THE IMPACT OF COVID VACCINATION ON COVID DEATH RATES

Empirical Evidence from California & Illinois

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Abstract: The purpose of this paper is to analyze the impact of the newly developed COVID vaccine on death rates related to COVID-19. When developing this vaccine, scientists from different pharmaceutical and biotechnological companies such as Pfizer and Moderna contended that their vaccine was more than 90% effective (95% for Pfizer and 94.1% for Moderna) and that it will prevent severe illness, hospitalization, and death. However, in the light of them releasing their methodology, we realized that the 95% efficacy claim was not entirely accurate, which motivated us to conduct further research on the effectiveness of the vaccines based on real-world observations. In evaluating the various objectives of the vaccine, we decided to focus our study on the relationship between the vaccine and COVID death rates. We were therefore interested in testing the impact of the vaccine on COVID death rates in two states, precisely in California and Illinois since both states have one of the highest vaccination rates in the nation. Our findings show that although the relationship is statistically significant as COVID death rates have been decreasing, the vaccine is not responsible for singlehandedly reducing these death rates. Our statistical results led us to conclude that COVID vaccines were not effective enough to unilaterally prevent COVID deaths from occurring despite their high rates of efficacy.

Keywords: *Econometrics, Statistics, Health Policy, Statistical Analysis, COVID-19*

1. INTRODUCTION

In March 2020, a peculiar virus spread throughout the whole world and compelled humanity into a lockdown. This lockdown has tanked the economy of almost every country. To remedy the spread and damages of COVID-19, a vaccine has been developed in late 2020 by several pharmaceutical and biotechnological companies such as Pfizer, Moderna, Johnson & Johnson, AstraZeneca, Oxford, or Sanofi.

In developing the vaccine, Pfizer and Moderna came out as the most effective. The scientists of Pfizer claimed the vaccine they developed is effective at 95% and the scientists of Moderna claim that their vaccine was effective at 94.1%.[1] The COVID vaccine was created for three essential purposes: (1) to prevent illness, (2) to prevent or reduce hospitalizations, (3) to prevent or reduce deaths related to the virus. In assessing the methodology of Pfizer regarding the efficacy of their vaccine, we believe that their approach was inaccurate.

During Pfizer-BioNTech's phase III Clinical trial to have their vaccine approved by the European Medicines Agency, the decision was made to only have 8 participants (7 aged from 16 to 64, and 1 aged 65+) represent the millions who will take the vaccine, compared to the 162 participants who were given the placebo.[2] We firmly believe that a pool of 8 participants is nowhere near enough to accurately represent the millions of people who are meant to take the vaccine. A pool of 8 participants violates the rule of the central limit theorem (CLT) which asseverates that the distribution of sample means approximates a normal distribution as the sample size gets larger regardless of the population's distribution. Hence, the sample size must equal to or be greater than 30 for the CLT rule to apply.

Moreover, in furthering our research regarding the rate of efficacy of these vaccines, we observed that many people still caught the virus despite being vaccinated. The CDC data showed that among the 8,054 people who have been hospitalized or have been victims of fatal vaccine breakthrough, 48% are women, 74% are people who are 65 years old or older, 17% have asymptomatic infections, 94% have been hospitalized, and 20% died.[3] These observations cannot be ignored.

The first vaccines have been administered in late 2020 and early 2021. In California, for example, the first COVID vaccines were administered in mid-December. COVID death rates nationwide, have been declining significantly since mid-January. Some have even speculated that the vaccine is the reason why these death rates have decreasing dramatically. Whether this claim is true or not, the whole vaccine contention has been politicized. Those in favor of the vaccine have argued that the vaccine saves lives and prevents death rates from occurring and doing so would be good to protect others from being exposed. Those who oppose the vaccine argue that this vaccine has been developed rapidly and does not guarantee that one will not catch the virus despite being vaccinated, which therefore appears useless from their perspective. Regardless of where one may stand on this politicized conundrum, the data clearly show that death rates have undeniably declined all across the United States. On January 15, 2021, total COVID deaths were about 3,750 and on August 23, 2021, total COVID death rates were at 185. On the other hand, on January 15, 2021, total vaccination rates were about 3.2% for those who have received at one dose and 0.5%

[1] Katella, Kathy. "Comparing the COVID-19 Vaccines: How Are They Different?" *Yale Medicine.* (2021).
[2] Methodology of Pfizer's Vaccine Procedure. (2020)
[3] Center for Disease Control and Prevention. "COVID-19 Vaccine Breakthrough Case Investigation and Reporting." August 13, 2021.

