Covid Lockdown Cost/Benefits: A Critical Assessment of the Literature

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ABSTRACT

An examination of over 100 Covid-19 studies reveals that many relied on false assumptions that over-estimated the benefits and under-estimated the costs of lockdown. The most recent research has shown that lockdowns have had, at best, a marginal effect on the number of Covid-19 deaths. Generally speaking, the ineffectiveness stemmed from individual changes in behavior: either non-compliance or behavior that mimicked lockdowns. The limited effectiveness of lockdowns explains why, after more than one year, the unconditional cumulative Covid-19 deaths per million is not negatively correlated with the stringency of lockdown across countries. Using a method proposed by Professor Bryan Caplan along with estimates of lockdown benefits based on the econometric evidence, I calculate a number of cost/benefit ratios of lockdowns in terms of life-years saved. Using a mid-point estimate for costs and benefits, the reasonable estimate for Canada is a cost/benefit ratio of 141. It is possible that lockdown will go down as one of the greatest peacetime policy failures in modern history.

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I. Introduction

In March 2020 countries around the world, including the U.S., Canada, and the U.K., deployed various forms of lockdown that dragged on for over a year in many jurisdictions and show signs of returning in the fall of 2021 under the threat of new Covid-19 variants. This response to the pandemic has dominated not only the daily lives of ordinary people, but also the economic reality within which most businesses have been forced to operate. Lockdowns and the reactions to them, have had consequences for consumer demands, supply chains, profitability, and the redistribution of wealth. The average citizen and business person has had to trust that such a blunt and destructive policy tool was justified in the face of a novel viral pandemic.

The public and business trust has been necessary because most people have limited or no access to the immense research response to the Covid-19 pandemic — with estimates of over 40,000 related papers produced in one year. Even with access, most people lack the time or training to decipher the complex and often conflicting reports. Thus, although the research covers every imaginable aspect of Covid-19, and despite the explosion of knowledge regarding the virus, the human reactions to it, and the consequences of these reactions, the average person and corporate executive remains unaware of most of it.

The public and business trust has also been reinforced by the one-sided, incomplete, and almost unchanging ubiquitous media, public health, and political response to the pandemic. With respect to lockdown policies, many political jurisdictions have repeated the same spring 2020 programs in 2021, ignoring what has been learned in the meantime. Often public announcements were made that were inconsistent with basic Covid-19 facts that were easy to find, if you knew where to look. Furthermore, when research results contrary to the official government response were shared on social media, they were often pulled from these platforms, making access to the full research picture generally unavailable to an average citi-

zen. As a result, for most citizens and business people the public media and official public health news conferences have been the only source of Covid-19 information.

At the same time, over the course of the pandemic, general information about the virus, transmissions, deaths, and lockdowns across different jurisdictions has become available on various platforms. On the surface, it appears that lockdowns are not necessary for viral waves of deaths and cases to end. Nor does it appear that there was ever any widespread over-utilization of hospitals, especially in locations with little or no lockdown. Furthermore, casual observation shows that jurisdictions with lockdowns often did not avoid large waves of cases and deaths. In many ways, the virus seemed to progress independently of lockdown policy. Thus, on the one hand citizens and business people have been asked, in a blind trust, to go along with drastic and unprecedented lockdowns; while on the other hand, becoming aware of apparent inconsistencies. How is a reasonable person to think about all of this?

This review of a segment of the Covid-19 literature is intended to give some broader access to the academic research and issues around the common response of lockdown, and to help provide an understanding of these issues to both access government lockdown policy and understand the general information they are receiving. The focus is to critically assess the cost/benefit studies that have been written over the past sixteen months on lockdown policies related to the Covid-19 pandemic. The review covers over 100 different academic studies, along with related Covid-19 data sites. I have sought out studies that i) dealt with matters of "lockdown" either directly or indirectly, and ii) were related directly or indirectly to issues relevant to the costs or benefits of lockdown.

The term "lockdown" is used to generically refer to state actions that imposed various forms of non-pharmaceutical interventions. That is, it is used to include mandatory state-enforced closing of non-essential business, education, recreation, and spiritual facilities; mask and social distancing orders; stay-in-place orders; and restrictions on private social gatherings.

