

Humanity Project - US Cause of Death Project

Summary/Abstract

We investigate trends in death rates from neurological diseases (ICD-10 codes G00-G98) for all age groups in the US using data from the CDC (Centers for Disease Control and Prevention). We also perform a detailed analysis for younger individuals aged 15 to 44. We investigate trends in neurological diseases where these appear on the death certificate under multiple causes (MC) of death, or as the underlying cause (UC), as well as the trends in the ratio of multiple cause to underlying cause death rates.

For individuals aged 15 to 44 we show a rise in excess mortality from neurological diseases reported as the underlying cause of death, with a 4.4% increase in 2020, 10.0% in 2021, 9.9% in 2022 and 8.1% in 2023, with Z-Scores of 4.9, 11.1, 11.0 and 9.0 in 2020, 2021, 2022 and 2023, respectively, indicating highly statistically significant changes, particularly in 2021, 2022 and 2023. When looking at excess neurological disease deaths reported as multiple cause (MC) of death, we observe that these track all-cause mortality rises, registering excess mortality of 11.2% in 2020, 20.6% in 2021, 14.7% in 2022 and 7.1% in 2023, which were also highly statistically significant. However, for excess neurological disease deaths reported as multiple cause of death, once deaths where COVID-19 was also reported are removed, we observe that these follow a very similar pattern of excess deaths to that observed for neurological deaths when reported as underlying cause.

We also show that excess deaths from neurological diseases as underlying cause occurred for most age groups, with the strongest effect in ages 15-44. For individuals 65 and older there appears to be no statistically significant rise in excess mortality. The larger rise of excess death rates from neurological diseases reported as one of multiple causes compared to the underlying cause indicates that some deaths from these diseases are being brought forward by other causes, such as COVID-19-related deaths. Consequently, the rise in neurological disease deaths as underlying cause we report in the paper likely under-reports the described effect, particularly for older individuals.

The results indicate that from 2020 a novel phenomenon leading to increased neurological deaths appears to be present particularly in younger, working age individuals aged 15 to 44, which requires further investigation.

Trends in UC Death Rates from Neurological Diseases in the US for Ages 15-44

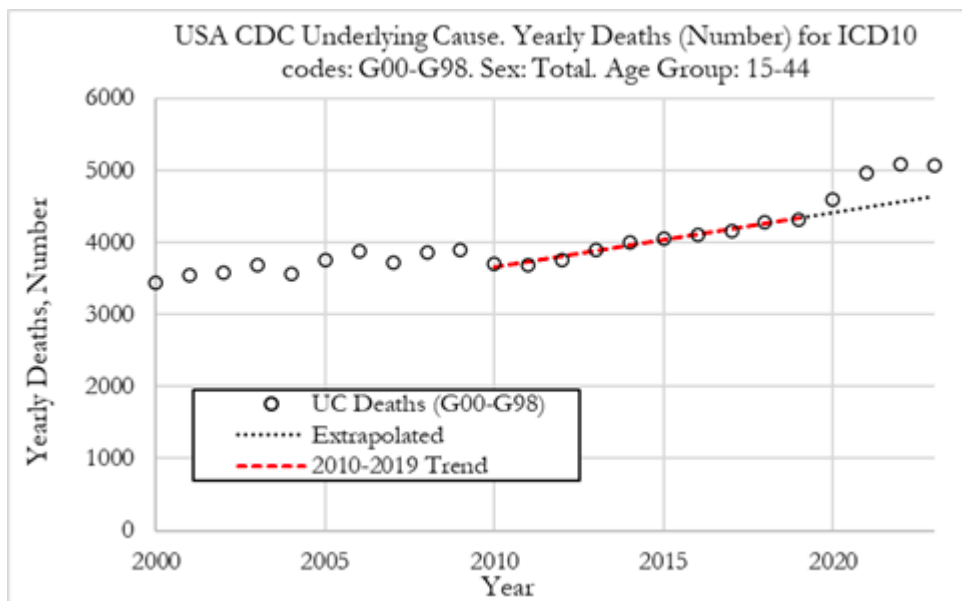
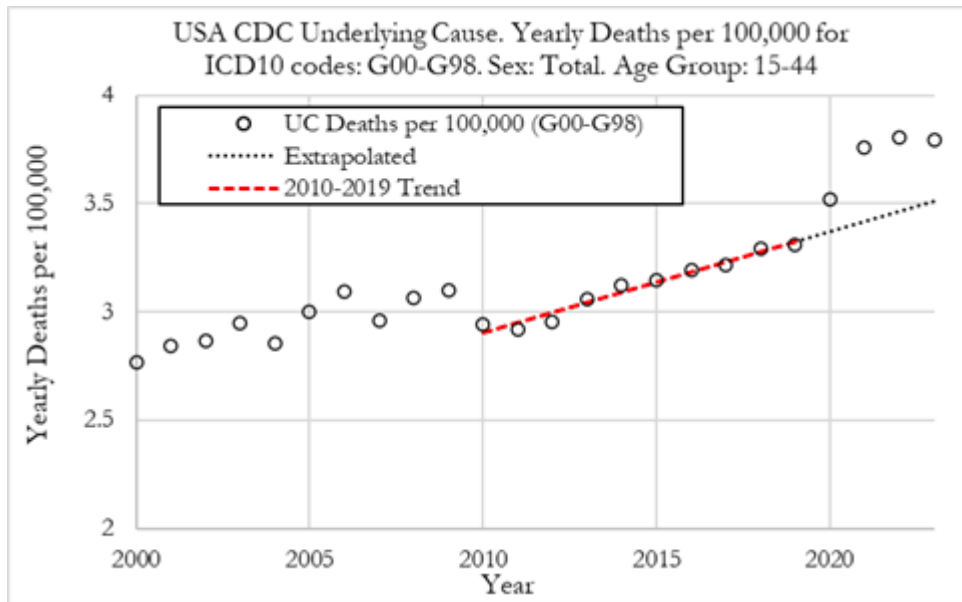
In this section we perform an analysis of the trend in yearly death rates for individuals aged 15 to 44 in the US, using the data from CDC WONDER. In this analysis we use the 2010-2019 trend in deaths per 100,000 (death rates) as the baseline estimate for excess death rates. Excess death rates for the 2010-2019 period are in-sample while the rates for 2020, 2021, 2022 and 2023 are out of sample computations.

