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Article

# Why COVID-19 Vaccination Cannot be Ruled out as an Explanation for All-Cause Excess Mortality in the Pandemic's Aftermath: A Population-Level Study of over 3000 US Counties with over 320 Million People

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## Abstract

**Background/Objectives:** Research has shown consistent excess all-cause mortality since the COVID-19 pandemic, but without a clear explanation. In parallel, research has shown side effects from COVID-19 vaccination and increased deaths. Therefore, one cannot rule out COVID-19 vaccination as an explanation for the excess mortality. **Methods:** US county-level data were used to model 2022 and 2023 all-cause excess mortality as dependent variables and per capita COVID-19 vaccine uptake by the end of 2021 and 2022 as independent variables. I included lagged dependent variables as controls. The data includes over 3,000 US counties with over 320 million people. **Results:** A one-unit increase in per-capita vaccination uptake was significantly associated with a 0.033 (95% CI: 0.021–.045) increase in 2022 all-cause excess mortality, and significantly associated with a 0.027 (95% CI: 0.021–.033) increase in 2023. Average vaccine uptake was associated with 4.39% (95% CI: 2.78–6.00) higher mortality in 2022 compared to assuming zero vaccine uptake, and 137,900 (95% CI: 89,537–186,262) additional deaths. For 2023, there were 5.16% (95% CI: 4.01–6.31) higher mortality and 151,543 (95% CI: 119,397–183,690) additional deaths. **Conclusions:** COVID-19 vaccine uptake was significantly positively associated with all-cause excess mortality. Given the time asymmetry between vaccine uptake and all-cause excess mortality, the inclusion of lagged dependent variables as controls, the large number of observations, and the strongly significant effects, the study has strong internal validity. I.e., vaccine uptake has genuinely caused increased mortality. Also, the study has strong external validity since it covers almost every US county.

**Keywords:** COVID-19 vaccination; all-cause excess mortality; population level; county; US; SARS-CoV-2

## 1. Introduction

Although COVID-19-related deaths have decreased since the beginning of 2022 [1], the all-cause excess mortality has been consistent [2–4]. Why? One potential reason is delayed diagnosis and treatment during the pandemic, and another is the effects of COVID-19 infection not captured by COVID-19-related deaths [2]. Not ruling out those, in this study, I address whether COVID-19 vaccination has affected all-cause excess mortality as another potential explanation.

My motive is grounded in research showing that COVID-19 vaccination increased the risk of myocarditis [5], which can be deadly [6], and other serious side effects have also been reported [7], including in randomized trials [8]. In line with those studies, “deaths increased significantly (95% CIs) in 10 of 11 weeks after COVID-19 vaccination compared to the first week”, among young people in England, and doubled in three [9, p. 908]. It is finally worth noting that a recent South Korean study showed increased cancer rates among COVID-19 vaccinated compared to unvaccinated [10]. Taken together, the studies indicate that COVID-19 vaccination may have had detrimental health

effects, and accordingly, cannot be ruled out as a potential explanation for the consistent all-cause excess mortality (2-4).

To study whether COVID-19 vaccination potentially explains all-cause excess mortality, requires a population-level unit of analysis. Accordingly, in this study, I analyzed US county-level data, which I elaborate on below.

## 2. Materials and Methods

To model the variables, I used the data from the US Centers for Disease Control and Prevention (CDC) databases concerning county-level population [11], deaths [11], and vaccination uptake [12]. They are publicly available, thereby increasing the study's transparency by making the analyses fully replicable.

### 2.1. All-cause Excess Mortality as the Dependent Variable

All-cause excess mortality is the dependent variable, and to estimate it, e.g., for 2022, I first carried out the following calculations for each county:  $(\text{total deaths in 2022} / \text{population 2022}) / ((\text{total deaths in 2018} + \text{2019}) / (\text{total population in 2018} + \text{2019}))$ . In other words, I used 2018 and 2019 as baseline pre-pandemic years. (Previous years were not available, but an advantage of including the two most recent is that it reduces trend variations. Particularly for counties with low populations, including relatively few pre-pandemic baseline years may—nonetheless—induce some random variation in the denominator, but without systematically skewing the results in any particular direction. Moreover, I shortly explain how both potential trend variation and random variation in the denominator are controlled for.) Next, I multiplied the expression by 100. E.g., a measure of 110 implies 10% positive excess mortality, and a measure of 95 implies 5% negative excess mortality.