"Lockdown" does not refer to cases of "isolation," where a country was able to engage in an early and sufficient border closure that prevented trans-border transmission, followed by a mandated lockdown that eliminated the virus in the domestic population, which was then followed by perpetual isolation until the population is fully vaccinated. This strategy was adopted by a number of island countries like New Zealand.[1] Here I will only consider lockdown as it took place in most of the world; that is, within a country where the virus became established.

The report begins with an examination of four critical assumptions often made within the context of estimating benefits and costs. Understanding these assumptions explains why early studies claimed that the benefits of lockdown were so high, and also explains why the predictions of those studies turned out to be false. Then I examine the major cost/benefit studies in roughly chronological order, and focus on the critical factor in these studies: distinguishing between mandated and voluntary changes in behavior. Preliminary work on the costs of lockdown is reviewed, and finally a simple cost/benefit methodology is used to generate several cost/benefit ratios of lockdown for my home country of Canada. In no scenario does lockdown pass a cost/benefit test; indeed, the most reasonable estimates suggest that lockdown is a great policy disaster.

II. Cost Benefit Studies

When it comes to the question of choosing any type of public policy, the Nobel prize winner Ronald Coase put it best:

> It would clearly be desirable if the only actions performed were those in which what was gained was worth more than what was lost. But in choosing between social arrangements within the context of which individual decisions are made, we have to bear in mind that a change in the existing system which will lead to an improvement in some decisions may well lead to a worsening of others.... In devising and choosing between social arrangements we should have regard for the total effect.

[1] Other island countries with this strategy include many Pacific island nations (like Samoa and Tonga), Caribbean islands (like Cuba and Jamaica), and Iceland.

[Coase p. 44, 1960]

Coase was making two points. The first should be obvious: policy decisions should be made based on both costs and benefits. To focus on one side of the issue and consider only costs or only benefits necessarily leads to a mistaken policy. The second point is more subtle: an attempt to achieve a particular benefit through one mechanism might lead to an exacerbation of the costs. There are multiple methods to achieve a goal, but the cost consequences might be different for each method. At the end of the day, choosing the optimal policy requires a "regard for the total effect."[2]

Over the course of the Covid-19 pandemic, there has been no public evidence that governments around the world have considered both the benefit and cost sides of their policy decisions. To my knowledge, no government has provided any formal cost/benefit analysis of their actions. Indeed, the steady press conferences and news releases almost entirely focus on one single feature of the disease. Although the focus of government announcements has changed over the year, from "flattening the curve", number of Covid-19 deaths, number of Covid19 cases, hospital capacity, and variant transmissions (especially the delta variant), there has seldom been any official mention of the costs of the actions taken to address these concerns.

Economists and other social scientists have naturally been attracted to the policy issues surrounding Covid-19. Economists in particular, given their training in modeling human behavior and testing those models with real world data, have written hundreds of papers that deal with both the costs and the benefits of lockdown.

[2] It has been a sad irony that Covid-19 policy has not been driven by economics, the discipline that specializes in the study of costs and benefits, but by epidemiologists who have "no expertise in weighing health benefits against other costs" (Boettke and Powell, p. 1092, 2021). For example, Miles *et al.* (August 2020) provide an excellent economic assessment of the first pandemic wave in Europe. They pointed out the need to consider all costs and benefits, and recognized that the costs of widespread severe restrictions likely exceeded costs. They also pointed out that economics suggests using more targeted measures to deal with the particular effects of Covid-19. Unfortunately, lockdown proponents have often portrayed arguments like this as a type of "moral bankruptcy."

Here, aside from going through some of the theoretical issues, I provide a summary of the major findings.