In our study we investigate trends in MC (multiple-cause) and UC (underlying cause) deaths rates from neurological diseases, and also, trends in MC* death rates (MC deaths where COVID-19-related death are removed).

To contextualise trends in death rates from neurological diseases, we first analyse the trends in all-cause death rates.

Trends in Death Rates from Neurological Diseases as Underlying Cause (UC) of Death

Figure 3 (left) shows the death rate per 100,000 individuals for deaths from neurological diseases (ICD10 codes: G00-G98) in the US from 2010 to 2023. We can observe that deaths per year from neurological diseases in the 15-44 age group have been trending higher from 2010 to 2019. In 2010 the death rate was 2.94 per 100,000 and in 2019 it was 3.31 per 100,000, a 12.6% rise.



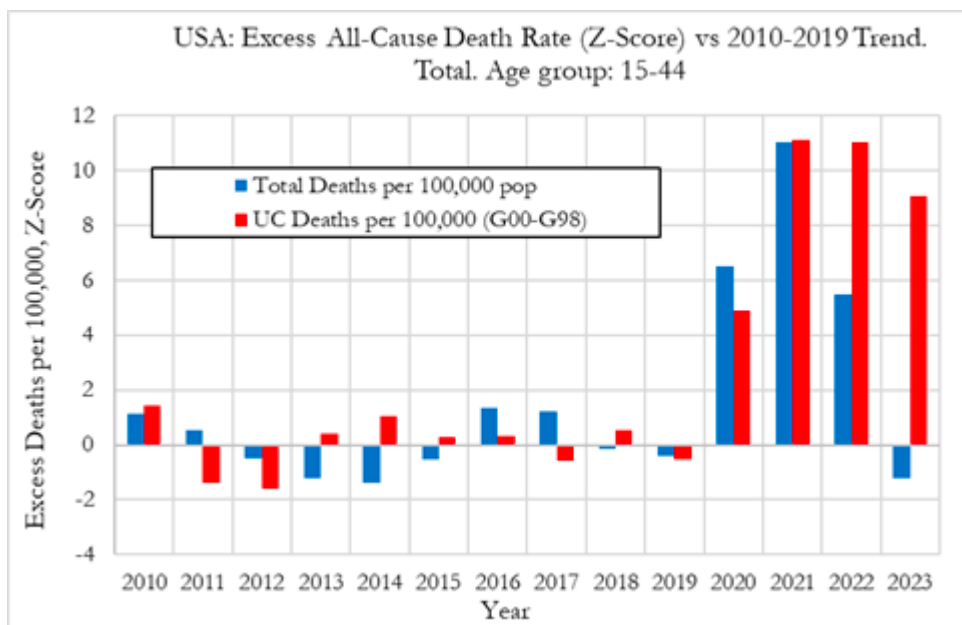
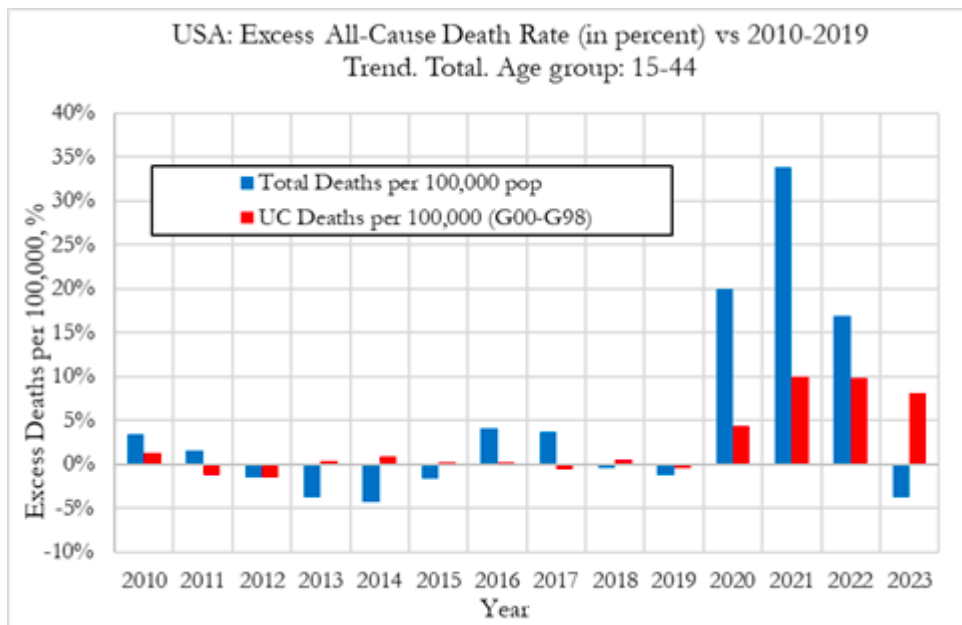
Summary:

The death rate rose in 2020 to 3.52 per 100,000, and then rose again to 3.76 per 100,000 in 2021. In 2022 the death rate rose further to 3.81 per 100,000 and in 2023 it was 3.80 per 100,000.

When presenting these numbers as the absolute number of deaths for diseases from neurological diseases, shown in the Figure (right), we can observe that in 2020 there were 4602 deaths, while in 2021 there were 4963 deaths, 5085 in 2022, and 5070 in 2023.

Analysis of Excess Death Rates from Neurological Diseases as Underlying Cause (UC) of Death

The Figure below shows the excess death rate from neurological diseases as underlying cause in the US, for the 15 to 44 age group from 2010 to 2023. The plots also show the excess all-cause deaths for comparison. The figure on the left refers to relative deviations from the 2010-2019 trend, while Figure on the right shows the Z-score (signal strength) for the deviations from trend.



Summary:

- We can observe that the excess death rates from neurological diseases as the underlying cause (UC) were 4.4% in 2020, then rose to 10.0% in 2021, 9.9% in 2022 and 8.1% in 2023. By comparison, the excess mortality for all-cause deaths was 19.9% in 2020, 33.8% in 2021, 16.8% in 2022, and -3.7% in 2023. Noteworthy is that while excess mortality for all-cause deaths dropped substantially from 2021 to 2022, excess deaths from neurological diseases as the underlying cause remained stable. This trend continued in 2023, with excess neurological deaths remaining high while all-cause excess deaths were negative.
- In terms of the statistical significance of the excess deaths, we observe from the Figure on the right, that the Z-scores for neurological disease death rate deviations from trend were 4.9 in 2020, 11.1 in 2021, 11.0 in 2022 and 9.0 in 2023. The strength of the statistical significance of the excess deaths from neurological diseases was very high, being considered extreme events, indicating a clear change from the prior 2010-2019 trend.

Trends in MC Death Rates from Neurological Diseases in the US for Ages 15-44

In this section we investigate the trends in death rates from 2010 to 2023 where neurological diseases (ICD-10 codes G00 to G98) were reported in one of the multiple causes of death (either underlying or secondary cause of death), for the 15-44 age group of both sexes.