If a county reported 1-9 deaths in a given year, the CDC database coded them as missing. For consistency, I also coded 0 reported deaths as missing for a very small number of counties. Missing data in either 2018 or 2019 during the baseline years, I also coded as missing for both years. I.e., if a county had missing data for 2018, 2019, or, for instance, 2022 as the observation year, all-cause excess mortality was coded as missing (for that particular county that particular year).

This study includes all-cause excess mortality in 2022 and 2023, respectively, as dependent variables in two separate models.

### 2.2. Vaccine Uptake as the Independent Variable

The independent variable—counties' COVID-19 vaccination doses per capita—was modeled in the lagged year. I.e., for the 2022 analysis, I included vaccine data reported by the end of 2021, and for the 2023 analysis, by the end of 2022.

Vaccine data were included from counties reporting positive values on Completeness\_pct [12]. To model a proxy for doses per capita, I first summarized the number of doses administered in each county for Administered\_Dose1\_Recip, Series\_Complete\_Yes (which typically includes two doses), Booster\_Doses, Second\_Booster\_50Plus, and Bivalent\_Booster\_5Plus. Next, I divided the number by the population sizes in 2021 and 2022, respectively, and multiplied the result by 100. I.e., per capita vaccine uptake refers to the number of doses administered per 100 people at a certain time point [12]. One county reporting more than 500 doses administered per 100 by the end of 2022 was omitted from the 2023 analysis.

### 2.3. Lagged Dependent Variables as Controls

For the 2022 analyses, I included lagged dependent variables for 2021 and 2020—i.e., all-cause excess mortality in 2000 and 2021—as controls, and for the 2023 analyses, I included lagged dependent variables for 2020, 2021, and 2022 as controls. The motive was that the approach accounts “for historical factors that cause current differences in the dependent variable that are difficult to account for in other ways”, according to Wooldridge [13, p. 315], probably among the most

authoritative voices in econometrics today (for further elaboration, see pp. 415-416). Moreover, including “additional lags yields more accurate parameter estimates” [14, p. 393], Monte Carlo simulations have shown.

To illustrate, counties with abnormally few (many) deaths in 2018 and 2019 have led to estimates of relatively high (low) excess mortality in the following years (cf. the previous discussion of random variation in the denominator), and the inclusion of lagged dependent variables accounts for this. It further accounts for trend effects between the baseline years and the year of observation, e.g., due to counties’ varying demographic projections. Additionally, county-level COVID-19 interventions in 2020 may have had lasting effects on mortality, which are also accounted for by lagged dependent variables.

In other words, lagged dependent variables as controls keep the all-cause excess mortality fixed in the years before the estimation year. I.e., a model estimates the vaccine effect on all-cause excess mortality in, for instance, 2022, while canceling out differences in all-cause mortality between counties in 2020 and 2021. It isolates the vaccine effect of interest. Not doing that would instead increase noise in the data, as counties with high or low all-cause excess mortality in 2020 and 2021 may experience the same in 2022. That would lead to overestimations (underestimations) of counties with high (low) 2022 values.

### 3. Results

Table 1 reports regressions with robust standard errors, weighted by counties’ population sizes. In Model 1, 2022 all-cause excess mortality is the dependent variable, and 2023 all-cause excess mortality is the dependent variable in Model 2. All analyses are done in Stata [15].

#### 3.1. 2022. All-Cause Excess mortality (Model 1)

Model 1 shows that a one-unit increase in county-level per-capita vaccination uptake by the end of 2021 was significantly associated with a 0.033 (95% CI: 0.021–0.045) increase in 2022 all-cause excess mortality (I report crucial numbers in bold). Variance inflation factor (VIF), taking a value of 1.18 (where 1 is the lowest value possible), reported in brackets, indicates no multicollinearity concerning vaccine uptake as the independent variable [cf. 15].

