0%	1%	1%	0%
	65-84	0%	0%	0%	0%	0%
	85+	0%	0%	0%	0%	0%

However, this time it was a good result for females under age 45.

Figure 22

DIGESTIVE DISEASE ASMR'S. FULLY UNDERWRITTEN INSURED FEMALES UNDER AGE 45



The original magnitude was small, but the first half trends had been increasing prior to the pandemic. This meant that the modest decreases in the first half of 2020 and 2022 meant more than a 3% shift to the good in overall mortality.

4.2.5 HYPERTENSION

Hypertension ASMRs in the insured population were much more likely to come in better than pre-pandemic trends than most causes in this study. It is unclear why they would be a candidate for displacement by COVID than another cause, especially since this was not evident in the population results.

Table 21
EXCESS PERCENT OF ASMR FROM HYPERTENSION IN THE INSURED POPULATION DURING THE PANDEMIC

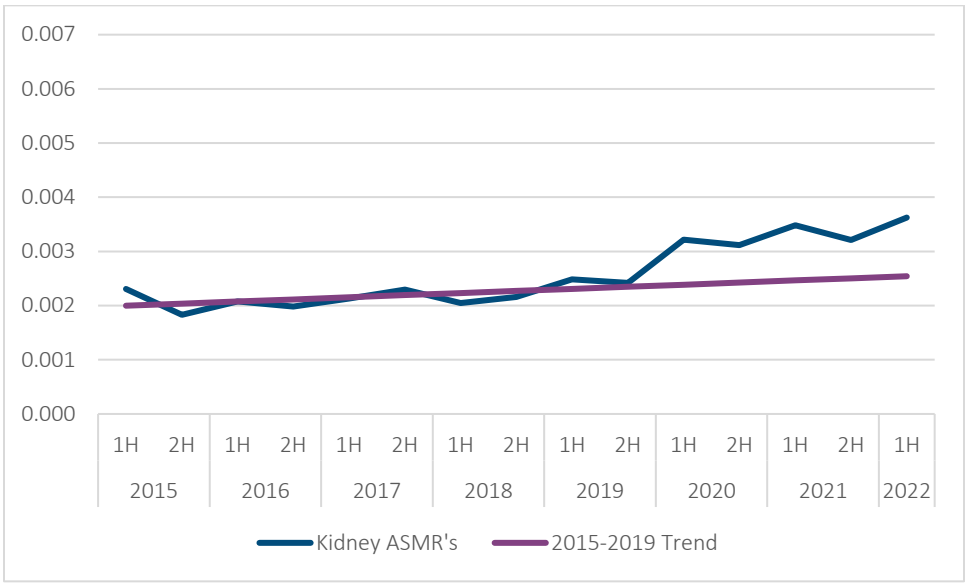
Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	0%	-1%	0%	-1%
	45-64	0%	-1%	0%	0%	0%
	65-84	0%	0%	0%	0%	0%
	85+	-1%	-1%	-1%	0%	-1%
Females	Under 45	0%	1%	0%	0%	0%
	45-64	1%	0%	0%	-1%	1%
	65-84	0%	-1%	-1%	0%	-1%
	85+	0%	0%	-1%	-1%	-1%

In general, this is a cause where the insured and the population have been divergent since this study began. This will be discussed briefly in the section on population-to-insured comparisons.

4.2.6 KIDNEY

Deaths from kidney disease developed similarly to deaths from diabetes. That is, they typically were significantly worse than pre-pandemic trends, but still did not rise to the level of contributing 1% or more excess deaths to all-cause mortality in any semi-annual pandemic period. Insured male ages 85 and older provide a relevant example.

Figure 23
KIDNEY DISEASE ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 85 AND OLDER



4.2.7 NERVOUS SYSTEM

Excess deaths in the insured population in this category were a generally negative contributor to all-cause mortality in the pandemic period. At the younger ages, these were more volatile than older ages, so some large excess values were not flagged as significantly impacted by the pandemic due to their higher volatility during the 2015 to 2019 lead-in.

Table 22

EXCESS PERCENT OF ASMR FROM NERVOUS SYSTEM CAUSES IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	0%	0%	0%	0%	1%
	45-64	1%	1%	1%	0%	0%
	65-84	1%	1%	0%	1%	1%
	85+	2%	3%	1%	2%	1%
Females	Under 45	2%	2%	0%	1%	-1%
	45-64	0%	-1%	0%	-1%	-1%
	65-84	1%	1%	1%	0%	1%
	85+	2%	2%	2%	1%	3%

4.2.8 RESPIRATORY

The impact of COVID deaths on respiratory deaths in the U.S. population appeared to support a case for displacement. In the insured population, the results are less supportive of that hypothesis. Of the seven semi-annual periods with a significant impact, four had significantly lower rates of death and three had significantly higher rates.

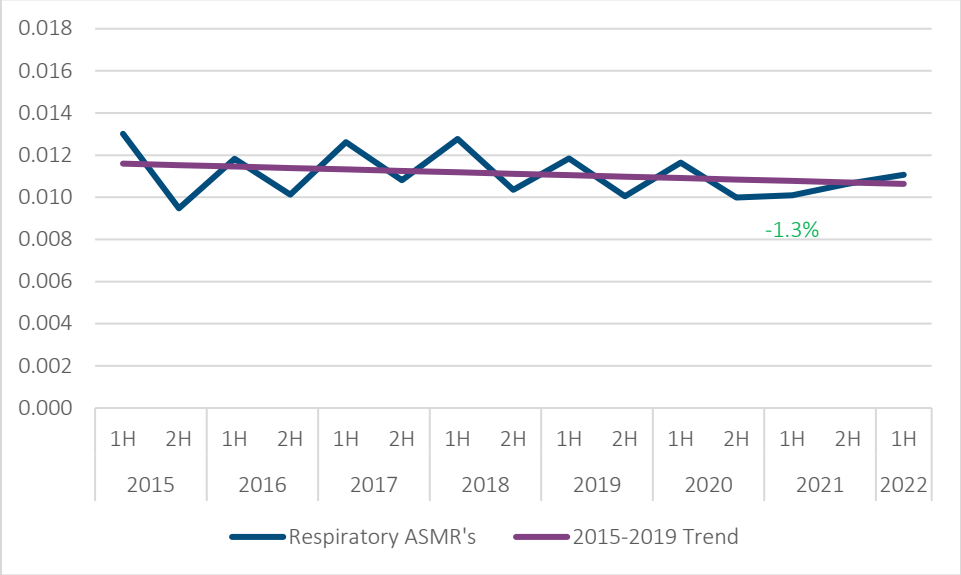
Table 23

EXCESS PERCENT OF ASMR FROM RESPIRATORY DEATHS IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	1%	0%	0%	0%	0%
	45-64	0%	0%	0%	1%	0%
	65-84	0%	0%	0%	2%	0%
	85+	0%	0%	-1%	0%	-1%
Females	Under 45	-1%	0%	-3%	0%	-2%
	45-64	0%	0%	-1%	-1%	0%
	65-84	-1%	0%	-2%	0%	-1%
	85+	0%	0%	-1%	0%	-1%

We still see a flattening of the seasonal trends during the pandemic, which may be a contributor to the lower results in the first half of 2021.