for fully vaccinated people.[4] On August 23, 2021, total vaccination rates for those vaccinated with at least one dose were 61.4% and 52% for those fully vaccinated.[5] By merely glancing at these numbers, one may be tempted to automatically draw conclusions asserting that the vaccine is responsible for significantly, and perhaps singlehandedly reducing these COVID death rates. Therefore, we were interested in empirically testing the impact of the vaccine on death rates. To be precise, we were interested in verifying if the vaccine is the cause for significantly reducing COVID death rates.

We chose to use the historical data of both states, California and Illinois, for three reasons in order to conduct our statistical test. First, Illinois and California are among the states to have the highest rate of vaccinated people. Second, California and Illinois are among the states to have one of the lowest COVID death rates in the country. Third, we are each resident in those two states.

2. THE MODEL

Our statistical test is based on using two independent regressions. Each regression is attributed to a state. Each regression model contains a variable of interest and three control variables. The control variables are held constant. The model could be written as the following:

$$(1)\ \mathrm{CVD_{CA}} = \beta_{10} + \beta_{11}\%\mathrm{FVAX_{CA}} + \beta_{12}\mathrm{NCVC_{CA}} + \beta_{13}\mathrm{HSP_{CA}} + \beta_{14}\%\mathrm{PST_{CA}} + \varepsilon_{CA}$$

$$(2)\ \mathrm{CVD_{IL}} = \beta_{20} + \beta_{21}\%\mathrm{FVAX_{IL}} + \beta_{22}\mathrm{NCVC_{IL}} + \beta_{23}\mathrm{HSP_{IL}} + \beta_{24}\%\mathrm{PST_{IL}} + \varepsilon_{IL}$$

Identification of variables

- $\mathrm{CVD_{CA}}$, $\mathrm{CVD_{IL}}$ = COVID death rates for California and Illinois, respectively (Dependent variables)
- $\%\mathrm{FVAX_{CA}}$, $\%\mathrm{FVAX_{IL}}$ = Population rate of fully vaccinated people for California and Illinois, respectively (variable of interests)
- $\mathrm{NCVC_{CA}}$, $\mathrm{NCVC_{IL}}$ = New COVID cases for California and Illinois, respectively (control variable 1)
- $\mathrm{HSP_{CA}}$, $\mathrm{HPS_{IL}}$ = Number of hospitalizations for California and Illinois, respectively (control variable 2)
- $\%\mathrm{PST_{CA}}$, $\%\mathrm{PST_{IL}}$ = rate of people who tested positive for California and Illinois, respectively (control variable 3)

Please note that we did not include the population rate of vaccinated people with at least one dose as a variable because it is correlated with the population of fully vaccinated people. Moreover, we selected the population rate of fully vaccinated people because the vaccine can only be effective to its full extent on those who have completed all their required doses.

3. THE DATA

Since we are working with two different states, we, therefore, built two datasets. For California, the data is a sample set of 246 observations (n = 246). It goes from December 15, 2020, to August 17, 2021. The values of the variables were mainly obtained from the California Department of Public Health. For Illinois, the data is a sample set of 211 observations (n = 211), going from January 13, 2021, to August 11, 2021. The reason why the Illinois dataset is slightly smaller than

[4] Center for Disease Control and Prevention. "COVID Data Tracker Weekly Review." August 23, 2021.
[5] Center for Disease Control and Prevention. (August 23, 2021).

California's is that the data for vaccination rate was not available until January 13. It stops on August 11 because the new data for the week was not yet released. The values of the variables were essentially obtained from the Illinois Department of Public Health and the John Hopkins University School of Medicine. For both states, we used the daily observations as our data points to build our cross-sectional data.