A. Issues in Determining Lockdown Benefits

Most of the "action" in the early cost/benefit studies came from the benefit side. That is, many early studies reported enormous benefits to lockdown, and little attention was given to the particulars of lockdown costs. The claims of extremely high benefits, however, were almost entirely theoretical and sensitive to model assumptions. It is important to understand these theoretical issues and how they manifested in determining Covid-19 lockdown benefits.[3]

The Counterfactual Number of Cases/Deaths

The argument for lockdown benefits is intuitive. If a new virus enters an unknowing population with no immunity and spreads *exponentially*, causing an overwhelming of hospitals and subsequent large numbers of deaths, then a physical, government mandated, intervention that isolates people and slows down the transmission of the virus can reduce the spike of infections, allow hospitals to cope given their capacity constraints, postpone deaths, and possibly reduce deaths until a vaccine can be created. Lockdown is a formal, state-mandated "one size fits all" version of the social norm "keep your distance from people who are sick."[4]

If lockdown reduces the transmission of the virus, the natural question to ask is "by how much?" In other words, "but for the lockdown" what would the level of infection/transmission/deaths be? What is the counterfactual to lockdowns?

[3] The vast majority of studies have focused on cases and deaths, and so that is what is dealt with here. Issues of "long-covid" and other non-mortality costs that might be reduced by lockdown are not addressed. See Kniesner and Sullivan (2020) for a discussion of non-fatal Covid-19 outcomes.

[4] It has become a stylized fact that lockdown was successful during the Spanish flu pandemic in 19818–1919. However, Barro (April 2020), showed early on in this pandemic that school closures, prohibitions on public gatherings, and isolation orders had no significant effect on overall mortality during the second wave of the great 1918–1919 pandemic. It is also the case that prior to Covid-19 the WHO was opposed to widespread border and school closures, stay at home orders, and lockdowns.

Within the field of epidemiology it is common to model disease through what is called a SIR model.[5] Although these models can vary in many ways, they all model virus progression through a population in a mechanical fashion. One key parameter is the basic reproduction number, R_t which indicates the expected number of secondary infections in a vulnerable population generated by a single given infection. Cases of the virus explode exponentially when the $R_t > 1$, and then collapse as herd immunity is reached and the virus recedes to an endemic state ($R_t \approx 1$). Lockdowns are often interpreted as a means of effectively altering the reproduction number.

Early in the pandemic the Neil Ferguson *et al.* (March 2020) model appeared to drive many lockdown decisions and was widely covered in the media. Figure 1 reproduces a key figure of that paper (Table 2, p. 8), and shows the results of various types of lockdown on occupied ICU beds. The symmetry, smoothness, and orderly appearance of the functions is a result of the mechanical nature of the model. This type of figure is found, in one form or another, in most papers based on a SIR model.

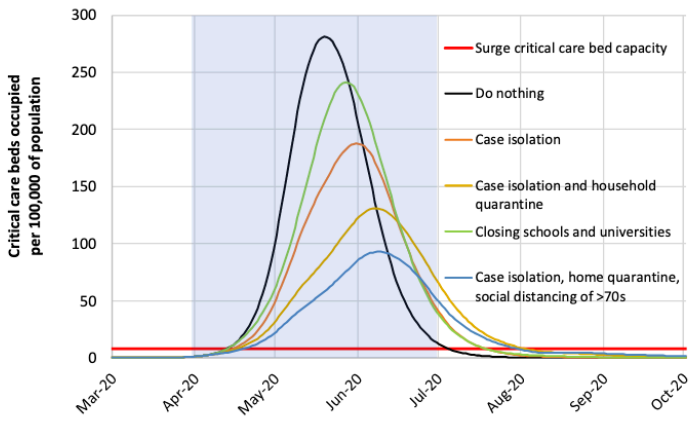

Figure 1: ICU Predictions in ICL Model

In Figure 1 the black "do nothing" line is the counterfactual to lockdown, while the other lines are various types of lockdowns. The harsher the lockdown, the "flatter" the case load, with the blue line being the strongest lockdown. The difference

[5] This model depends on number of people susceptible (S), infectious (I), or recovered (R).

between the the black line and another line is the benefit of that particular lockdown in terms of cases delayed. Clearly the exponential growth of the "do nothing" counterfactual leads to enormous differences, and makes lockdown look better.