Figure 24
RESPIRATORY ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 85 AND OLDER



4.2.9 OTHER NON-COMMUNICABLE

The insured ASMRs for the causes contributing to the group "other non-communicable" were noteworthy for how consistently low they came in versus pre-pandemic expectations.

Table 24
EXCESS PERCENT OF ASMR FROM "OTHER NON-COMMUNICABLE" CAUSES IN THE INSURED POPULATION DURING THE PANDEMIC

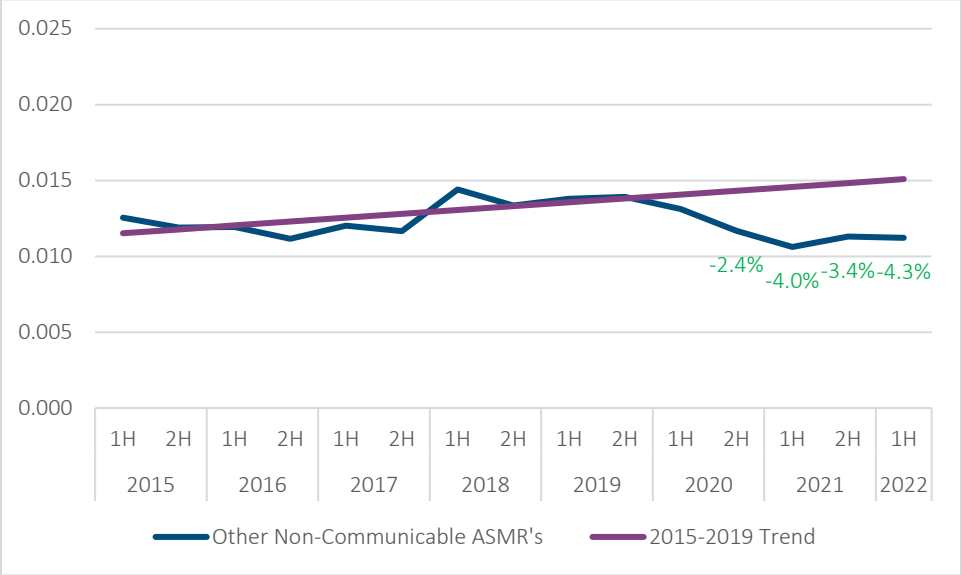
Sex	Age Group	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	1%	-1%	0%	1%	-1%
	45-64	-1%	**-2%**	**-1%**	**-1%**	**-2%**
	65-84	-1%	-1%	-2%	-1%	**-2%**
	85+	-1%	**-2%**	-2%	**-3%**	-2%
Females	Under 45	0%	**-4%**	**-2%**	**-2%**	0%
	45-64	-1%	-1%	-1%	-1%	**-3%**
	65-84	-1%	-1%	**-2%**	0%	**-3%**
	85+	-1%	**-2%**	**-4%**	**-3%**	**-4%**

The U.S. population values were noteworthy because they behaved radically differently but without a clear bias towards being good or bad.

This is a broad mix of categories; for older females – who appeared most impacted – the main driver is non-specific dementia.

Figure 25

"OTHER NON-COMMUNICABLE" ASMR'S. FULLY UNDERWRITTEN INSURED FEMALE AGES 85 AND OLDER



4.3 INSURED COMMUNICABLE (EXCLUDING COVID) DEATHS

The insured study population had more favorable influenza and pneumonia mortality and less favorable mortality from other communicable causes of death compared to pre-pandemic trends.

Table 25

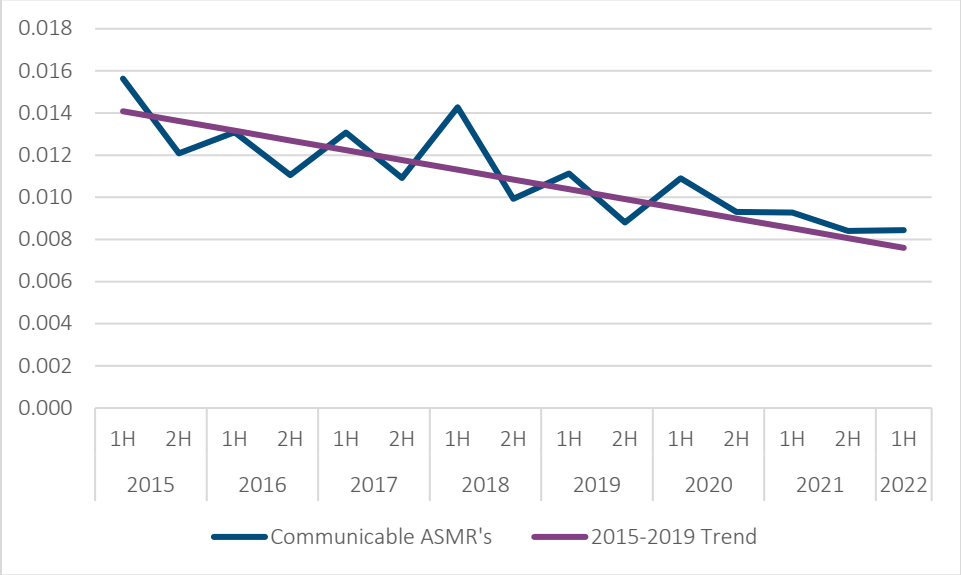
EXCESS PERCENT OF ASMR DUE TO COMMUNICABLE CAUSES (EXCLUDING COVID) IN THE INSURED POPULATION DURING THE PANDEMIC

