ESTIMATING THE VALUE OF STATISTICAL LIFE (VSL) LOSSES FROM COVID-19 INFECTIONS IN THE UNITED STATES

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ABSTRACT

This paper uses the Value of Statistical Life (VSL) literature to weigh the costs and benefits of non-pharmaceutical interventions of the U.S. COVID-19 stay-at-home orders that affected 92 percent of the U.S. workforce at their peak in April 2020. We calculate the pre-vaccine COVID-19 infection fatality rate to have been 0.85 percent. We find that the stay-at-home orders saved most likely about 71,000 lives and led to a net benefit to the United States of 1.7 percent of GDP after accounting for lives saved and drops in workforce participation. Through October 31, 2021, the VSL of U.S. lives lost to COVID-19 was over $8.4 trillion.

Journal of Economic Literature Codes: G22, I1, I18, J31, J65, K32

Keywords: death rates, CFR, COVID-19, IFR, non-pharmaceutical intervention, NPI, SARS-CoV-2, social distancing, stay at home orders, VSL

INTRODUCTION

In this paper we model the benefits of social distancing measures in terms of the value of statistical lives (VSL) saved in the SARS-CoV-2 or COVID-19 pandemic. We find that the unprecedented state stay-at-home orders at their peak affected over 92 percent of the workforce. Those stay-at-home orders were likely economically justified in terms of the value of lives saved. Nevertheless, the cost benefit analysis is not positive in all scenarios. The U.S. state-level stay-at-home orders that stretched from March 11, 2020, to June 14, 2020, most likely led to net economic benefits of about 1.7 percent of 2019 U.S. GDP or $368 billion and saved over 71 thousand lives. The range of the net benefits was about $1.7 trillion to -$0.4 trillion.

Prior to pharmaceutical treatments becoming available, economically costly social distancing interventions as advocated by Ferguson *et al.* (2020) were one of the few tools available to suppress COVID-19. By the start of November 2021, COVID-19 had claimed the lives of over 745 thousand Americans or about 0.2 percent of the pre-pandemic population. There is some evidence that social distancing may be effective. RT is the number of additional persons that an infected person goes on to infect on average. Rocklöv *et al.* (2020) estimate that uncontrolled RT for COVID-19 on the Diamond Princess cruise ship was 14.8 before social isolation and 1.8 afterward. Chowell *et al.* (2011) argued that school closures in Mexico reduced

[1] The views expressed are of the author alone.

the RT of the H1N1 outbreak by more than 30 percent. Fowler *et al.* (2021) found that stay-at-home orders that lasted over three weeks suppressed COVID-19 cases by 48.6 percent.

By April 7, 2020, we found that 92 percent of the U.S. population was under a stay-at-home orders that meant that many businesses were shuddered. Morath and Chaney (2020) report that by April 16, 2020, 13 percent of the U.S. workforce or 22 million workers had filed unemployment insurance claims. The COVID-19 multi-state stay at home orders, and associated non-essential business shutdowns, began with Alaska, on March 11, 2020, and ended with New Hampshire on June 14, 2020. Before the SARS-CoV-2 disruptions, the U.S. unemployment rate stood at a record low 3.5 percent in February 2020, according to the Bureau of Labor Statistics.

Eichenbaum *et al.* (2021) estimate that containing COVID-19 "optimally" with social distancing will lead to consumption dropping by 22 percent versus 7 percent without containment of the virus. Since consumption is about 68.1 percent of GDP, according to the St. Louis Fed, and 2019 GDP was $21.43 trillion, they are arguing macroeconomic consumption losses are about (0.22 – .07)*$21.43 trillion = $3.2 trillion. We find more modest losses from the March to June 2020 stay-at-home orders, which were relatively short in duration. Without considering the benefits in terms of lives saved, the ninety-six days of stay-at-home orders cost about $0.4 trillion according to our calculations.

Yale News (2020) estimated the daily losses of shutdowns at $19 billion per day or about $7 trillion per year. Our estimates of the daily costs of stay-at-home orders were less. We find in this paper that, on a workforce weighted average basis, the U.S.A. had about 44.1 days of stay-at-home orders, which cost U.S. output worth $4.7 to $14.8 billion per day.

We also find that the number of deaths and value of statistical life (VSL) losses are extremely high from high rates of COVID-19 infection in the range of $5.2 to $11.5 trillion by October 31, 2021. Thus, major economic disruptions from social distancing, stay at home orders, and school closures could be justified if they in fact prevent illness and death. Nevertheless, the emergency approval of the first COVID-19 vaccine in the U.S.A. on December 11, 2020, has likely made more costly social distancing interventions harder to justify economically.

In section 2, we discuss how to value human life with the value of statistical life (VSL) literature and estimate the economic cost of the COVID-19 pandemic. In section 3, we estimate the infection fatality rate (IFR) of the SARS-CoV-2 virus from the U.S. Centers for Disease Control's (CDC's) large serology studies. In section 4, we weigh the expected VSL of lives saved from the March to June 2020 stay-at-home orders against the lost economic output from those partial economic shutdowns. Finally, in section 5 we conclude.