In line with previous arguments, the 2021 lagged dependent variable was positively associated with the 2022 all-cause excess mortality. The effect of the 2020 lagged dependent variable, on the other hand, was non-significant, as the 2021 lagged dependent variable absorbed the effect.

The F-value shows a significant model fit, where the R-sq. is 44.7%. The number of counties in Model 1 is 3,060, with a population of 327,898,854.

Below the bold line, Model 1 reports that the county-population weighted average—i.e., the “overall”—per-capita vaccine uptake by the end of 2021 was 144.3 doses per 100. Using Stata’s margins post-estimation command [16] with that number on Model 1 returned a value of 113.8 (95% CI: 113.4–114.1). I.e., when including control variables, the 2022 all-cause excess mortality was 13.8%, based on the county-population weighted average vaccine uptake by the end of 2021. Assuming zero vaccine uptake, on the other hand, Stata’s margins effects post-estimation function for Model 1 with that number returned a value of 109.0 (95% CI: 107.5–110.5). I.e., the all-cause excess mortality was 9.0% when assuming zero vaccine uptake by the end of 2021.

The findings imply that county-population weighted average vaccine uptake was associated with 4.39% (95% CI: 2.78–6.00) higher mortality compared to assuming zero vaccine uptake. As the US in 2022 had 3,279,857 deaths [17], this implies that the county-population weighted average vaccine uptake was associated with 137,900 (95% CI: 89,537–186,262) more deaths compared to zero vaccine uptake. (The CIs in this paragraph were achieved by using Stata’s [18] nlcom algebra function on the margins post-estimations.)



3.2. 2023. All-Cause Excess Mortality (Model 2)

Model 2 shows that a one-unit increase in county-population weighted—i.e., the “overall”—per-capita vaccination uptake by the end of 2022 was significantly associated with a 0.027 (95% CI: 0.021–.033) increase in 2023 all-cause excess mortality. Variance inflation factor (VIF), taking a value of 1.28 (where 1 is the lowest value possible), reported in brackets, indicates no multicollinearity concerning vaccine uptake as the independent variable [cf. 15].

In line with previous arguments, the 2022 lagged dependent variable was positively associated with the 2023 all-cause excess mortality. The effect of the 2021 lagged dependent variable was lower, but still significant, while the effect of the 2020 lagged dependent variable was significantly negative, likely due to an oscillatory pattern or mortality deficit [19].

The F-value shows a significant model fit, where the R-sq. is 57.4%. The number of counties in Model 2 is 3,067, with a population of 329,420,891.

Below the bold line, Model 2 reports that the county-population weighted average per-capita vaccine uptake by the end of 2022 was 194.3 doses per 100. Using Stata’s margins post-estimation command [16] with that number on Model 2 returned a value of 106.9 (95% CI: 106.6–107.1). I.e., when including control variables, the 2023 all-cause excess mortality was 6.9%, based on the county-population weighted average vaccine uptake by the end of 2022. Assuming zero vaccine uptake, on the other hand, Stata’s margins effects post-estimation function for Model 2 with that number returned a value of 101.6 (95% CI: 100.6–102.7). I.e., the all-cause excess mortality was 1.6% when assuming zero vaccine uptake by the end of 2022.

The findings imply that county-population weighted average vaccine uptake was associated with 5.16% (95% CI: 4.01–6.31) higher mortality compared to zero vaccine uptake. As the US in 2023 had 3,090,964 deaths [20], this implies that the county-population weighted average vaccine uptake was associated with 151,543 (95% CI: 119,397–183,690) more deaths compared to an assumption of zero vaccine uptake. (The CIs in this paragraph were achieved by using Stata’s [18] nlcom algebra function on the margins post-estimations.)