Sex	Age Group	Cause	2020 1H	2020 2H	2021 1H	2021 2H	2022 1H
Males	Under 45	Influenza & Pneumonia	0%	0%	0%	1%	0%
		Other Communicable	0%	0%	1%	1%	2%
	45-64	Influenza & Pneumonia	0%	1%	0%	1%	0%
		Other Communicable	1%	0%	1%	3%	2%
	65-84	Influenza & Pneumonia	0%	0%	-1%	1%	-1%
		Other Communicable	0%	1%	0%	1%	0%
	85+	Influenza & Pneumonia	0%	0%	-1%	0%	-1%
		Other Communicable	0%	1%	0%	1%	0%
Females	Under 45	Influenza & Pneumonia	-1%	2%	-1%	2%	-2%
		Other Communicable	1%	0%	2%	2%	2%
	45-64	Influenza & Pneumonia	1%	0%	-1%	1%	0%
		Other Communicable	0%	1%	1%	2%	1%
	65-84	Influenza & Pneumonia	0%	0%	-1%	1%	-1%
		Other Communicable	0%	0%	1%	1%	1%
	85+	Influenza & Pneumonia	-1%	0%	-2%	0%	-1%
		Other Communicable	0%	1%	0%	1%	0%

This cause group that is traditionally susceptible to seasonality had that impact muted during the pandemic.

Figure 26

COMMUNICABLE ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 85 AND OLDER



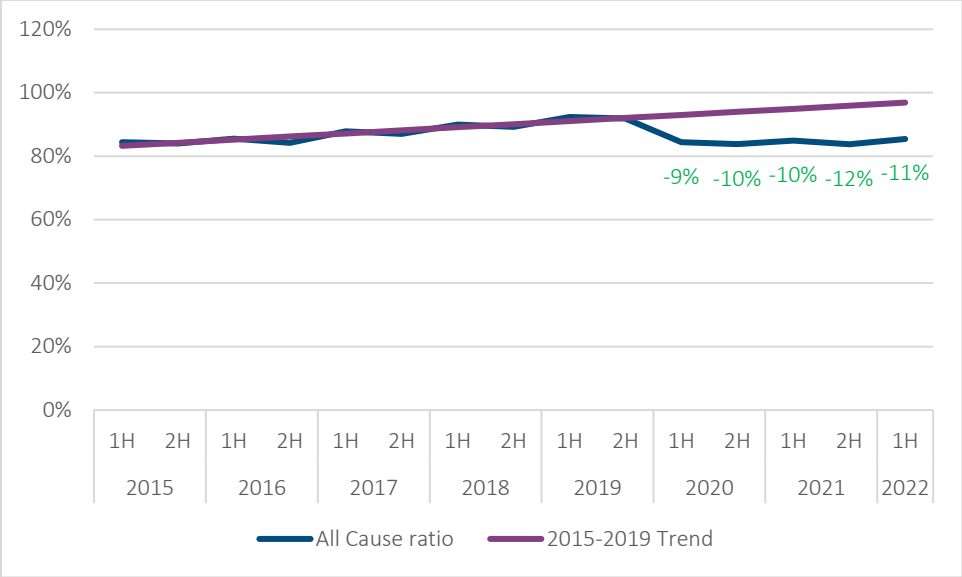
Section 5: Comparing the U.S. and Insured Populations

During the pandemic, actuarial researchers often looked first to population mortality estimates while waiting for claims data to come in. Understanding the relationship between population results and insured results requires comparable data sets. The cause groupings used in this study are the most consistent we could achieve for direct comparisons to the CDC population data. While it is unlikely that they match perfectly, at the very least there is consistency across time periods within cohorts when looking at the insured to population comparisons.

The LIMRA-hosted Tableau dashboard (https://www.limra.com/en/research/dashboards/cause-of-death-2023/) has all comparisons of the type shown below.