VALUE OF STATISTICAL LIFE LOSSES

To weigh the costs of social distancing measures, we need to be able to estimate the value of human life. Clearly, we cannot stomach sacrificing all of society's resources to save one life and let 99.99999 percent of the world starve to death. There must be some price at which saving a human life is too dear. The value of statistical life (VSL) literature says we should value human life at the rate that individuals value their own life. An individual chooses between a risky job and a safe job or a risky product and a safer product. This choice trades money for a small probability of death. VSL = (extra money gained)/(extra probability of death). For example if an individual gains $4,000 from a 1 in 2,000 probability of death, then VSL = $4,000/(1/2000) = $8 million.

This is a large literature that O'Brien (2018) does a good job of introducing the reader to. We selected the studies that looked at a range of ages at least as large as 18 to 62. Selected studies reviewed by O'Brien (2018) are in table 1. We only selected studies with a minimum age of persons studied of 18 or lower. All selected studies had to have a maximum age of 62 or higher. In addition, we only selected studies that had a range of VSL estimates. The upper and lower bound estimates of the selected studies Johannesson *et al.* (1997), Aldy and Viscusi (2003), Viscusi and Aldy (2007), Aldy and Viscusi (2008), and Kneisner, Viscusi, and Ziliak (2006) are in table 1. Our lower bound estimate is the average of those studies' lower bound, $5.75 million. The upper bound average VSL estimate is $12.57 million. The average of the upper and lower bound is $9.16 million. The inflation multiple from the Bureau of Labor Statistics from 2009 to 2020 is 1.2218. Thus, in 2020 dollars our low, expected, and high VSL estimates are $7.0 million, $11.2 million, and $15.4 million.

Table 1: Value of statistical life (VSL) studies upper and lower estimates in 2009 U.S. dollars

Study	Lower VSL in 2009 US Dollars	Upper VSL in 2009 US Dollars	Age Range Studied
Johannesson et al. (1997)	$4.83	$7.48	18-74
Aldy and Viscusi (2003)	$4.00	$10.42	18-62
Viscusy and Aldy (2007)	$7.30	$15.35	18-62
Aldy and Viscusi (2008)	$4.22	$9.70	18-62
Kneisner, Viscusi, and Ziliak (2006)	$8.42	$19.92	18-65
Average	**$5.75**	**$12.57**	

Source: O'Brian (2018)

This is a subset of the studies of the value of statistical lives (VSL) in O'Brien (2018)'s Table 1 which are in 2009 prices. We selected the studies that at least looked at an age range that started no higher than 18 years old and had a top age no lower than 62 years old. There had to be an upper and lower bound to the VSL estimates cited in O'Brian for a study to be selected. A simple average of the five studies lower and upper bounds were taken. The average of the average upper and lower bound was calculated as our VSL expected estimate.

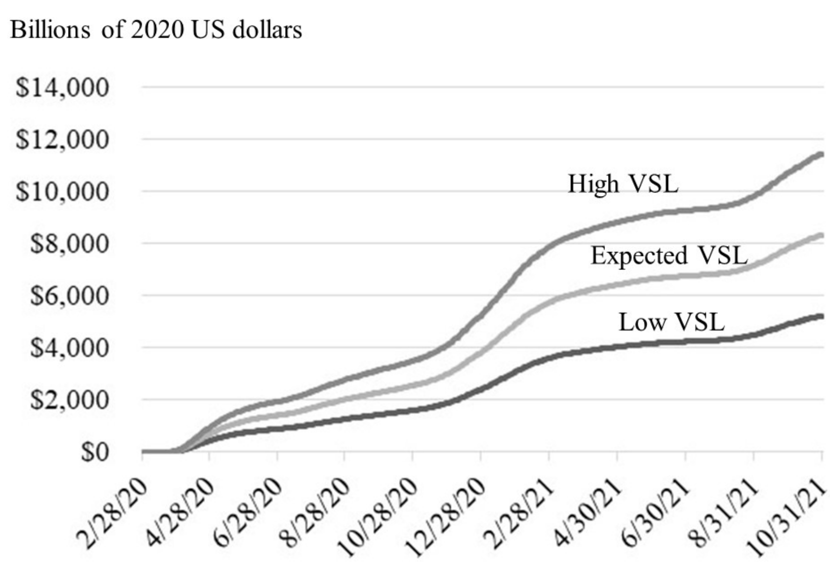
O'Brien (2018) points out that many studies, including O'Brien (2018), find an inverted U-shape that seems to conform to people's valuations of their lives depends on their current income. The young and post-retirement persons have lower VSL's than persons in their peak earning years. Unfortunately, most studies do not track VSL into the 70s, 80s, and 90s because employment choices are the most common method of calculating VSL. Thus, we don't have a good idea of how much the VSL of a person in their 50s differs from someone in their 90s. Nevertheless, VSL does not track closely with life expectancy because we see VSL increasing from the 20s to the 50s while life expectancy declines.

For simplicity, we do not distinguish between age and VSL. Our low, expected, and high estimates do not differ between age categories. Thus, a 90-year-old man with a life expectancy of 4.1 years has the same VSL as a 1-year-old girl with a life expectancy of 80.4 years in our analysis. Porter and Tankersley (2020) argue that the U.S. Environmental Protection Agency (EPA) under the George W. Bush administration abandoned attempts to discount VSL for seniors by 33 percent after a political backlash. Eichenbaum *et al.* (2021) use the $9.5 million VSL which the EPA uses. $9.5 million is between our lower end expected VSL estimates of $7 million and $11 million.