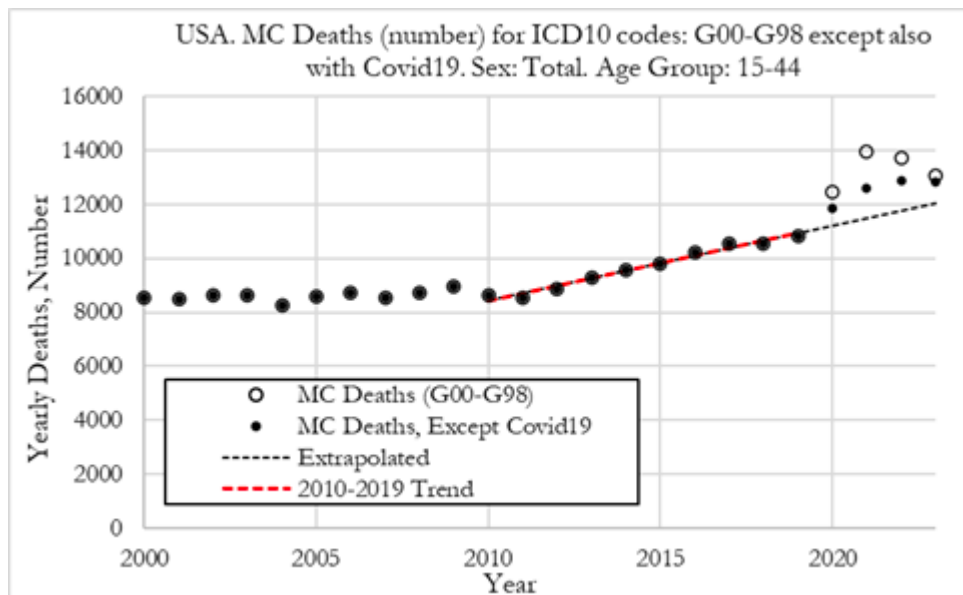
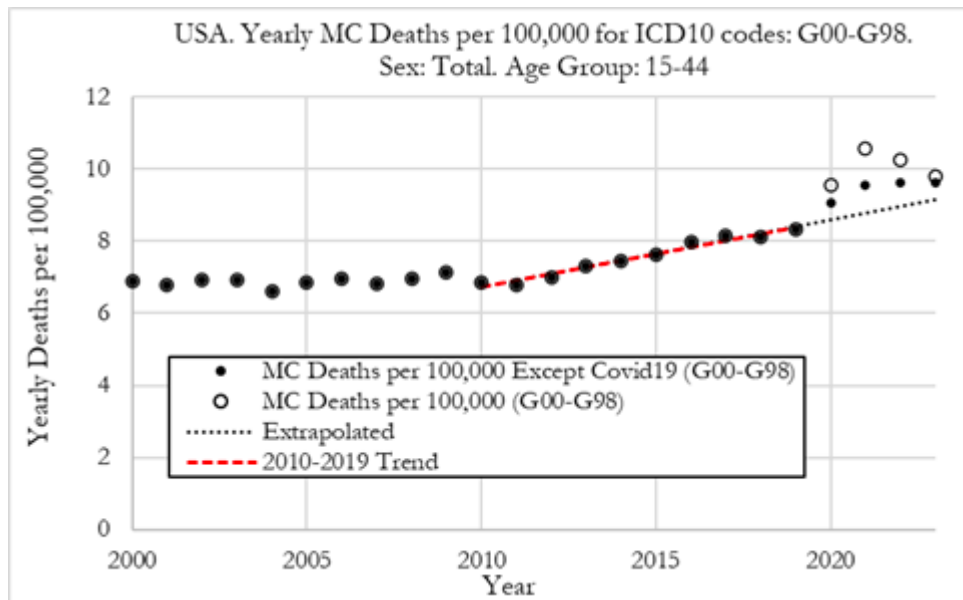
MC deaths rates need to be analysed with a degree of caution as they refer to death rates for a given disease where it is either the underlying cause or a contributing factor towards death. Neurological diseases tend to be contributing causes of death instead of underlying cause which means that MC death rates from neurological diseases could amount to several times the UC death rate.

Nonetheless, by analysing both MC death rates and UC death rates, we can have a better understanding of the underlying phenomena that lead to neurological-related deaths.

Trends in Death Rates from Neurological Diseases as Multiple Cause (MC) of Death

The Figure (left) shows the death rate per 100,000 individuals for deaths from neurological disease in the US from 2010 to 2023, where neurological diseases appear as one of multiple causes of death (either underlying or contributing). The figure also shows the MC* death rates from neurological diseases, which is death rates with neurological diseases as a multiple cause, except where COVID-19 is also reported as the underlying or a contributing cause.

We can observe that MC deaths per year from neurological diseases have been trending upwards from 2010 to 2019. In 2010 the death rate was 6.85 per 100,000 and in 2019 it was 8.32 per 100,000, a 21.5% rise.



Summary:

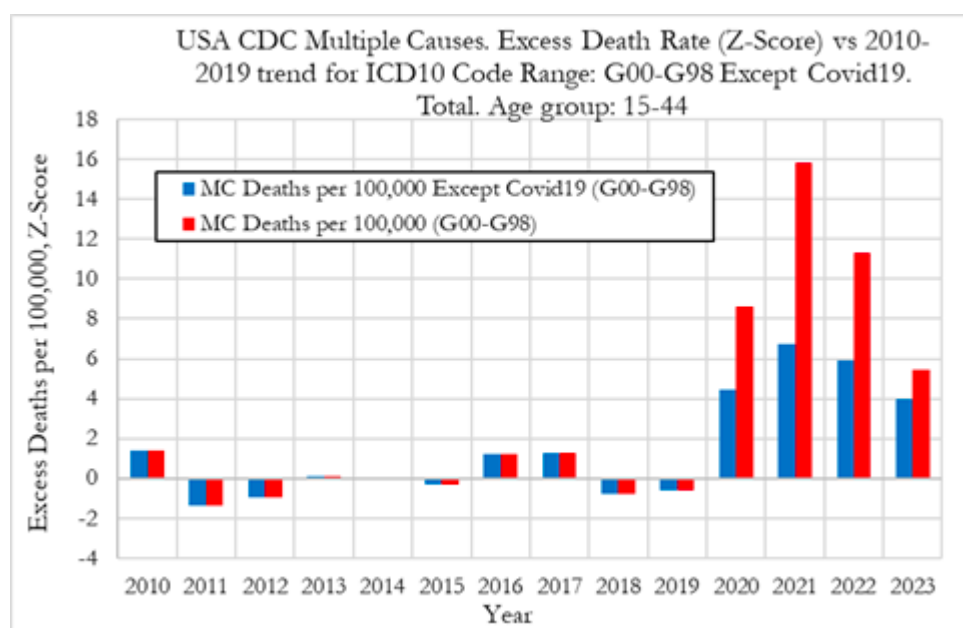
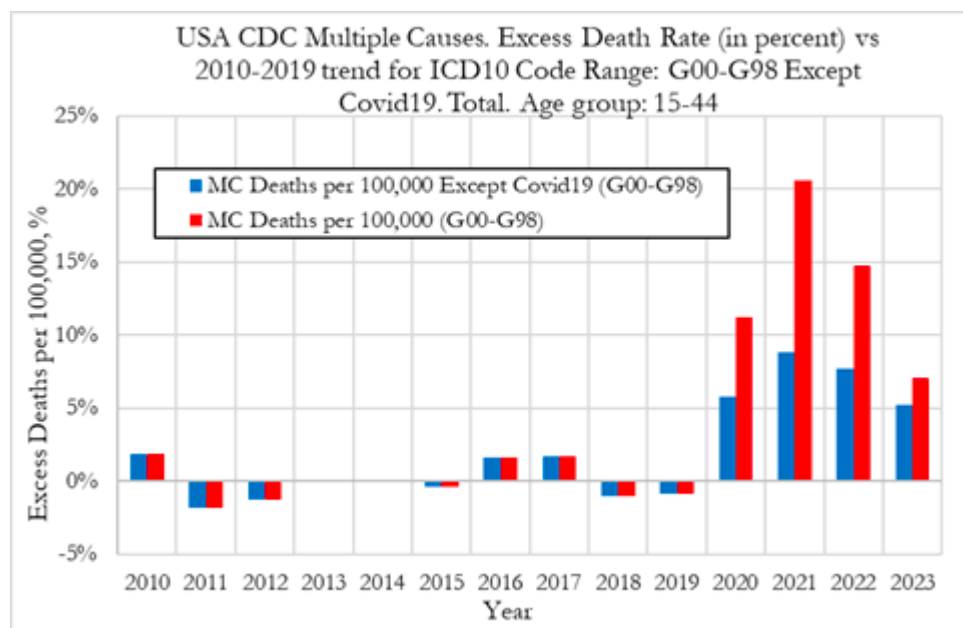
MC death rates from neurological diseases rose substantially in 2020 to 9.54 per 100,000 and then rose to 10.57 per 100,000 in 2021 and then dropped slightly to 10.26 per 100,000 in 2022 and to 9.78 per 100,000 in 2023.

When deaths where COVID-19 was also reported as a cause of death were removed, we observe that the MC* death rates (per 100,000) from neurological diseases were 9.07 in 2020, 9.53 in 2021 and 9.63 in 2022 and 9.61 in 2023. Even after removing COVID-19 related deaths, we observe an increase in MC* neurological deaths in 2020, 2021 and 2022, and a stabilisation in 2023 rather than a reversion to trend.

Analysis of Excess Death Rates from Neurological Diseases as Multiple Causes (MC) of Death

The Figure below compares the excess MC death rates from neurological diseases from 2010 to 2023, while also showing, for comparison, the excess from MC deaths from neurological diseases where COVID-19-related deaths were not counted, for ages 15 to 44 in the US. The figure on the left refers to relative deviations from the 2010-2019 trend, while Figure 6 (right) shows the Z-score (signal strength) for the deviations from trend.

It should be noted that the way excess death rates (either MC death rates or UC cause death rates) are computed, they adjust for prior trends in deaths rates and are also scale-adjusted when relative deviation from trends are computed. We also compute volatility-adjusted (dispersion around the trend) excess death rates which allows us to have an idea of the signal strengths, and which also allows for a direct comparison of excess MC death rates with excess UC death rates.