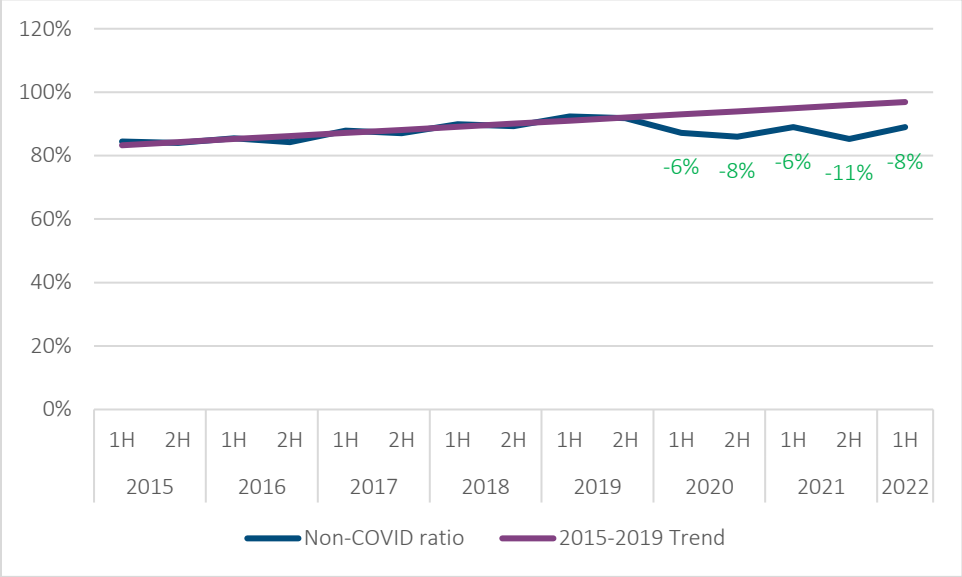
Figure 27

ALL-CAUSE INSURED-TO-POPULATION ASMR RATIOS; MALES AGES 85 AND OLDER



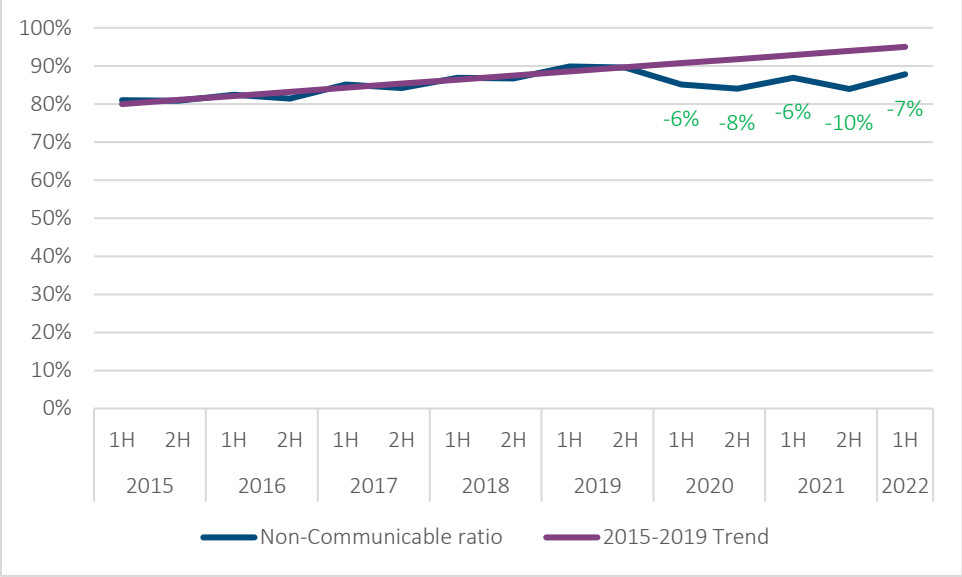
There are eight cohorts and 16 individual causes of death. There are three broad groupings (non-medical, non-communicable, communicable). There are COVID, non-COVID, and all-cause. Drilling down from that all-cause cohort of older males above to see how things differed between the fully underwritten insured population and the U.S. population, we can look at all non-COVID experience, all non-communicable experience, and some specific cause experience in turn.

Figure 28
NON-COVID INSURED-TO-POPULATION ASMR RATIOS; MALE AGES 85 AND OLDER



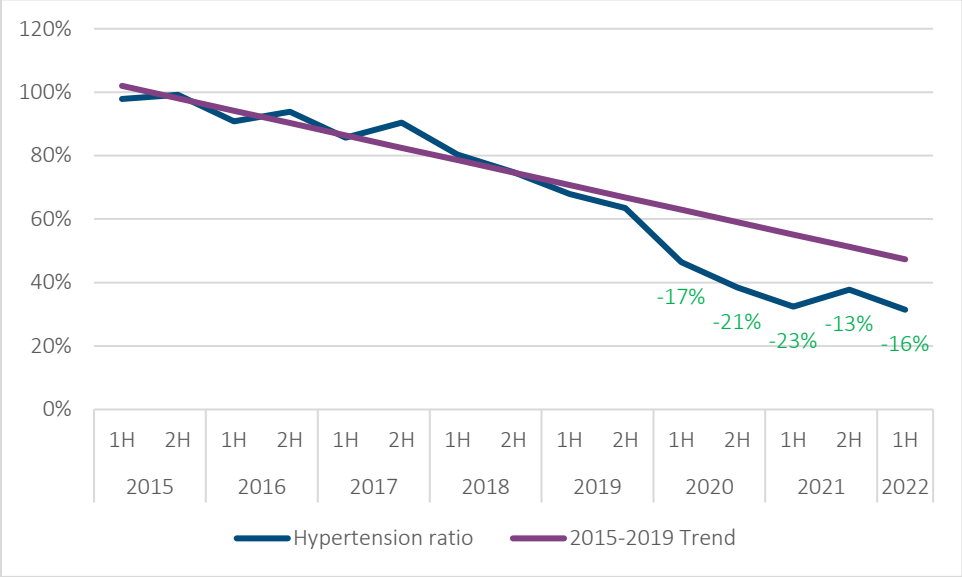
There was clearly improved experience for the insured versus population regarding non-COVID causes. That is, it was not only superior experience against COVID-involved deaths that led to the all-cause gains shown earlier.

Figure 29
NON-COMMUNICABLE INSURED-TO-POPULATION ASMR RATIOS; MALE AGES 85 AND OLDER



The relative improvement for the insured versus population from non-communicable causes was also quite strong.

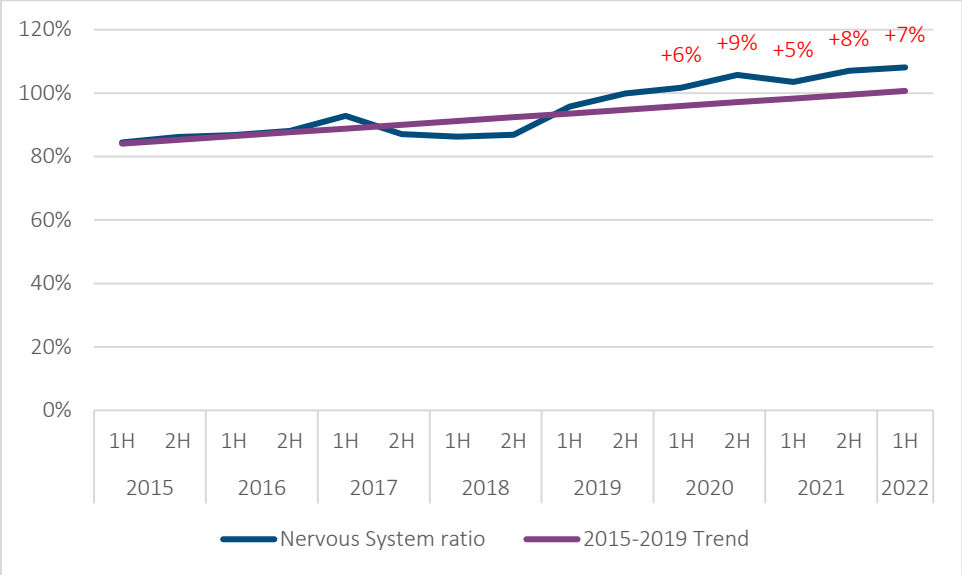
Figure 30
HYPERTENSION INSURED-TO-POPULATION ASMR RATIOS; MALES AGES 85 AND OLDER



Hypertension ASMRs in this age group started out essentially even with the population in 2015 before rapid improvement brought that relationship from 99% to 63% by the start of 2020. After that, the disparity became much more pronounced. Since 2015, the insured experience has been improving and the population experience has been disimproving. In less than eight years, the ratio of insured to population ASMRs for hypertension has gone from 99% to 31%.

If the insured-to-population hypertension ratios came in this much better, then some cause(s) must have been worse. Deaths in the nervous system group of causes certainly qualified.