The ICL model made dire predictions that saturated media coverage in the first wave of the pandemic. Table 1 shows some death predictions for four countries. Column (i) contains Ferguson *et al.*'s predictions for an unmitigated, no lockdown pandemic. In the U.S., close to 2.2 million people were predicted to die by the end of July 30, 2020. Column (ii) is the Ferguson *et al.* prediction with full lockdown, based on a reproduction number of 2.4.[6] Column (iii) is the actual cumulative deaths as of July 30, 2020. The U.K., U.S., and Canada all had lockdowns in the spring of 2020, and so the appropriate comparison is between columns (ii) and (iii). Column (iv) takes the ratio of these two columns and shows that the Ferguson *et al.* model was spectacularly wrong; off by factors of 5.88 to 14.71. Sweden had minimal restrictions, and so depending if actual deaths are compared to column (i) or (ii), the error ratio is either 11.56 or 5.30; either way, the model missed for Sweden as well.

Given the prediction that lockdowns would lower deaths by one-half, the authors made a dramatic recommendation: "We therefore conclude that epidemic suppression is the only viable strategy at the current time. The social and economic effects of the measures which are needed to achieve this policy goal will be profound." (Ferguson *et al.* p. 16, 2020). In retrospect it is remarkable that such a conclusion was drawn. The authors recognized that the "social and economic effects" would be "profound," and that the predictions were based on the "unlikely" behavioral assumption that there would be no change to individual reactions to the virus. However, given the large counterfactual numbers, presumably they felt no lockdown cost could justify remaining open.

[6] This was the *lowest* value considered. Other predictions used values as high as 3.3, with considerably more deaths predicted.

Table 1: Predicted and Actual Deaths

	(i) **No Lockdown** (Predicted) $R_0 = 2.4$	(ii) **Lockdown** (Predicted) $R_0 = 2.4$	(iii) **Actual** July 30, 2020	(iv) **Error Ratio** (ii) / (iii)
U.K.	489,828	242,593	41,254	5.88
U.S.	2,186,315	1,099,095	152,747	7.19
Sweden	66,393	30,434	5,739	11.56/5.30
Canada	266,741	132,687	9,019	14.71

Sources: https://www.imperial.ac.uk/media/imperial-college/medicine/mrc-gida/ Imperial-College-COVID19-Global-unmitigated-mitigated-suppression-scenarios.xlsx, and Our World in Data.

Problems with the ICL model were pointed out immediately: i) the reproduction number (R_t) of 2.4 was too high; ii) the assumed infection fatality rate (IFR) of 0.9% was too high and not age dependent; iii) hospital capacity was assumed fixed and unchangeable; and iv) individuals in the model were assumed to not change behavior in the face of a new virus.[7] All of these assumptions have the effect of over-estimating the counterfactual number of cases, transmissions, and deaths.[8]

[7] Estimates of the IFR have continued to fall over the year. Ioannidis (October 2020) estimated that the median IFR was 0.27% across 51 locations around the world. He noted that this IFR was "much lower than estimates made earlier in the pandemic" (p.1). Ioannidis (March 2021) later estimated the average global IFR at 0.15%.

[8] There are many forms of SIRs models, and the exact channel by which the virus mechanically progresses varies across studies. For example, Ambikapathy and Krishnamurthy (April 2020) model the exponential viral growth using a system of differential equations that mimic a SIR model. Given the assumed parameters in the model, lockdowns inhibit the transmission rates and produce a predicted benefit. See also Sjódin *et al.* April 2020, or Liu *et al.* May 2020 for other examples of mechanical virus models. One problem with SIR models that is not addressed here is their sensitivity to model specification. Chin *et al.* (March 2021) show that the original SIR models used by the ICL were "... non-robust and highly sensitive to model specification, assumptions and data employed to fit models." (p. 102).