**Summary:**

- In the Figure (left) we can observe that the excess MC death rates from neurological diseases were 11.2% in 2020, then rose to 20.6% in 2021, before declining to 14.7% in 2022, and 7.1% in 2023. These numbers track the rises in all-

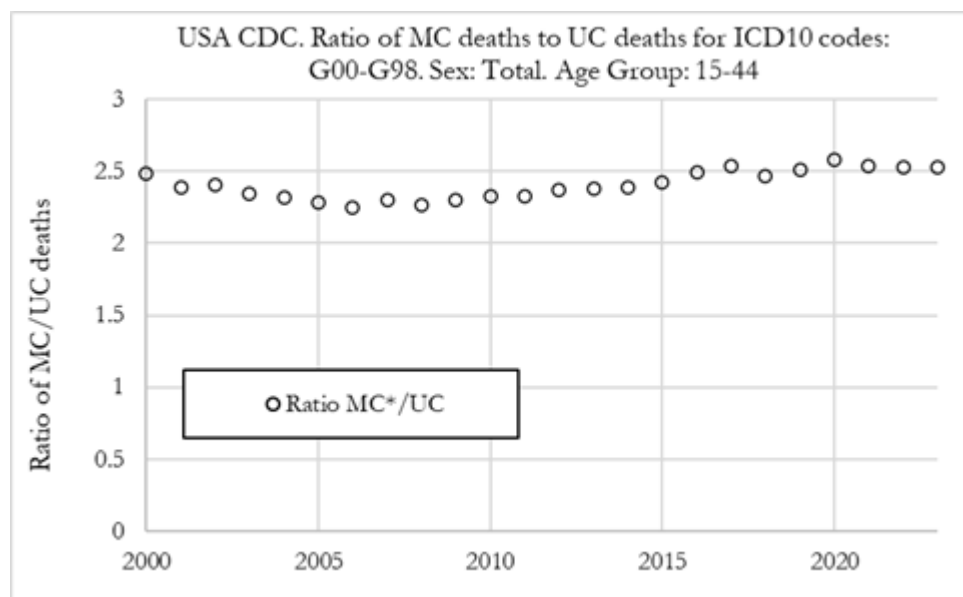
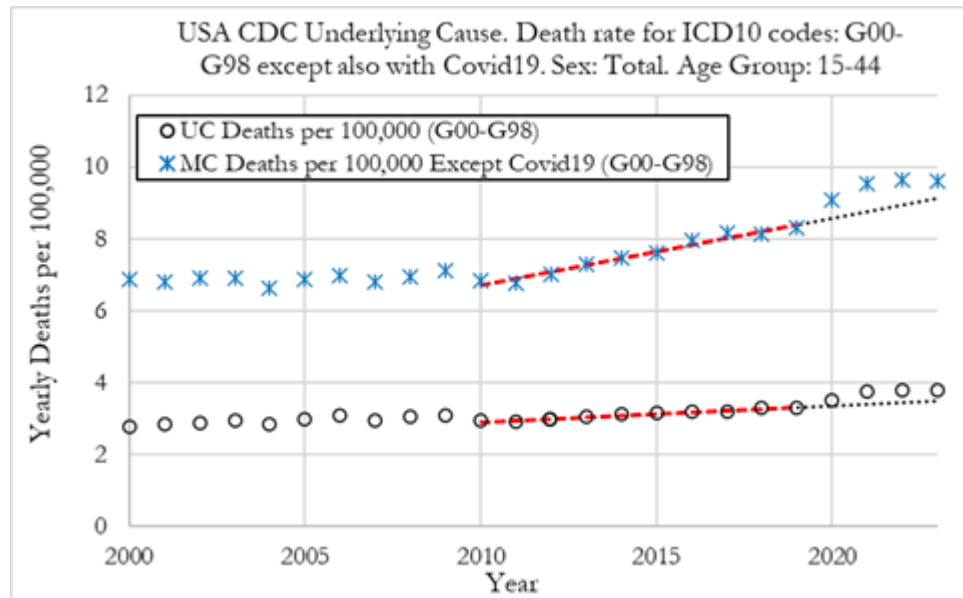
- cause mortality which we mentioned in Figure 4, and are closely associated with COVID-19-related deaths.
- By comparison, the excess MC death rates from neurological diseases where COVID-19-related deaths were removed, were 5.8% in 2020, 8.8% in 2021, 7.7% in 2022 and 5.2% in 2023. Of note is that the rise in excess mortality for MC deaths from neurological diseases where COVID-19-related deaths were removed, exhibited a similar pattern to UC excess death rates from neurological diseases.
 - In terms of the statistical significance of the excess deaths, when looking at excess MC deaths from neurological diseases, the Z-score in 2020 was 8.6, 15.8 in 2021, 11.3 in 2022 and 5.4 in 2023. These are extreme events.
 - In terms of the statistical significance of the excess deaths, when looking at excess MC* deaths from neurological diseases (where COVID-19-related deaths are not counted), the Z-score in 2020 was 4.5, 6.7 in 2021, 5.9 in 2022 and 4.0 in 2023. These values show high statistical significance.