Figure 31
NERVOUS SYSTEM INSURED-TO-POPULATION ASMR RATIOS; MALE AGES 85 AND OLDER



The ratios had been getting worse prior to the pandemic, and that accelerated during the pandemic to the point where the insured-to-population ratios of ASMRs exceeded 100% throughout.

One question from all this is, what does the new all-cause equilibrium look like for each cohort? The insured did better relative to the population in all eight cohorts included in this study than they had been doing before the pandemic. Will the ratios return to pre-pandemic levels? If so, what will be the driver(s) of that? Is the new equilibrium already in place where the insured cohorts ended up with even better mortality relative to the population than they had prior to the pandemic? Actuaries who use population trends to contextualize the insured population will need to understand the ramifications of these shifts.

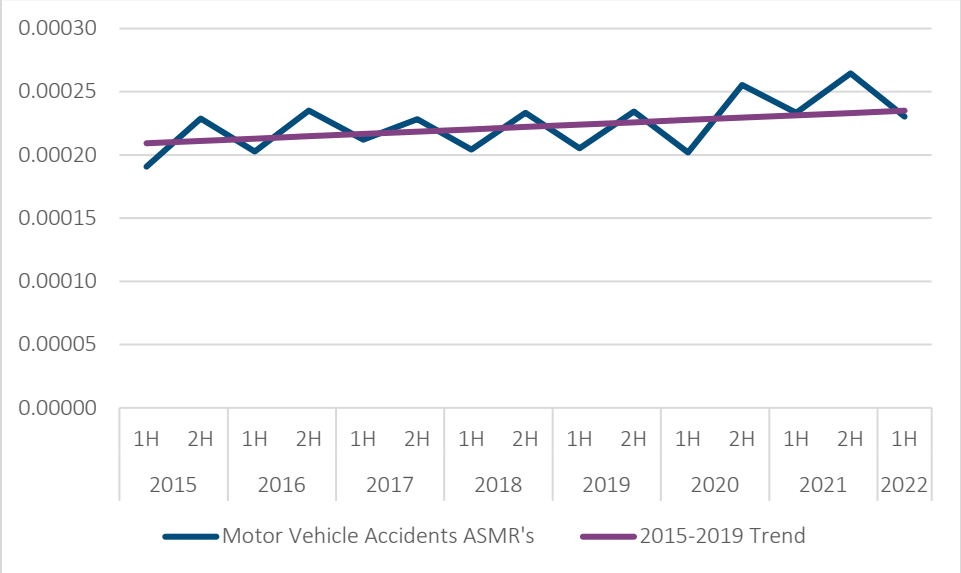
Section 6: Seasonality Impacts and Mortality Improvement

Throughout this report, both in the U.S. population and the fully underwritten insured population sections, there have been instances calling out the flattening of seasonal effects in some causes during the pandemic. This flattening of seasonality was not limited to communicable causes of death; non-communicable causes that had shown clear seasonal patterns prior to the pandemic had far less seasonality during the pandemic. This could have a broader implication in evaluating how much influence seasonality may have on some causes where we do not always emphasize it, such as kidney disease. Understanding the added burden that infections such as COVID, influenza and RSV may contribute to these other causes could improve predictions around future mortality and improvement assumptions.

Motor vehicle accident deaths were more prevalent in the second half of the year and that continued during the pandemic.

Figure 32

MOTOR VEHICLE ACCIDENT ASMR'S. U.S. POPULATION MALE AGES 45-64

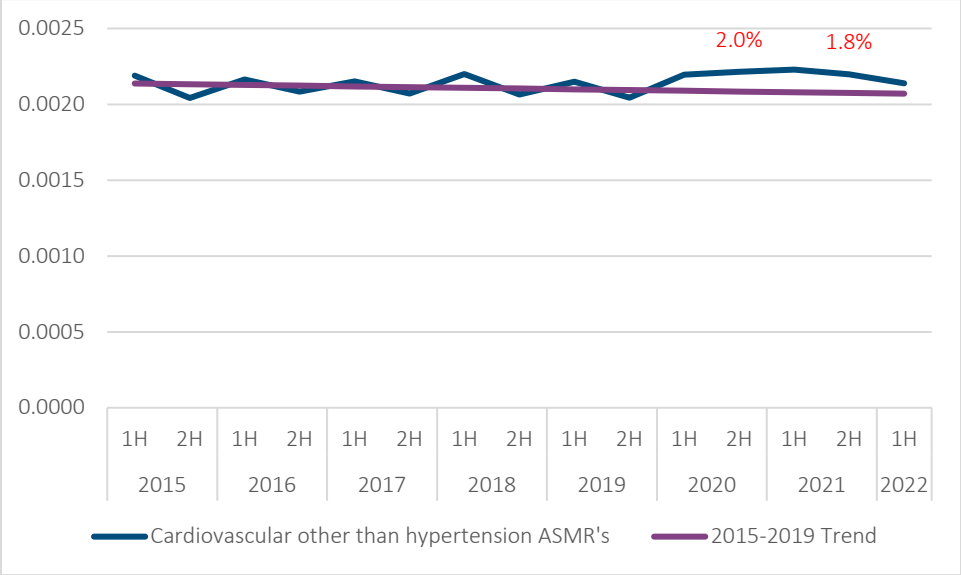


The jagged ASMR pattern where the second half of the year is higher than the first half that immediately precedes or follows it is obvious in the chart for the male ages 45-64 cohort. The increase in deaths coincident with the pandemic is evident. Motor vehicle deaths are the only example of a cause with seasonal patterns that was not muted during the pandemic.

Unlike motor vehicle accidents, medical causes of death with a seasonal pattern prior to the pandemic largely flattened those trends during the pandemic. Most medical causes in the middle aged and older cohorts demonstrate this effect, which can lead to some curious-looking results:

Figure 33

CARDIOVASCULAR (OTHER THAN HYPERTENSION) ASMR'S. U.S. POPULATION MALE AGES 45-64



That same cohort of 45 to 64-year-old males that had a seasonal pattern of motor vehicle deaths also had a seasonal pattern for cardiovascular deaths. This time, it is reversed where the first half ASMRs are higher than the second half results that immediately precede or follow, but notice the pandemic period; the seasonality disappears. All results appear elevated, though the only ones that are flagged are the two second-half results, which are compared to the typically low expectation for this cause during the second half of the years.