4. DESCRIPTIVE STATISTICS

Descriptive Statistics for California

Variables	Obs.	Mean	Median	Std. Dev	Min.	Max.
CVD	246	161.934959	31	220.52208	2	704
%FVAX	246	87952.6951	61550	74072.9599	0	270127
NCVN	246	9955.57724	3257	13744.2548	0	61016
HSP	246	4889.18699	1922	5380.50465	650	17083
%PST	246	11438.7642	3819.5	16207.1587	528	73295

Table 1

Descriptive Statistics for Illinois

Variables	Obs.	Mean	Median	Std. Dev.	Min.	Max
CVD	211	31.0616114	25	29.1680026	0	148
%FAVX	211	26.5691943	29.4	17.6677497	0.6	49.3
NCVC	211	1940.25592	1874	1255.12817	156	6907
HPS	211	1515.74408	1437	765.718045	467	3574
%PST	211	3.68246445	4	1.45032856	1	7

Table 2

The descriptive statistics show that the variables for Illinois are skewed. To avoid that the skewness of our data leads us to misleading results, we will apply the log transformation on the dependent and variable of interest.

5. EMPIRICAL RESULTS AND DISCUSSIONS

5.1.Empirical Results

Regression Output for California

Dependent Variable	R^2	Adjusted R^2	P-Value	F-Statistics	Obs.
CVD	0.96407487	0.96332643	4.227E-171***	1288.11221	246
Variable of interest					
%FVAX	0.30077167	0.2950167	1.3219E-19***	52.2629818	246
Control Variables					
NCVN	0.72323639	0.72210211	5.1854E-70***	637.618791	246
HSP	0.95624293	0.9560636	8.42E-168***	5332.24156	246
%PST	0.6663559	0.66498851	4.3216E-60***	487.318196	246

Table 3

Regression Output for Illinois

Dependent Variable	R^2	Adjusted R^2	P-Value	F-Statistics	Obs.
CVD (log)	0.48179806	0.47173589	1.985E-28***	47.8821066	211
Variable of Interest					
%FVAX (log)	0.38784452	0.38491555	4.6868E-24***	132.416532	211
Control Variables					
NCVC	0.23266684	0.22899539	1.0771E-13***	63.3719134	211
HPS	0.41498493	0.41218581	3.9667E-26***	148.255752	211
%PST	0.12793311	0.12376054	9.1676E-08***	30.6605142	211

Table 4

Note on level of significance: $p > 0.05$ (not significant), $p \leq 0.05$* (significant), $p \leq 0.01$**(very significant), $p \leq 0.001$***(highly significant).

Note on the scientific (E): The (E) that appears within the p-value columns suggests that the value contains an exponent. Usually, this exponent is ($n \times 10^n$). In our analysis, the scientific (E) is followed by the minus sign (−). Therefore, if we take the examples of the p-values of our dependent variables, 4.227E-71 equals 4.227×10^{-171} and 1.985E-28 is equal to 1.985×10^{-28}.