**Table 2.** Regressions with robust standard errors, weighted by counties’ population sizes. The dependent variables are all-cause excess mortality in 2022 (Model 1) and 2023 (Model 2).

|                                                        | Model 1                           | Model 2                           |
|--------------------------------------------------------|-----------------------------------|-----------------------------------|
| Observation year                                       | 2022                              | 2023                              |
| Per-capita vaccine uptake by the end of 2021           | 0.033*** [1.18]<br>(0.021; 0.045) |                                   |
| Per-capita vaccine uptake by the end of 2022           |                                   | 0.027*** [1.28]<br>(0.021; 0.033) |
| Dependent variable in 2022                             |                                   | 0.589***<br>(0.548; 0.631)        |
| Dependent variable in 2021                             | 0.492***<br>(0.450; 0.533)        | 0.152***<br>(.120; 0.185)         |
| Dependent variable in 2020                             | 0.010<br>(-0.024; 0.044)          | -0.086***<br>(-0.115; -0.058)     |
| F-value                                                | 223.6***                          | 522.3***                          |
| R-sq.                                                  | 0.447                             | 0.574                             |
| Number of counties                                     | 3,060                             | 3,067                             |
| Population                                             | 327,898,854                       | 329,420,891                       |
| Population-weighted average per-capita vacc. uptake    | 144.3                             | 194.3                             |
| All-cause excess mort. if vacc. uptake is weighted av. | 113.8<br>(113.4; 114.1)           | 106.9<br>(106.6; 107.1)           |
| All-cause excess mortality if vaccine uptake is zero   | 109.0<br>(107.5; 110.5)           | 101.6<br>(100.6; 102.7)           |
| Pct. change in mort. due to the vaccine                | 4.39                              | 5.16                              |

|                                     |                                     |                                      |
|-------------------------------------|-------------------------------------|--------------------------------------|
|                                     | (2.78; 6.00)                        | (4.01; 6.31)                         |
| Total US deaths                     | 3,279,857                           | 3,090,964                            |
| Change in deaths due to the vaccine | <b>137,900</b><br>(89,537; 186,262) | <b>151,543</b><br>(119,397; 183,690) |

Two-tailed tests of significance concerning the regression coefficients. †  $p < 0.10$ ; \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ . 95% CIs in parentheses. Numbers in bold are of particular interest. Variance inflation factors (VIFs) in brackets concerning per-capita vaccine uptake by the end of 2021 and 2022, respectively.

4. Discussion and Conclusions

US county-level data showed that COVID-19 vaccine uptake was significantly positively associated with all-cause excess mortality in both 2022 and 2023. Further analyses showed that the county-population weighted average—i.e., “overall”—vaccine uptake induced mortality increases of 4.39% in 2022 and 5.16% in 2023 compared to the assumption of zero vaccine uptake. There were 137,900 increased deaths in 2022, 151,543 in 2023, and 289,445 altogether using the same analogy.

Given the time asymmetry between vaccine uptake and all-cause excess mortality, the inclusion of lagged dependent variables as controls, the large number of observations from over 3,000 US counties with over 320 million people, and the strongly significant effects, I argue that the study has strong internal validity. I.e., I argue that vaccine uptake has genuinely caused increased mortality. Also, I argue that the study has strong external validity since it covers almost every US county.

As other research has shown consistent all-cause excess mortality in the COVID-19 pandemic’s aftermath [2–4], this study is a valuable contribution by explaining the observed trend. Another contribution is showing that side effects from COVID-19 vaccination [5,7,8,10] and increased deaths after inoculation [9] are also reflected in increased US county-level mortality.

It is worth noting that COVID-19 vaccination was associated with a higher increase in deaths in 2023 than in 2022, despite lower all-cause excess mortality. It may indicate that COVID-19 vaccination has an extended and increasing effect on mortality, which should motivate similar analyses when later data become available.

A limitation of the study is that it does not clarify the underlying mechanisms at play concerning the observed association between COVID-19 vaccine uptake and all-cause excess mortality, which I encourage future research to investigate. Another limitation is that it does not distinguish between different types of COVID-19 vaccines administered, which I also encourage future research to investigate.

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