There are 11 medical causes of death (besides COVID) in the study. Depending on the age group – it is more pronounced in older ages – all medical causes except cancer and nervous system deaths show clear seasonality impacts prior to the pandemic in the overall population. The seasonality essentially disappeared during the pandemic period for the remaining nine medical causes.

Even influenza and pneumonia deaths that are well understood to be seasonal lost that pattern during the pandemic, though it is still there a bit in the insured results.

Figure 34
INFLUENZA AND PNEUMONIA ASMR'S. U.S. POPULATION MALE AGES 85 AND OLDER

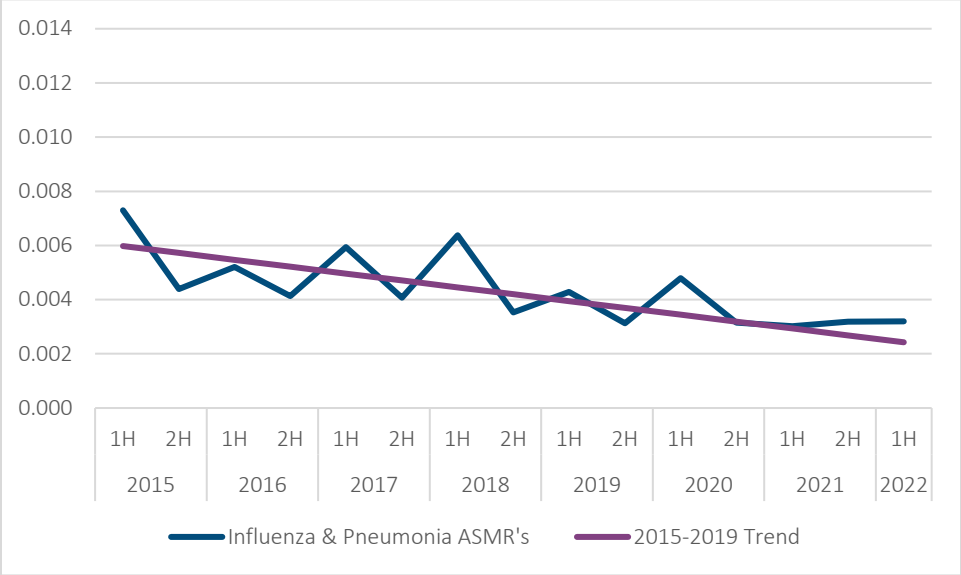
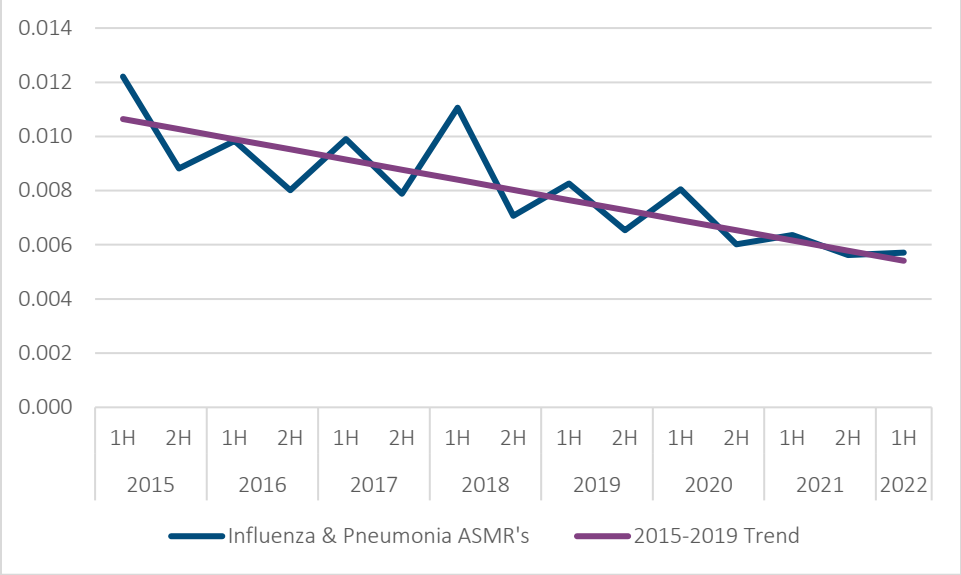


Figure 35
INFLUENZA AND PNEUMONIA ASMR'S. FULLY UNDERWRITTEN INSURED MALE AGES 85 AND OLDER



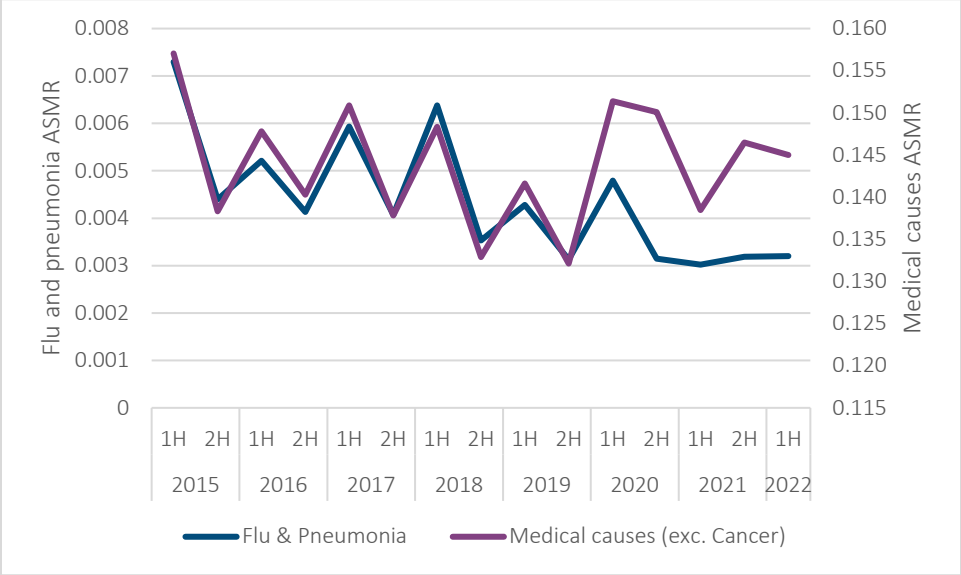
The non-communicable causes with seasonality may contain some information to help develop mortality improvement, especially at the older ages. Mortality improvement is extremely sensitive to small changes. This has been an issue of concern in this study, which essentially uses pre-pandemic trends over a short time frame (2015 to 2019) and trends them into the pandemic period for a comparison point. That trend essentially represents the improvement for whatever cause and/or cohort we were investigating, but five data points, even aggregated and smoothed as we did here, are not very many to project; that is why we have been adamant in including information on confidence bands in our studies. The confidence gets lower as we slice the data in multiple dimensions.