The Exogenous Behavior Assumption

A major reason for the failure of SIR models to predict *actual* cases and deaths is because they assume no individual in the model ever changes behavior.[9] The implication of ignoring individual responses to a viral threat are dramatic. Atkeson (February 2021) used a standard SIR model (with exogenous behavior) that included seasonal effects and the introduction of a more contagious variant in December 2020 to forecast daily U.S. deaths out to July 2023. The results of this standard model were typical: the model made apocalyptic predictions on deaths that were off by a factor of twelve by the summer of 2020. However, he then used *the same model* with a simple behavioral adjustment that allowed individuals to change behavior in light of the value of R_t. The new forecast of daily deaths based on this single addition completely changed the model's predictive power. The model now tracked the actual progression of the daily deaths very closely. In correspondence with Atkeson he provided his explanation for this result:

> The intuition for this result is simple. If new infections and daily deaths from the disease grow too high, people take costly efforts to avoid interaction and thus slow disease spread. Likewise, if the prevalence of the disease falls toward zero, then the demand for costly disease prevention efforts also falls towards zero, and so the disease will come back unless the population has already achieved herd immunity measured at pre-pandemic levels of behavior.

Whether Atkeson (February 2021) has correctly modeled the Covid-19 virus is not at issue. Nor is it the case that the assumption of exogenous behavior is the only failing of the SIR model.[10] The point is, there is a dramatic change in predicted

[9] The notion that epidemiological models should contain endogenous human behavior was explained in a classic paper by Philipson (2000). This feature is common in economic models of Covid-19. For example Farboodi *et al.* (July 2020) and Luther (May 2020) found that individual responses to the virus were substantial and happened before lockdowns were mandated. Leeson and Rouanet (April 2021) point out the various ways this endogenous response self-limits the externality of infection, which reduces the presumed rationale for lockdowns in the first place.

[10] The effects of lockdown on transmission turned out to be much more nuanced. For example, Mulligan (2021) found that workplaces quickly adopted safety protocols, making them safer places

behavior once human reactions are included. Voluntary changes in behavior are optimal for the individual given their health circumstances, and therefore are likely to have large effects on cases and mortality. On the other hand, the blunt instrument of lockdown has little impact on mortality for those who have voluntarily locked down on their own, and likewise little impact on mortality for those who have not locked down but are either immune or unlikely to die given their age and health status. A model lacking endogenous individual adjustment then, radically overestimates the number of daily deaths, and this is a common problem in many cost/benefit studies.

The fact that individuals privately and voluntarily respond to risks has two important implications. First, it influences how any counterfactual outcome is understood with respect to the lockdown. When no voluntary response is assumed, models predict exponential case loads and deaths without lockdowns. If lockdowns are imposed and cases coincidently fall, the actual number of cases is then compared to a counterfactual that never would have happened.[11] Therefore, not accounting for rational, voluntary individual responses within a SIR model drastically overstates any benefit from lockdown.[12]

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than households where people were locked down. Social networks, patterns of immunity, population age distributions, and the like all played large roles in transmissions and interfered with the naive lockdown predictions.

[11] An example of this is found in Hsiang *et al.* (August 2020), who use the pre-lockdown growth rates of the virus in their calculation of the counterfactual trajectory of new cases. This ignores the fact that transmission and infection rates vary over time, and that a major reason for this variation is voluntary changes in behavior.

[12] The use of these models has continued into 2021 with respect to covid-19 variants. Michael Osterholm, director of the Center for Infectious Disease Research and Policy at the University of Minnesota, stated on February 2, 2021 that the new variant would cause a 'hurricane' of new cases, and "The fact is that the surge that is likely to occur with this new variant from England is going to happen in the next six to fourteen weeks. And, if we see that happen, which my forty-five years in the trenches tell me we will, we are going to see something like we have not seen yet in this country ...". Quoted from https://nationalinterest.org/blog/coronavirus/health-expert-prepare-category-5-coronavirus-hurricane-177476. According to OurWorldInData, on February 2, 2021 there were 428 cases per million (cpm) people in the U.S. Six weeks later on March 14 there were 163 cpm; fourteen weeks later on May 4 there were 145 cpm. Cases did not rise to unprecedented hurricane levels, but rather fell by more than two times. By late August cases were up to 258 cpm, but due to a different (delta) variant and behavior changes caused by vaccinations.