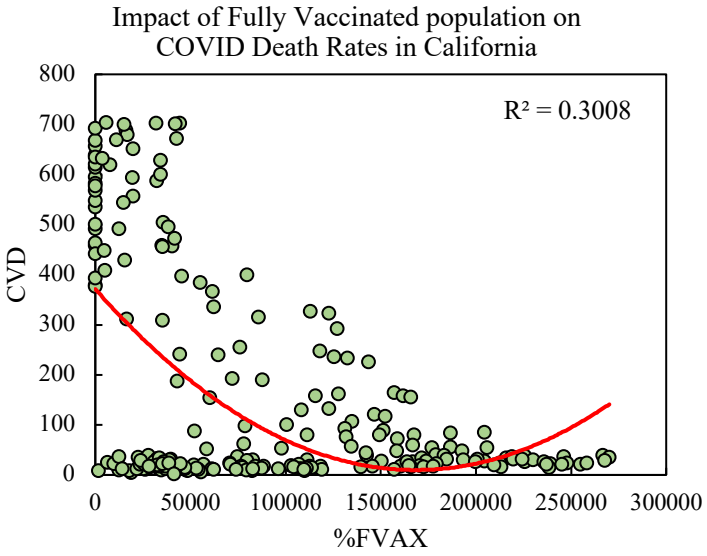

Figure 1

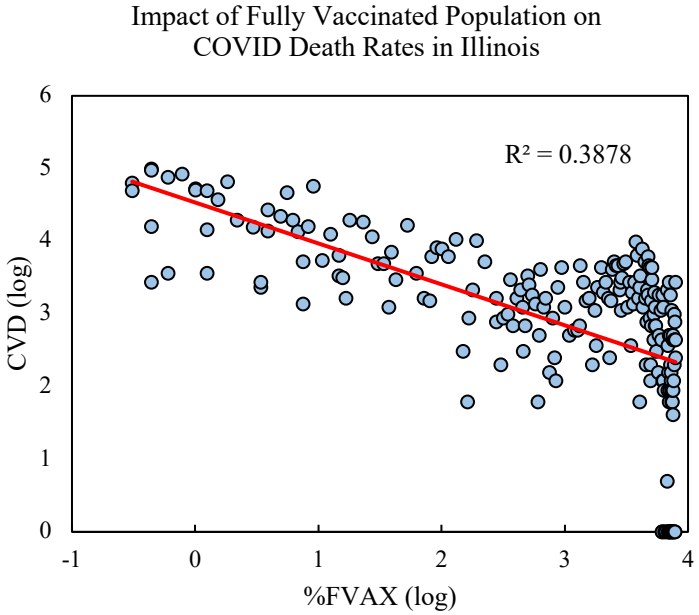

Figure 2

5.2. Discussion

The results of our regressions show that in both states, the variable of interest (rate of the population fully vaccinated) and the dependent variable (COVID death rates) are highly statistically significant. It is clear that there is a correlation between the population fully vaccinated and the reduction of COVID death rates. On this matter, the evidence from our two states shows that the hypothesis that the vaccine reduces COVID death rates is consistent with the data. In both states, we see that the p-value is less than 0.001 ($p < 0.001$). The evidence from our two states also shows, however, that vaccine does not significantly or singlehandedly reduce COVID death rates. Indeed, the data show that the strength of the correlation for California is 30% ($R^2 = 0.30$) and 38%

($R^2 = 0.38$) for Illinois. In both states, we see that the vaccine plays a minor role in either reducing or preventing COVID death rates from occurring. The hypothesis that the vaccine significantly or singlehandedly reduces COVID death rates is not consistent with the data. If the vaccine is not mostly responsible for reducing COVID death rates, then what other factors may contribute to reducing these death rates?

If we look closely at the case of California, we see that the number of hospitalizations is highly correlated with the decrease of COVID deaths. This correlation suggests that the number of hospitalizations in California has been in a sharp decline. Since December 2020, the number of hospitalizations has been decreasing significantly. The number of patients hospitalized with confirmed COVID-19 cases declined 3.1% in early February, to 12,863 and a 41% drop from January 6 peak.[6] The number of patients in intensive care unit beds with confirmed COVID-19 cases also declined 5.6% to 3,432.[7] One of the reasons that led to this decline was the shelter-in-place ordered enforced for a definite period of time. Restaurants and other places reopened in late January, and the number of hospitalizations kept declining sharply. Social distancing measures remained enforced in the Californian public sphere. More than 46,000 people have died in California since the pandemic began last year, more than in any other U.S. state.[8] The state became the first in the United States to surpass 3 million total infections in January.[9] The state has struggled with its vaccine rollout, with 5.8 million shots administered, but vaccinations centers struggled to operate at full capacity due to dose shortages.[10] We are not sure to what extent has the mask mandate been effective in preventing or reducing hospitalization rates in California, but so far, it seems like one of the other reasons is the number of asymptomatic people. Asymptomatic individuals do not need to be hospitalized since they show no symptoms and are therefore considered "non-affected by the virus." Hence a great number of asymptomatic people would necessarily reduce the number of hospitalizations.

For the case of Illinois, the data suggest that the number of hospitalizations is also the most dominant factor in the reduction of COVID death rates. Like in California, the number of hospitalizations has dramatically decreased as well. Interestingly, new COVID cases and the rate of tested-positive people did not much impact the decline of death rates. For the second consecutive week in August, new COVID breakthrough hospitalizations declined in Illinois according to the data from the Illinois Department of Public Health.[11]The state recorded 134 breakthrough hospitalizations over the past week, down from 157 the week prior. The total breakthrough hospitalizations in Illinois are about 1,190, which represents 0.018% of the state's more than 6.7 million fully vaccinated.[12] Besides the vaccine contributing to this decline to a minor extent, Illinois residents have been more cautious of the dangers of the pandemic and have been taking measures to ensure their own safety. The economy has been reopened, but private businesses and public facilities have enforced safety measures as a means to contain the spread of the virus among people. From January 2021 to late July and early August 2021, most states progressively reopened their economy in phases. Illinois entered phase 5 in April and June, which removed capacity limits