The overall burden of COVID and flu/pneumonia are not well understood, but even the limited evidence available in this study supports the idea that the burden of these viruses extends beyond direct deaths. Understanding the extra impact on all-cause mortality could allow the opportunity to limit the underlying volatility in the rates of death used in mortality improvement calculations. Smoother inputs into the mortality improvement model could yield a cleaner core mortality improvement assumption.

As an example, here are the population ASMRs for male ages 85 and older for two cause groups. The first is simply influenza and pneumonia. The second is the composite ASMR for all medical causes except cancer (and without influenza and pneumonia, of course).

Figure 36

FLU/PNEUMONIA ASMRS OVERLAID WITH OTHER MEDICAL CAUSES. U.S. POPULATION MALES AGES 85 AND OLDER



The correlation between the two lines during the pre-pandemic lead-in is 0.97. Note that the worst influenza and pneumonia season (2015) was also the worst season for the composite group. The best influenza and pneumonia season (2019) was also the best for the composite group. That relationship also held for female ages 85 and older in this study. Those seasonal peaks contribute to overall rates of death that are not always monotonically increasing or decreasing. Modeling mortality improvement using the full rates of death that include seasonal influence may mean *modeling the volatility of seasonal deaths* rather than truly modeling improvement.

Stripping away the volatile components of the rates of death would seem desirable. As actuaries look into modeling improvement in a COVID endemic world, determining a less volatile foundation for the rates of death that are input into their models may be worth considering. Deriving annual core influenza and pneumonia rates of death may be as simple as determining the *minimum* rate from that cause over a short time frame (half year, quarter, or even month) within each year. Determining and removing the burden from influenza and pneumonia imposed on other causes is likely much more complex, but it could lead to better mortality improvement projections if done well.

A running theme throughout this report has been the added burden to other causes of death from post-COVID sequelae. We are now entering a period where that COVID burden will be added to the traditional RSV and influenza/pneumonia burdens, neither of which is well enumerated. We are also in a time where mRNA vaccines are proving promising in lowering the impact from all of those communicable diseases and,

therefore, also lowering the impact of their downstream effects on other diseases. With those factors in play on top of the massive shake-up to mortality in the pandemic period, modeling mortality improvement is more difficult than it has been in decades – and it was never easy to begin with.

Section 7: Accelerated Deaths, Displacement, and Improvement

Accelerated deaths are deaths that occur sooner than anticipated. COVID was the main driver of accelerated deaths during the pandemic, but not the only source as we have hopefully demonstrated throughout this report. Displacement is where one cause displaces another that would have occurred in a similar time period. It is highly likely that COVID displaced some portion of causes rather than accelerating deaths that would have occurred far into the future. For example, respiratory deaths (largely COPD) were one of the few causes that had noticeably better experience during the pandemic than prior to the pandemic. This can be viewed as evidence of COVID displacing a portion of those specific expected respiratory deaths.

We called out the possibility of displaced cancer deaths in the population cancer section even in a situation where cancer deaths come in on trend. This is important because there were so many accelerated deaths in the cohort of 45 to 64-year-old females that seeing no real decrease in the ASMRs to the *leading cause of death* in that cohort could be viewed as a bad result for cancer mortality. That is to say, if COVID displaced cancer deaths, then the cancer ASMRs should have been down significantly. Because they did not decrease, then it could be a sign of poor cancer mortality, but there is also a positive that may arrive from that type of result in a reshaping of the risk profiles of the population.

Underlying health conditions fundamentally affected COVID-related mortality outcomes. For deaths that were displaced in the near-term by COVID, the ASMRs in the displaced causes going forward may be better than expected because the percentage of people in that population with the underlying condition decreased.

With all-cause mortality, the impact of accelerated deaths may eventually show a similar effect. That is, there were well over one million deaths occurring ahead of schedule in the U.S. over a three-year period. Those deaths were more likely striking people with a poor health profile than people in good health. Following that logic, the surviving lives should have undergone a shift to a higher share of people in good health than existed going into the pandemic, and better than what would have been expected had the pandemic not occurred.

These accelerated deaths may then give rise to some period of better mortality improvement than would have otherwise been anticipated in the population. Of course, there is no guarantee of that, and one of the leading strikes against that concept is our still woefully inadequate understanding of the long-term health impacts of COVID on all of the healthy survivors who experienced it. If having fought off COVID is damaging enough to the overall health of the survivors, then any supposed gains from the reapportionment of healthy lives may be washed away.

Section 8: Methodology

This report was created using only cause of death and exposure data. The insured data comes from fully underwritten policies with multiple causes ascribed. Limited underwriting policies have less complete cause of death data and were omitted for that reason. The population data comes from the Centers for Disease Control and Prevention for the deaths and from the Census Bureau for exposures. (CDC WONDER, 2023) (United States Census Bureau, 2023)

Cause of Death Notes:

- The set of 16 causes was designed to make as direct of a comparison to population results as possible from the 20 participant datasets received.
- Most companies in the study were submitting claims as "COVID" death if COVID appeared anywhere on the death certificate.
    - The corresponding population data from the CDC was extracted following the same directive.
    - All "COVID" deaths in this report are more accurately thought of as "Involving COVID" rather than deaths due directly to COVID.
- Most of the 16 cause groups are self-evident by their name, but a few need more explanation:
    - "Other accident" is dominated by drug overdoses at younger ages and by falls at older ages.
    - "Other non-medical" is dominated by homicides.
    - "Other non-communicable" is dominated by "mental and behavioral disorders due to psychoactive substance abuse" at younger ages and by "unspecified dementia" at older ages.
    - "Digestive" includes alcoholic liver disease. Because of this, some users may wish to mentally group those results at least partially with the non-medical "Other accident" category.