After adjusting Merrill (2017) for inflation, the median wrongful death jury award was only $2.6 million, the median 9/11 compensation was $2.4 million, and the average lifetime earnings of college graduates was $2.8 million in 2020 U.S. dollars. Thus, both the EPA and our VSL range place a much higher value on American lives than juries have done or the 9/11 commission did.

By October 31, 2020, Ritchie *et al.* (2021) tabulated over 745 thousand COVID-19 deaths in the United States. The first recorded COVID-19 death in the U.S. was on February 29, 2020. By comparison, heart disease has been the number one killer of Americans, and it results in 647 thousand deaths per year according to Bacon and Yomtov (2020).

Figure 1: The Cost of COVID-19 Deaths in the United States Over Time. The Value of Statistical Lives (VSL) Lost from SARS-COV-2 in the USA.



By the end of October 2021, the United States had over 745 thousand COVID-19 deaths that amounted to 0.23 percent of its February 28, 2020, population of 331,331,747 estimated by the U.S. Census at https://www.census.gov/popclock/. That economic cost of those lost lives is estimated at between $5.2 and $11.5 trillion dollars with an expected total VSL of $8.4 trillion. The high, expected, and low value of statistical lives (VSL) per COVID-19 death is from table 1. According to the Bureau of Labor Statistics 2009 U.S. dollars are worth

1.2218 times 2020 U.S. dollars. The figure is in 2020 U.S. dollars. The per death expected VSL of $11.2 million is the average of the averages of the upper and lower VSL from the surveys studied adjusted for inflation. The per death high VSL estimate of $15.4 million is from the average of the upper VSL estimates adjusted for inflation. The low VSL per death of $7.0 million is the average of the lower estimates in table 1 adjusted for inflation. Per person VSL is multiplied by the cumulative number of COVID-19 deaths reported by Ritchie *et al.* (2021).

The deaths calculated for the low, expected, and high estimates in figure 1 are multiplied by the low. midpoint, and high VSL estimates of $7.0 million, $11.2 million, and $15.4 million per death, respectively. Those estimates are plotted in figure 1. Our midpoint VSL estimate produces losses of $8.351 trillion with a high and low range of $11.458 and low of $5.235. Scaling those numbers by pre-pandemic 2019 U.S. GDP of $21.43 trillion from Mataloni and Aversa (2020), those costs through October 31, 2021, are equal 39.0 percent of the U.S. annual output with a range 53.5 to 24.5 percent of U.S. GDP.

INFECTION FATALITY RATES

The economic losses from COVID-19 depend on the disease's infection fatality rate (IFR). IFR is the rate at which infected persons die. Ferguson *et al.* (2020) uses Verity *et al.* (2020)'s overall IFR estimate of 0.9 percent with a 95 percent confidence interval of 0.4 and 1.4 percent. Ferguson *et al.* (2020) is in line with the IFR estimate by Wilson (2020) of 0.850 percent using New York City data.

Case fatality rates (CFRs) measure death rates of persons tested. The IFR is meant to measure the death rates of all persons infected. A significant portion of COVID-19-positive persons might not be tested. For example, in part, early on in the pandemic that may have been due to testing shortages and testing protocols in many states that require symptoms. Moreover, persons with asymptomatic COVID-19 cases may have failed to seek out testing regardless of testing availability. Sutton *et al.* (2020), tested all women admitted to deliver a baby at New York Presbyterian Hospital. That study found that over eighty percent of COVID-19-positive pregnant women were asymptomatic at the time of their test. Only about ten percent of the asymptomatic women developed any symptoms during their three-day stay at the hospital. Gudbjartsson *et al.* (2020) conducted a randomized test of persons in Iceland. 54 percent of the persons testing COVID-19-positive had no symptoms.

The Centers for Disease Control conducted twenty nationwide serology studies to detect the incidence of COVID-19 antibodies from July 27, 2020, to July 11, 2021. Bajema *et al.* (2021) summarizes the results of the first four of these serology surveys. In these large studies, which all had over 38,000 observations, the percent of the U.S. population that had been infected by COVID-19 grew from 5.9 percent in July and August of 2020, to 22.1 percent by June and July of 2021. The seroprevalance surveys by the CDC seem in line with the estimates reported in Henderson (2021) from the study of Noh and Danuser (2021). In February 2021, the CDC estimated that 20.0 percent of U.S. population had been infected with COVID-19. Noh and Danuser (2021) found 21.5 percent had likely been infected with the virus.