Second, any empirical work that considers *only the total* change in outcomes and does not attempt to separate the mandated effect from the voluntary effect, will necessarily attribute all of the change in outcome to the mandated lockdown. Once again, this will over-estimate the effect, and quite likely by an order of magnitude.

Individuals change behavior for two reasons. They voluntarily respond to the threat of a virus, and they react to mandated lockdowns.[13] Both channels of behavior create a *total* effect. It is important for lockdown empirical work to distinguish between the two channels of behavior to determine how much behavior changed because of mandated lockdowns and how much because of voluntary changes.[14]

The Assumed Value of Life

All economic cost/benefit studies of Covid-19, either directly or indirectly, utilize some method to estimate the number of cases, infections, or deaths as the virus progresses through the population over time. Counting cases and deaths, however,

[13] Furthermore, these two responses are inter-related:

> The endogenous behavioral response ... may also limit the effectiveness of efforts to reduce the spread of COVID-19. ... A lockdown, for example, that does not end the pandemic may suppress disease prevalence temporarily only to encourage behavior that leads the disease to become just as prevalent as before the lockdown.
>
> [Leeson and Rouanet, p. 1111, 2021]

[14] For example, if only 10% of change in cases is caused by mandated lockdown and 90% is caused by voluntary changes in behavior, then attributing all of the effect to lockdown over-estimates the lockdown effect by nine times. The less important mandated lockdowns are, the greater the over-estimation. This issue was publicly known as early as April 2020. Abouk (April 2020) examined differences in policies across the U.S. and separated out the voluntary effect. He noted (p. 2):

> While there is strong evidence for reduced social contact in the US, not all of these reductions can be attributed to NPIs: mobility data show that people in most states had already started to reduce the time they spend outside their homes before any NPI was implemented.

He found that stay-at-home orders had a substantial effect on confirmed cases, but business and school closures, along with bans of large gatherings did not.

is only half the process. To estimate benefits and compare them to costs economists assign a dollar value to the change in outcomes. If lockdown benefits are in terms of the number of deaths delayed, then a value to these lives must be used.[15]

Economic value is based on the idea of maximum sacrifice. Thus, when it comes to the value of an individual's life, this value is determined by the actual individual. In practice, what is measured is the marginal value to extend one's life a little bit by reducing some type of harm, and then use this to determine a total value of life. This measure, developed in the 1960s by Thomas Schelling, is called "The Value of a Statistical Life" (VSL), and is widely used in policy work. The VSL is estimated by observing individual marginal tradeoffs. Thus, if someone pays $1000 to reduce the chance of death by 1/10,000 over the next year, then this implies a value of life of $10,000,000. One problem with using the VSL for estimating the benefits of saving lives through lockdown is that it measures the total value of life based on a marginal value. Thus, using a VSL (which is based on observing ordinary people *not at the point of death*) as a measure of the value of a life of someone about to die, is likely to provide an *over-estimate* of the value of the life.[16]

In many Covid-19 cost/benefit studies, however, there is another more serious problem with how the VSL is used. Namely, it is often assumed that i) the VSL is independent of age, and ii) that the VSL is equal to around $10,000,000. Both of these claims are not true.[17]

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[15] Many object to the assignment of a number to the value of a life. To do so, however, makes it impossible to compare the costs and benefits of a policy decision. Arguing that assigning values to lives is immoral has been one method used to prevent the policy discussions from using cost/benefit analysis.

[16] The major alternative to using VSL is a "quality of life adjusted years" (QALY), which takes into account the health status of the individual. Given the age and health of most people who died of Covid-19, the QALY produces a value of life generally lower than the VSL. I ignore the debate over which method is more appropriate since most cost/benefit studies used the VSL; however, see Miles *et al.* for an example of the use of QALY in a Covid-19 study.

[17] See Hammitt (June, 2020) for an excellent discussion of the VLS and descriptions of how it varies with age.

Hammitt (pp. 10–12) surveys the literature on VSL estimates and shows that all studies reject the idea that the VSL is constant over the life-cycle. For example, one age based VSL estimate from Robinson, *et al.* (July 2020) is shown in Figure 2.