Creating an expected basis and excess estimate for each cause/cohort:

- Definitions
    - Exposures: Policy count in the insured data, population count in the population data
    - Rate of Death: Claims divided by exposures in the insured population and deaths divided by exposures in the overall U.S. population
        - Prior to trending, rates of death undergo a smoothing process described later.
    - Standard Exposures: In this study, the exposures we standardize against are the insured population in 2019. That is sex-specific and is the standard for the overall population as well.
    - Age-Standardized Mortality Rate (ASMR): Sum of the products of the rates of death and standard exposures divided by the sum of the standard exposures in a cohort
    - Weighted Age: Sum of the products of the age and the standard exposures divided by the sum of the standard exposures in a cohort
    - Trend: The "trend" is the linear trend of the smoothed ASMR results by cause group, developed over the 2015-2019 period. Separate trends were created for the first and second half of each year.
    - Expected Deaths: The final ASMR applied to the exposures in the pandemic period
    - Excess Deaths: The difference in actual deaths versus the expected deaths
        - This number can be negative.
    - Excess Percentage: The excess deaths divided by the expected deaths, expressed as a percentage.
- Development of Excess Estimates
    - Smoothing the rates of death

        - For each cause and sex-specific five-year age band (for example, female ages 20-24, 21-25, 22-26, etc.):
            - Calculate the ASMR
            - Trend the pre-pandemic ASMRs into the pandemic period for the initial expected
            - Convert the pandemic period ASMR to an excess percentage using the initial expected
            - Calculate the weighted age
    - Use those weighted ages and excess percentages in a new trend calculation that is applied to discrete ages in the pandemic period.
        - Use the nearest data from the five-year cohorts that overlap with the target age.
            - Example: To calculate the excess of a 27-year-old female in 2020, use the weighted age and excess percentages from the age 23-27, 24-28, 25-29, 26-30, and 27-31 female cohorts to develop the forecast that is applied to the discrete age 27.
    - Within each individual age, the excess percentage by cause may be used to back into the excess deaths. The actual deaths that materialized are divided by the excess percentage (plus one), leaving the expected deaths. Subtract that from the actual deaths to calculate the excess deaths.

Calculating the percent of all-cause excess contributed by a cause:

- Use the methodology above (Creating an expected basis and excess estimate for each cause/cohort):
    - Estimate the total excess deaths from a cause in a cohort
    - Divide that number by the total expected deaths from all causes in that cohort
    - Example: In the male under age 45 cohort in the U.S. population in the first half of 2022, the all-cause expectation of deaths was estimated as 95,127. The *excess* from motor vehicle deaths in that cohort was estimated as 1,546. That indicates an excess percentage of 1.6% contributed from motor vehicle accidents.

Some causes of death are naturally more volatile than others from year-to-year, such as influenza and pneumonia. Other causes in this report occur less frequently, such as deaths due to kidney disease. Fewer deaths can mean more volatility. Further, because we are now estimating expected deaths and excess deaths in 2022 based on data from 2015-2019, we need to be cautious in assigning significance and apply higher thresholds to designate a change in a cause as significant.

Assessing significance:

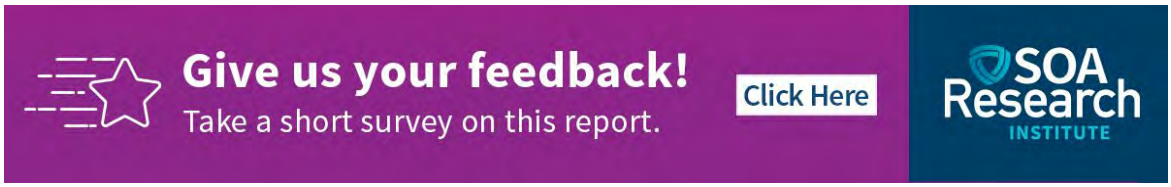
- Two factors must be met for a cause to be called out as significantly altered and impactful.
    - It contributes at least ±1% excess deaths versus expected.
        - This meets the “significantly impactful” threshold.
    - It deviates from its pre-pandemic trend at the $p < 0.01$ level.
        - This meets the “significantly altered” threshold.
        - The trend is a simple linear trend using the 2015-2019 ASMRs by cause group.
        - Pandemic period ASMRs are compared against confidence values at the $p < 0.01$ level to assess divergence.
- Importance in the combination of thresholds:
    - A naturally volatile cause may contribute more than 1% (or less than -1%) excess deaths in a cohort, but if the volatility is within the pre-pandemic expectation, then it is hard to ascribe that impact as strictly occurring due to the pandemic.

- A lesser cause may have a significant increase or decrease in the pandemic period beyond the pre-pandemic $p < 0.01$ confidence intervals, but not have a large overall impact on the excess deaths (kidney disease deaths in people over 85).

Section 9: Reliance and Limitations

No assessment has been made concerning the applicability of this experience to other purposes. In developing this report, the SOA relied upon data and information supplied by the participating company contributors. For each contributor, this information includes, but is not limited to, the data submission for mortality experience and the responses to follow-up questions.

The results in this report are technical in nature and are dependent on certain assumptions and methods. No party should rely upon these results without a thorough understanding of those assumptions and methods. Such an understanding may require consultation with qualified professionals. This report should be distributed and reviewed only in its entirety.



Section 10: Acknowledgments

LIMRA, RGA, the SOA Research Institute, and TAI would like to acknowledge the Individual Life COVID-19 Project Work Group. Without their efforts, this project could not have come to fruition.

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Section 11: List of Participating Companies

We gratefully acknowledge the participation of the following companies that provided data for this project:

AIG Life
Allstate
Amica Life
Global Atlantic Financial Group
Government Personnel Mutual Life
Kansas City Life
Lincoln Financial
MetLife
Mutual of Omaha
Nationwide
Northwestern Mutual
New York Life Insurance Company
OneAmerica
Pacific Life
Principal Financial Group
Prudential Financial
SBLI
Symetra
Thrivent Financial
Western & Southern

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Reinsurance Group of America, Incorporated (RGA), a Fortune 500 company, is among the leading global providers of life reinsurance and financial solutions, with approximately $3.5 trillion of life reinsurance in force and assets of $84.7 billion as of December 31, 2020. Founded in 1973, RGA today is recognized for its deep technical expertise in risk and capital management, innovative solutions, and commitment to serving its clients. With headquarters in St. Louis, Missouri, and operations around the world, RGA delivers expert solutions in individual life reinsurance, individual living benefits reinsurance, group reinsurance, health reinsurance, facultative underwriting, product development, and financial solutions. To learn more about RGA and its businesses, visit the Company's website at www.rgare.com.

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