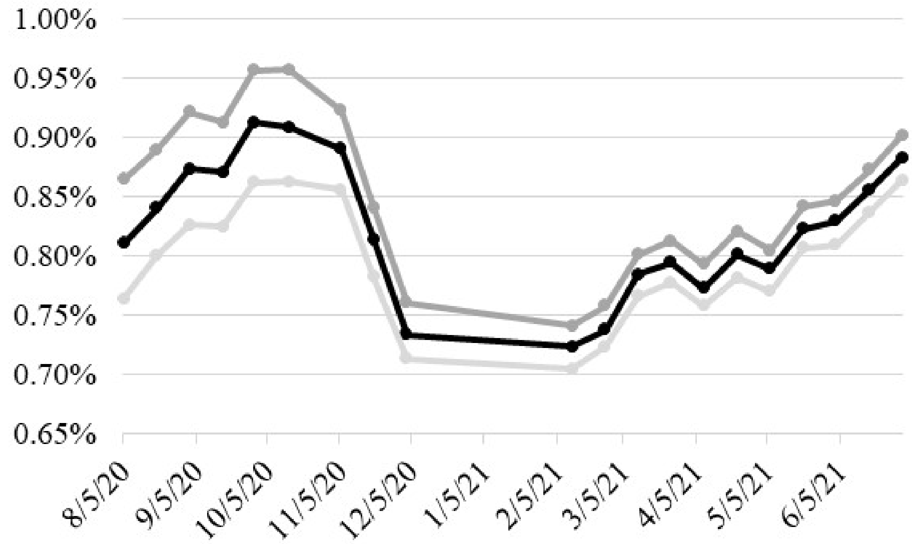
Table 2: Summary Statistics of the CDC's Serology Surveys and the Implied Infection Fatality Rate

	Min	Max	Median	Average	St Dev
Serology Study Start Date	7/27/20	6/21/21	2/8/21	1/11/21	111
Serology Study End Date	8/13/20	7/11/21	2/28/21	1/30/21	112
Length in Days of Serology Survey	18	22	21	20	1
Observations in Serology Survey	38,776	64,717	59,427	56,164	7,811
Median Date of Serology Survey	8/5/20	7/1/21	2/18/21	1/21/21	111.53
% U.S. Infected with COVID-19	5.90%	22.10%	20.20%	15.01%	7.01%
% U.S. Infected Lower Estimate	5.53%	21.67%	19.75%	14.60%	6.94%
% U.S. Infected Upper Estimate	6.26%	22.64%	20.72%	15.44%	7.07%
U.S. COVID-19 Deaths	158,626	604,533	494,964	403,550	182,089
Confirmed Cases	4,828,127	33,750,712	28,019,431	20,961,387	12,093,805
Case Fatality Rate (CFR)	1.746%	3.285%	1.812%	2.209%	0.564%
Estimated Population of the U.S.	331,030,119	332,475,723	332,141,912	332,040,304	345,626
Total U.S. Cases Implied by Serology	19,567,521	73,439,542	67,095,549	49,856,468	23,322,048
% of U.S. Cases Unreported	50.722%	75.326%	58.646%	61.040%	7.510%
Infection Fatality Rate (IFR)	0.723%	0.913%	0.818%	0.822%	0.057%
Infection Fatality Rate (IFR) low	0.704%	0.864%	0.791%	0.794%	0.049%
Infection Fatality Rate (IFR) high	0.741%	0.957%	0.844%	0.851%	0.065%

These are the summary statistics of the twenty nationwide serology studies conducted by the CDC from July 27, 2020, to July 11, 2021. Those COVID-19 antibody studies were available at https://covid.cdc.gov/covid-data-tracker/#national-lab. Confirmed cases and U.S. COVID-19 deaths are from Ritchie *et al.* (2021). The estimated U.S. Population for the median day of each survey is from the U.S. Census' population clock at https://www.census.gov/popclock/. Case fatality rates (CFR) are U.S. deaths over confirmed cases in Ritchie *et al.* (2021) on the median day of each of the twenty serology surveys. Total U.S. cases implied by serology is the estimated population on the median day of the survey times estimate of the percent of the U.S. infected by the serology survey. Percent of cases unreported is the difference between total cases implied by serology and the confirmed cases. That number is divided by total cases implied by serology. The serology studies indicate that only fifty to twenty-five percent of all COVID-19 cases were confirmed over this period. Infection Fatality Rate (IFR) is the total deaths on the median day of the study divided by the total number of people infected. Infected persons are the U.S. population estimate on the median day of the survey times the serology surveys' point, upper, and lower estimate.

Table 2 shows that the numbers of infected Americans was grossly understated by official case counts. 51 to 75 percent of infections were not reported in official cases counts according to these antibody studies sponsored by the CDC. We can used the number of infections implied by these studies to get twenty observations for the infection fatality rate. Deaths are taken from Ritchie *et al.* (2021) and the estimated U.S. population is from the U.S. Census. The average COVID-19 infection fatality rate across the studies was 0.822 percent. In figure 2, we plot the point estimate and the 95 percent confidence interval of the IFR for each of the twenty nationwide antibody studies.