Comparison of MC* and UC Death Rates from Neurological Diseases in the US for ages 15-44

We now compare the trends in MC* death rates and UC death rates from neurological diseases (ICD-10 codes G00 to G98), from 2010 to 2023 for the 15-44 age group of both sexes.

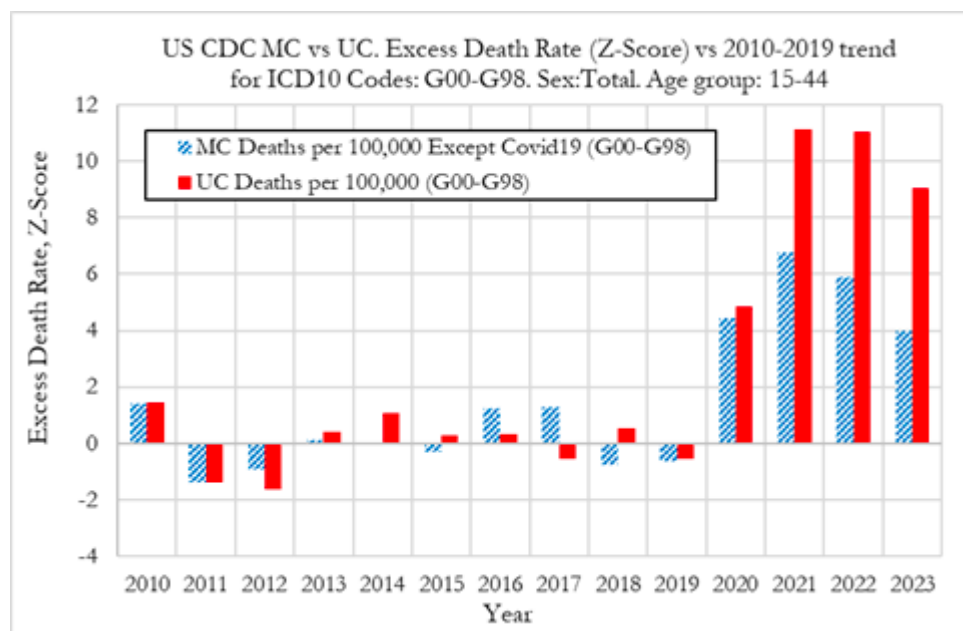
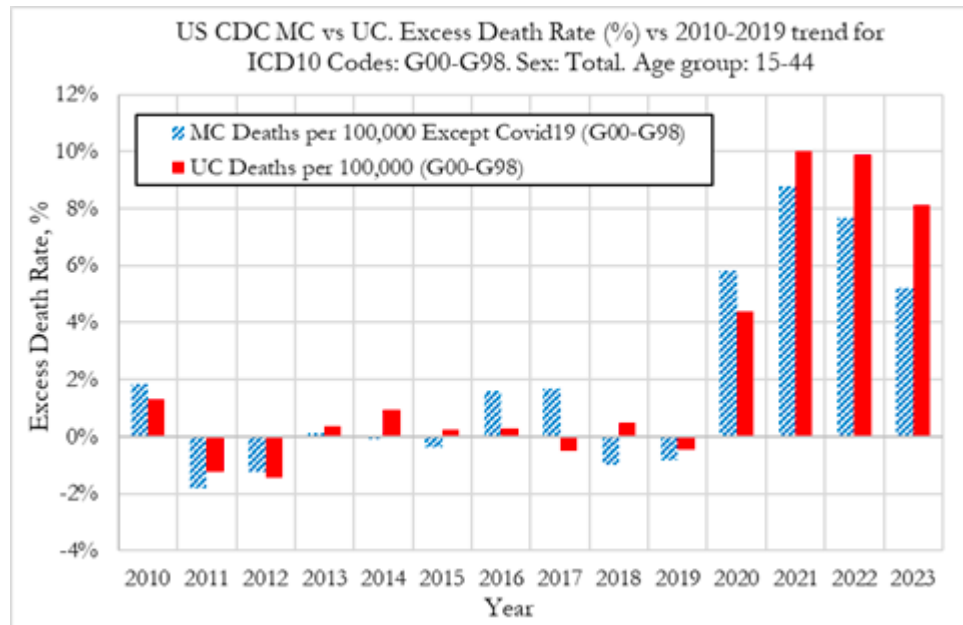
Figure (left) below shows the MC* deaths rates and UC death rates from neurological diseases for ages 15 to 44 in the US, from 2010 to 2023. When comparing UC and MC* death rates, we observe that both have been trending higher from 2010 to 2019.