[6] Castañeda, Leonardo. "Coronavirus: New cases, hospitalizations keep declining in California." *The Mercury News.* (2021).
[7] Castañeda. (2021)
[8] Bowden, John. "California Coronavirus hospitalizations dropping, death rate holds steady." *The Hill.* (2021).
[9] Bowden. (2021)
[10] Bowden. (2021)
[11] Illinois Department of Public Health, "COVID-19 Statistics." August 25, 2021.
[12] Sahly, John. "New Illinois COVID-19 breakthrough hospitalizations decline for the second straight week." *Shaw Media.* (2021).

and restrictions on all sectors of the economy, with "businesses, schools, and recreation resuming normal operations with new safety guidelines and procedures," according to state officials.[13] Conventions, festivals, and large events would also be able to resume, according to the Illinois Department of Public Health. The implementation of the phase process by restricting gatherings to a small number of people appears to be an effective measure in containing the spread of the virus and reducing the number of hospitalizations.

6. THE ECONOMIC & SOCIAL IMPACT OF THE VACCINE

The impact of the vaccine is not solely limited to its healthcare and medical dimension. It also has an economic and social impact on society. The federal, state and local governments have been advocating for the vaccine to become mandatory in order to do basic life activities such as going to restaurants or going to the movies. For example, New York City Mayor, Bill De Blasio enforced a law by decree obliging New York City residents to be fully vaccinated if they want to do their basic daily activities.

This law would require the vaccinated person to always have a vaccine passport if he/she seeks to eat out, watch a movie, or doing any other type of social activity. Restaurant owners and staff would be required to check at the entrance the identification card and vaccination proof of the customers. This will require additional resources to be spent on security guards. This measure could lead to the foreclosure of many restaurants because many customers will be disincentivized from wanting to eat out. They would rather stay home or go to another city nearby where restaurants will not have the same COVID restrictions as New York. This will create unemployment and a substantial decrease in consumer demand in the food and entertainment industry.

Moreover, this law requires all New York City Department of Education employees to have received at least one dose of a coronavirus by September 27, 2021. The city's vaccine requirement, which applies to roughly 148,000 education workers, is also almost certain to be the harbinger of future mandates around the country for school districts, municipal employees, private business, and federal government agencies in the days and weeks to come, following the Food and Drug Administration's approval of the Pfizer-BioNTech vaccine for those 16 and older in late August.[14] This vaccine requirement comes with severe consequences. Mayor De Blasio announced last July that educators who did not comply with the vaccination or testing requirement would be suspended without pay, and a similar consequence is likely for those who refuse to be vaccinated under the new mandate.[15] Such measure would eventually increase unemployment because a suspension would potentially lead to a termination. On a social ground, such a law is contradictory to the principles of liberty on which this country was found. If there was any empirical evidence proving that the vaccine singlehandedly reduces the rate of COVID deaths, then it would be more comprehensible to perhaps go the extra mile to ensure total safety despite the use of drastic measures. In the current situation though, drastic measures about the vaccine are being taken while there is no evidence to show that the vaccine significantly reduces death rates.

[13] Editors, "Illinois Coronavius Updates; State Hits Low in Hospitalizations 50% Adults Vaccinated." *NBC Chicago.* May 2021.
[14] Shapiro, Eliza. "Educators will be First N.Y.C. Workers to Face Full Vaccine Mandate." *The New York Times.* August 23, 2021.
[15] Shapiro. (2021)

7. CONCLUSION

The quintessential purpose of our analysis was to empirically verify the relationship between the vaccine and death rates related to COVID-19. We used two predominant states of the U.S. economy to measure our hypothesis since these two states had the lowest death rates as well as one of the highest rates of fully vaccinated population.

Our findings clearly show that the vaccine is not highly correlated with the reduction of COVID death rates in these two states. Instead, the vaccine only plays a minor role in this steady decline of COVID death rates. Since the number of hospitalizations was a significant factor in reducing COVID death rates, we could infer that the fate of most of the hospitalized confirmed-COVID patients was the one who determined whether death rates would increase or decrease. The more hospitalized people there are, the higher is the likelihood that COVID death rates will surge.

We can evidently not use our results to infer that the vaccine plays a minor role in reducing COVID death rates in the other 48 U.S. states. We can only speak with a certain degree of certainty with our results for our own states since they are the ones on which we conducted our analysis. Notwithstanding, our analysis paves the way for more statistical analyses to be performed on the other 48 remaining states. This analysis invites other researchers, statisticians, econometricians, and scientists interested in this topic to also perform the same investigation for their respective states.

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15. Shapiro. (2021)