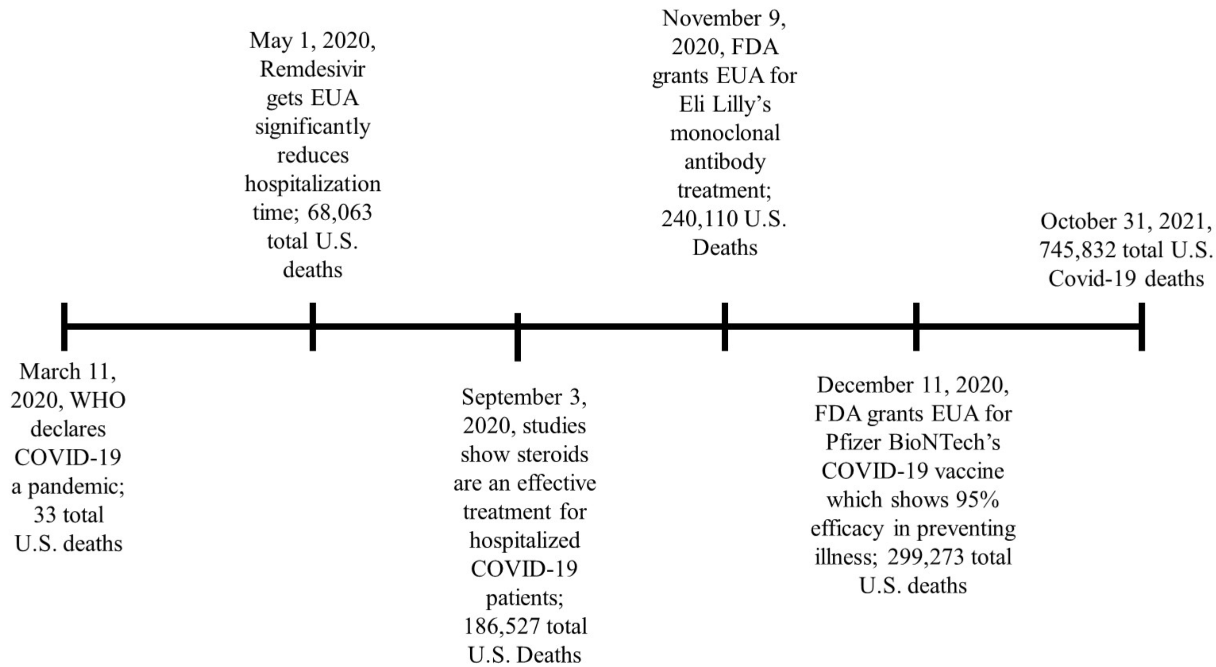
Figure 2: SARS-CoV-2 Infection Fatality Rate in the United States Implied by the CDC's Serology Surveys



The U.S. Centers for Disease Control (CDC) conducted large COVID-19 serology surveillance from July 27, 2020, to July 11, 2021, called the Nationwide Commercial Laboratory Seroprevalence Survey, at https://covid.cdc.gov/covid-data-tracker/#national-lab. There were twenty surveys conducted. The point estimate and 95 percent confidence interval of COVID-19 infections are used to calculate the infection fatality rate. U.S. COVID-19 deaths are from Ritchie *et al.* (2021).

For most of 2020, the pharmaceutical treatments for COVID-19 were modest according to AJMC Staff (2020). Figure 3 gives a timeline of select pharmaceutical breakthroughs throughout the pandemic. Remdesivir was not shown to reduce death, but it reduced hospitalization times. The efficacy of steroid treatments for moderate to severe cases of COVID-19 was demonstrated in studies appearing in September 2020. Monoclonal antibody treatments received an emergency use authorization (EUA) on November 8, 2020. Nevertheless, the most significant breakthrough was not available until after December 11, 2020, when the first COVID-19 vaccine was approved for an EUA in the United States. The Pfizer BioNTech SARS-CoV-2 vaccine received an EUA after showing 95 percent efficacy in preventing infection.

Figure 3: Timeline of Select Pharmaceutical Breakthroughs in the COVID-19 Pandemic through October 31, 2021



The dates of pharmaceutical breakthroughs are from AJMC Staff (2020). U.S. Covid-19 deaths are from Ritchie *et al.* (2021).

We might suspect that the increasing number of preventative and treatment measures available by the end of 2020, would have made COVID-19 less deadly in 2021 than in 2020. That is what we find looking at the implied infection fatality rates from studies conducted in 2020 versus 2021. The average IFR in 2020 was 0.850 percent versus 0.799 percent in 2021. The 2020 IFR was significantly higher than the 2021 IFR with over 95 percent confidence according to table 3.

Table 3: T-test of Means of U.S. Infection Fatality Rates (IFR) Implied by the CDC Serology Studies in 2020 and 2021

Year	2020	2021
Mean	0.850%	0.799%
Observations	9	11
df	15	
t-statistic	2.139	
P(T<=t) two-tail	0.049	
P(T<=t) one-tail	0.025	

This is a two-sample t-test with unequal variances assumed. With over 95 percent confidence, the COVID-19 IFR was significantly lower in 2021 after the COVID-19 vaccine began to be administered in the United States than in the serology surveys in 2020, which were conducted prior to Emergency Use Authorization (EUA) of the first COVID-19 vaccine in the U.S. on December 11, 2020. The last of nine seroprevalence studies by the CDC in 2021 was conducted between November 23, 2020, to December 12, 2020. The first study in 2021, was conducted from February 1, 2020, to February 21, 2021. Deaths are for the median date in the studies and are taken from Ritchie *et al.* (2021).

THE BENEFITS AND COSTS OF STATE STAY-AT-HOME ORDERS

To estimate the benefits in terms of lives saved by the stay-at-home orders, we use the estimate of Fowler *et al.* (2021). Fowler *et al.* (2021) found that cases declined by 48.6 percent during U.S. stay-at-home orders which were 22-days and longer with a 95 percent confidence interval of 31.1 to 61.7 percent.