We also observe that MC* death rates are substantially higher than UC death rates from neurological diseases, as illustrated by the ratio of MC*/UC death rates (Figure - right) which is close to 2.5 across the 2010-2023 period. The ratio did not vary significantly during the pandemic years, 2020, 2021, 2022 and 2023, indicating that both MC* and UC death rates from neurological diseases had similar trends during those years.



This is confirmed in the Figure below that illustrates the excess MC* and UC deaths rates from neurological diseases, which overall show similar pattern of excess death rates in 2020, 2021, 2022 and 2023. In 2020, the excess UC death rate from neurological diseases was 4.4%, while 5.8% for MC* death rate, both having high Z-scores of 4.9 and 4.5, respectively (as shown in the Figure below - right).

In 2021, the excess UC death rate was 10.0% with a Z-Score of 11.1, while for MC*, the excess death rate was 8.8% with a Z-score of 6.7. In 2022, the UC excess death rate was 9.9%, while 7.7% for MC*, with respective Z-Scores of 11.0 and 5.9. In 2023, the UC excess death rate was 8.1%, while 5.2% for MC*, with respective Z-Scores of 9.0 and 4.0.



Interestingly, for comparison, the excess UC death rates from neoplasms for individuals aged 15 to 44 in the US were 1.7% in 2020, 5.6% in 2021, and 7.9% in 2022, with Z-Scores of 3.5, 11.8 and 16.5, respectively, as reported in our previous paper showing an equivalent analysis for neoplasm deaths (Alegria, Wiseman, & Nunes, US -Death Trends for Neoplasms ICD codes: C00-D48, Ages 15-44, 2024).

We conclude that UC neurological disease deaths show a similar pattern of excess death rates as previously reported for neoplasms, with the main difference being that neurological death rates showed larger rises in 2020, a rise that already represented a signal with high statistical significance.

Possible explanations for the change from the historical trend in neurological deaths in 2020, include the collateral effects of the lockdowns on the lifestyle habits of individuals aged 15 to 44, such as alcohol consumption, fentanyl, or other drugs. Other explanations could include COVID-19 side effects that were not recognised or recorded on the death certificates. From 2021 onwards, lockdowns likely played a smaller role in the continued rising excess death rates from neurological diseases, while a new factor was introduced in the form of the novel COVID-19 vaccinations which could have played a significant role, together with enduring effects from multiple SARS-CoV-2 exposures.

Conclusions

- Our results show that the excess UC death rates from neurological diseases for individuals aged 15 to 44 age were 4.4% (Z-Score 4.9) in 2020, then rose to 10.0% (Z-Score 11.1) in 2021, 11.2% (Z-Score 12.4) in 2022 and 8.1% (Z-Score 9.0) in 2023. In 2020 we already observe a significant deviation from the 2010-2019 trend in UC death rates, and the excess UC death rates in 2021, 2022 and 2023 can be considered extreme occurrences due to their very high statistical significance. The results show a clear break from the prior historical trend in death rates from neurological diseases, pointing to a new phenomenon in action, worsening in 2022 and persisting through 2023.
- When analysing excess MC death rates from neurological diseases we show that these were 11.2% in 2020, which then rose to 20.6% in 2021 before subsiding to 14.7% in 2022 and 7.1% in 2023. These numbers track closely the rises in all-cause mortality which we mentioned in Figure 4, and are closely associated with COVID-19-related deaths as was confirmed by the MC* analysis. When analysing MC* death rates from neurological diseases (where COVID-19 deaths are excluded) we show that these followed a similar pattern to UC death rates, suggesting that the rises in excess MC* death rates were driven by the rises in excess UC death rates.
- Of note, the larger rise in MC death rates from neurological diseases when compared with UC death rates implies that there was a pull forward effect due to the early deaths of the most fragile individuals of the 15-44 age group with neurological diseases. Consequently, we would expect that this would lead to lower (or even negative) excess UC death rates from neurological diseases in subsequent years, which was contrary to what has so far occurred.
- How can we explain the excess UC deaths from neurological diseases in 2020, 2021, 2022 and 2023? In 2020, this could be explained by deaths from health effects related to the pandemic management measures such lockdowns and lack of medical care, or other related factors such as stress, less exercise, worse food habits, or from under-diagnosed COVID-19 itself, or related side effects.
- The acceleration in excess death rates from neurological diseases in 2021, 2022 and 2023 is more difficult to explain due to COVID-19 on its own. Given the case studies of neurological adverse events following COVID-19 vaccination cited in the literature, one possible factor could be adverse effects of the COVID-19 vaccines.

Further work:

- Given the literature showing the emergence of neurological diseases following COVID-19 vaccination cited above, future studies should focus on COVID-19 vaccinated and unvaccinated individuals and whether the vaccination rollout or COVID-19-related conditions such as Long COVID are contributing factors to the ongoing rise in neurological-related deaths.
- For a more detailed analysis please read our full paper ([Link to paper](#)).