Theoretically, deaths, d, are a linear function of cases, c, and IFR. $d = cIFR$. IFR can be estimated as in table 3. Backing out cases from death, we believe the cases are better estimated from the pre-COVID-19 vaccine serology estimates in 2020 table 3, because in table 4 we find that infections are significantly understated relative to the CDC's serology estimates.

Table 4: Paired T-test of Total U.S. Cases Implied by the CDC's Serology Surveys and Total U.S. Confirmed Cases

	Total U.S. Cases Implied by Serology	Confirmed Cases	Difference
Mean	49,856,468	20,961,387	28,895,081
Observations	20	20	
df	19		
t-statistic	11.363		
P(T<=t) one-tail	0.000		
P(T<=t) two-tail	0.000		

This is a paired t-test of the estimated cases from the CDC's twenty nation-wide serology surveys and the confirmed cases on the median date of those surveys from Ritchie *et al.* (2021). With over 99 percent confidence, confirmed cases understated actual COVID-19 infections. The average number of confirmed cases understated the actual number of infected Americans by 28.9 million on average. The CDC's COVID-19 antibody studies were available at https://covid.cdc.gov/covid-data-tracker/#national-lab. The estimated U.S. Population for the median day of each survey is from the U.S. Census' population clock at https://www.census.gov/popclock/. Total U.S. cases implied by serology is the estimated population on the median day of the survey times estimate of the percent of the U.S. infected by the point estimate of the serology survey.

Marschner (2021) estimates that deaths lag confirmed cases by eighteen days on average. Thus, cases are best approximated by 18-day forward deaths divided by *IFR*. The infection fatality rate (IFR) for 2020 was 0.850 percent with 8 degrees of freedom and a 95 percent confidence interval of 0.895 to 0.806. Let $d_{t,i}$ equal deaths at time t where t takes on the value zero 18-days after the start of the stay-at-home order and one 18-days after the end of the stay-at-home order. i is an index for all fifty U.S. states and the District of Columbia. Let infections be $c_{t,i}$ where $t = 0$ at the start of the stay at home order and $t = 1$ at the end of the stay at home order. $c_{t,i} = d_{t,i}/IFR$. Given that a state or the District of Columbia had a stay-at-home order, we find that all those state stay-at-home orders exceeded 21-days. Let r_j = reduction in cases estimated by Fowler *et al.* (2021) where $j = L, E,$ or H corresponding to the 95 percent confidence interval and point estimate of case reductions of $\{r_L, r_E, r_H\} = \{0.311, 0.486, 0.617\}$. The lives saved, $s_{j,i}$, in scenario j in a state or the District of Columbia i from its stay-at-home order are as follows:

$$s_{j,i} = [r_j/(1- r_j)](d_{1,i} - d_{0,i}) \quad (1)$$

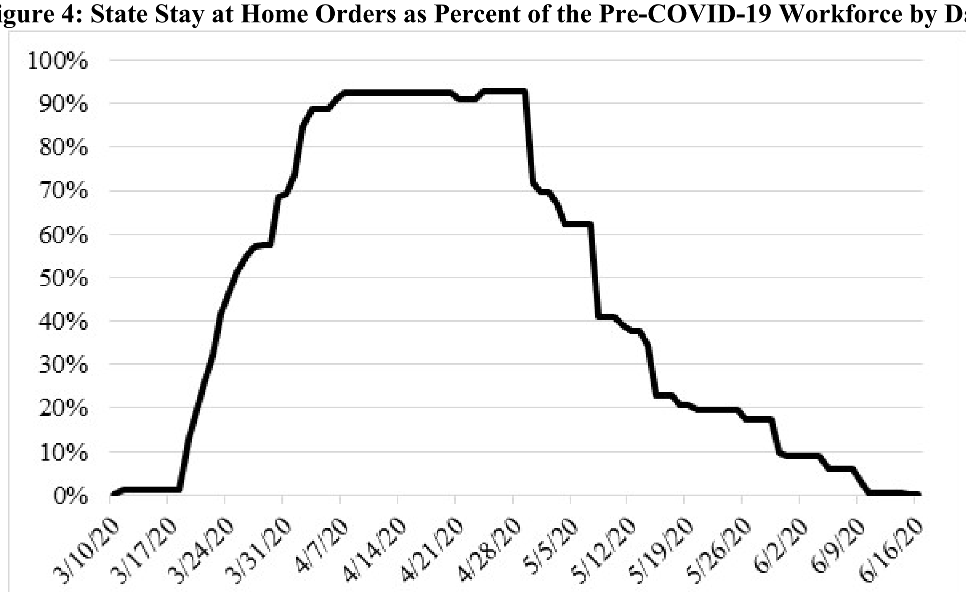
Total lives saved for our low, expected, and high estimates are as follows:

$$s_j = \sum_{i=1}^{51} s_{i,j} \quad (2)$$

We find that stay-at-home orders saved between 35,701 and 121,657 lives with a point estimate of 71,404 lives. We use the VSL estimates of VSL_j = {\$7.0 million, \$11.2 million, and \$15.4 million} per death, respectively, which was discussed in section 2. s_jVSL_j is equal to the economic benefits, B_j, from the stay-at-home orders. We estimate the economic benefit in terms of lives saved from the stay-at-home orders are B_L = \$0.251 trillion to B_H = \$1.869 trillion with a point estimate of B_E = \$0.799 trillion.

Stay-at-home orders began in the fifty states and district of Columbia with Alaska on March 11, 2020, and ended with New Hampshire on June 15, 2020, according to USA Today (2021), Levin (2020), Arco (2020), Oregonian (2020), and Kentucky Governor's Office (2020). We use the seasonally adjusted non-farm payroll data from the Bureau of Labor Statistics at https://www.bls.gov/web/laus/ststdsadata.txt in February 2020 to calculate the percent of the U.S. workforce subject to stay-at-home orders. The end of a stay-at-home order was defined as a "Phase 1" re-opening of a majority of non-essential retail stores. Most non-essential stores had to be open for business in some capacity for us to designate the stay-at-home order over. Seven states never had a stay at home order. The percent of the workforce covered by stay-at-home orders peaked at 92.3 percent of the pre-pandemic, February 2020, workforce between April 7, 2020, and April 20, 2020.

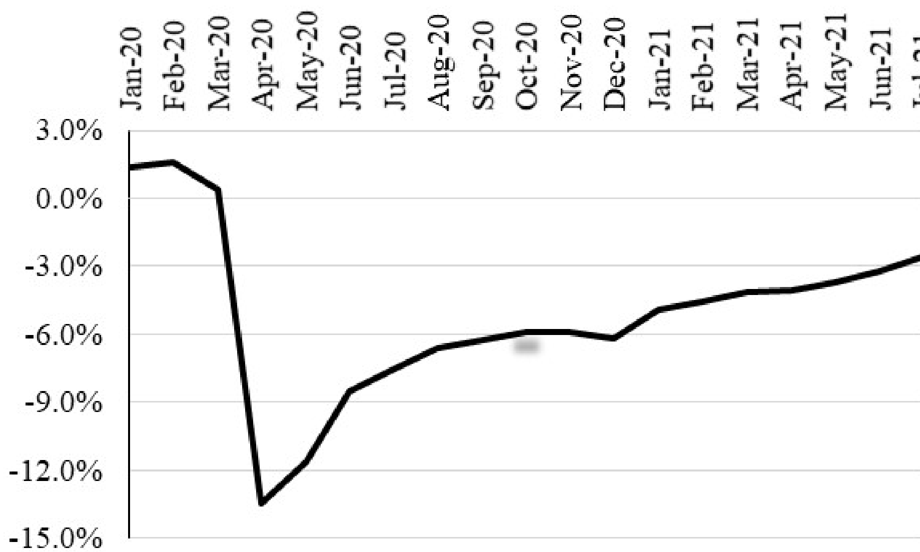
Figure 4: State Stay at Home Orders as Percent of the Pre-COVID-19 Workforce by Date



The figure tracks the percent of the February 2020 seasonally-adjusted, non-farm payroll workers who resided in one of the 50 states or District of Columbia which had active stay at home orders from March 10, 2020, to June 16, 2020. The first stay-at-home order was enacted on March 11, 2020, in Alaska. New Hampshire was the last state in this period to end its state-wide stay-at-home order on June 15, 2021. The seasonally adjusted non-farm payroll data was from the Bureau of Labor Statistics at https://www.bls.gov/web/laus/ststdsadata.txt. State stay-at-home orders beginning and ending dates were from USA Today (2021), Levin (2020), Arco (2020), Oregonian (2020), and Kentucky Governor's Office (2020). A "Phase 1" re-opening which allowed the majority of non-essential retail stores to conduct business was treated as the end of the stay-at-home order. Seven states had no stay-at-home orders over this period.

On the cost side of the ledger, stay-at-home orders reduced labor force participation. We look at seasonally adjusted labor force participation. It fell from a high of 100.4 percent of the pre-pandemic March 2019 level in March 2020 to 86.5 percent of the April 2019 level in April 2020. After the last stay-at-home order ended in June, workforce participation only rebounded to 92.5 percent of its June 2019 level and stayed down below 2019 levels through July 2021.

Figure 5: Change in the Labor Force Participation Rate from that Month in 2019



The plot shows the change in the U.S. seasonally adjusted non-farm labor force participation rate from 2019 levels. The labor force participation rate was the lowest down 13.5 and 11.7 percent, respectively, from pre-pandemic 2019 levels in April and May of 2020, when most workers were affected by stay-at-home orders as plotted in figure 4. The seasonally adjusted non-farm workers data was from the Bureau of Labor Statistics at https://www.bls.gov/web/laus/ststdsadata.txt. Labor force participation did not reach 95 percent of 2019 levels until January 2021 after the first COVID-19 vaccine was approved by the FDA on December 11, 2021, according to figure 3.

We believe the unprecedented intertemporal transfers make GDP changes misleading metrics of the economic impacts of stay-at-home orders. According to Snell (2020) and Taylor *et al.* (2020) the Coronavirus Aid, Relief, and Economic Security Act (CARES) Act signed into law on March 27, 2020, had a $2.2 trillion price tag. It included $300 billion in cash payments to most households, $260 billion in generous unemployment benefits, and $300 billion in *de facto* grants to businesses to not lay off workers with its Paycheck Protection Program (PPP). Individuals were paid an unprecedented sum for not working. Because of these huge transfer payments, we cannot expect GDP and consumption to dip to fully reflect the lost productive opportunities due to government prohibitions on economic activity within the COVID-19 stay-at-home orders. For this reason, we measure the economic losses in terms of the decline in workforce participation.

Let n_i be the seasonally adjusted non-farm payroll number in February 2020 of the *i*-th state or District of Columbia. Total non-farm payroll workers in February 2020 sum to $N = \sum_{i=1}^{51} n_i$. T_i is the days that that the *i*-th state (or DC) was under a stay-at-home order. Thus, $T_i/366$ is the fraction of the year that the stay-at-home order was in effect in the *i*-th state (or DC). This ranged from zero to 80 days in the sample. We find that the weighted average days, $\frac{\sum_{i=1}^{51} n_i T_i}{N}$, in which were covered by stay-at-home orders was 44.1 or about 12.1 percent of 2020.

The 2019 Q4 GDP was $21.43 trillion according Mataloni and Aversa (2020). The monthly average non-farm payroll for 2019, according to the Bureau of Labor Statistics was just over 150 million workers. GDP divided by the average seasonally adjusted non-farm workers was $143,767, which we will denote as *w*. In the three months after stay-at-home orders took effect beginning in March 2020, April 2020, May 2020, and June 2020, workforce participation dipped on average 11.2 percent from the seasonally adjusted levels for those months in 2019. In March 2020, workforce participation was up 0.4 percent from March 2019. 0.38% – (-11.24%) = 11.62%. That is our upper bound estimate for the percent of the workforce lost due to the stay-at-home orders. Some of the dip in workforce participation may have been due to worker hesitancy to work and not just the Governors' mandates. In July 2020, after all the stay-at-home orders ended, workforce participation was still down 7.5 percent from 2019. Thus, our lower bound estimate for the drop in workforce participation was –7.52% – (-11.24%) = 3.72%. The middle estimate was a simple average of the two estimates or 7.67%. Let k = 1, 2, or 3 where d_1 = 0.1162, d_2 = 0.0767, and d_3 = 0.0372. The monthly national labor force participation numbers reflect stay-at-home orders affecting only parts of the country. Workforce participation was only partially prohibited between March 11, 2021, and June 15, 2021, when the orders were in effect. That was 96 days or 96/366 = 26.2 percent of the year. C_k is the cost of the stay-at-home order in scenario k.

$$C_k = \frac{w d_k 96}{366} \tag{3}$$

C_1 = \$0.653 trillion, C_2 = \$0.431 trillion, and C_3 = \$0.209 trillion. Thus, the benefits are VSL of lives saved minus the costs of lost output. We will look at three scenarios. The scenario of the least VSL benefit, B_L, and the most economic cost, C_1, has the stay-at-home orders being a net economic loss of $402 billion. That is, $B_L - C_1$ = \$(0.251 – 0.653) trillion = -\$0.402 trillion. The scenario of the most lives saved, B_H, and the least economic cost, C_3, has a net economic benefit of $1,660 billion. That is, $B_H - C_3$ = \$(1.869 – 0.209) trillion = +\$1.660 trillion. Finally, the most likely scenario is that the stay-at-home orders generated B_E and cost C_2 and lead to a net economic benefit to the U.S. economy of $368 billion. That is, $B_E - C_2$ = \$(0.799 – 0.431) trillion

= +$0.368 trillion. The actual net benefits of the stay-at-home orders depend on the lives saved and the costs in terms of declines in workforce participation. On balance, the stay-at-home orders led to a large-to-modest benefit in the order of -1.9 to 7.7 percent of 2019 GDP. We expect that the state stay-at-home orders increased national well-being by about 1.7 percent of the previous year's GDP.

CONCLUSION

In this paper, we attempt to weigh the costs and the benefits of the non-pharmaceutical interventions (NPIs) of the United States' state-level stay-at-home orders which were in force from March 11, 2020, to June 15, 2020. Our review of the Value of Statistical Life (VSL) literature weighs each life saved from NPIs at $7.0 million to $15.4 million with a mean estimate of $11.2 million in 2020 U.S. dollars. Using the CDC's pre-COVID-19 vaccine serology studies conducted in 2020, we estimate that the SARS-CoV-2 infection fatality rate (IFR) was 0.850 percent with a 95 percent confidence interval of 0.895 percent to 0.806 percent. We calculate that state stay-at-home orders from March 11, 2020, to June 15, 2020, saved between 35,701 and 121,657 lives with a point estimate of 71,404 lives. That economic benefit in terms of lives saved from the stay-at-home orders was $0.251 trillion to $1.869 trillion with a point estimate of $0.799 trillion. We estimate that the stay-at-home orders cost the U.S. economy between $0.209 trillion and $0.653 trillion with a point estimate of $0.431 trillion. That put the net benefits from stay-at-home orders at -$0.402 trillion to $1.660 trillion with a point estimate of $0.368 trillion.

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