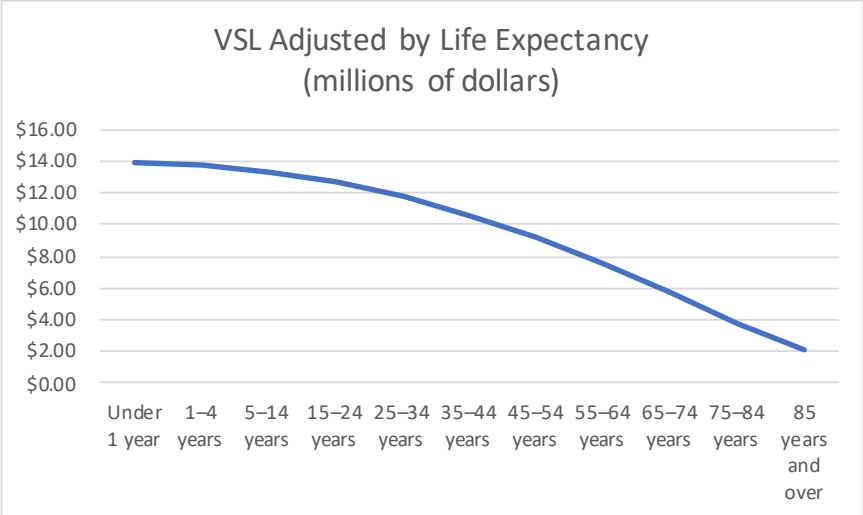

Figure 2: Age Related Estimates of VSL

To assume that the VSL is constant implies that individuals are indifferent between living one more day or eighty more years. Figure 2 shows more reasonable estimates, with the value of a child being seven times the value of an 85 year old. The VSL of $2,000,000 for an 85 year old is based on the assumption that life expectancy is still ten years. For someone who is 85, in poor health with multiple serious illnesses, the VSL would be much lower.[18]

Assuming a VSL of $10,000,000 creates a strong bias in the conclusion of many early cost/benefit studies. Since those over age sixty make up a minority of the population, but account for the vast majority of Covid-19 deaths, the use of a constant and large VSL leads to a vast over-estimate of the benefits of lockdown.

[18] It has been understood for some time that those dying of Covid-19 have comorbidities. According to the March 17, 2021 CDC weekly update (https://www.cdc.gov/nchs/nvss/vsrr/covid_weekly/index.htm#ExcessDeaths) only 6% of Covid-19 deaths in the U.S. were attributed to Covid-19 alone. The average number of comorbidities of those who died was 3.8. Thus, even assigning a VSL of $2,000,000 for individuals with multiple comorbidities is too high.

Consider the ICL case applied to the US. That model predicted 2.2 million Covid-19 deaths by June without lockdown. If each life lost was worth $10,000,000, then the benefit of lockdown would be $22 trillion dollars. In 2019 US GDP was $21.4 trillion dollars. At this estimate of death and VSL, it would make sense to shut down (not just lockdown) 100% of the US economy for an entire year![19]

B. An Issue With Lockdown Costs

Comparing Apples to Oranges

The final theoretical issue relates to what costs are compared to benefits. As noted, when considering the value of lockdown the VSL is used to determine the value of lives saved. The VSL is based on preferences, as it should be, and so the VSL is a dollar measure of the *utility* an individual receives from living. Most notably, the VSL is not a measure of how productive an individual is in terms of the dollar value of goods and services they produce. An infant is valuable, as is a retired senior citizen, but neither produces any market goods and services.

In contrast, it is common in cost/benefit studies to only use lost GDP as the measure for the cost of lockdown. That is, the reduced value of goods and services caused by lockdown is the only cost of the lockdown considered. For example, US GDP over 2020 fell by 3.5%.[20] If 100% of the fall in GDP (approximately $770 billion) is attributed to the lockdown (that is, the virus directly had no effect on production), then compared to the presumed "22 trillion" dollar savings in lives, lockdown seems like an excellent policy.

This type of comparison, however, is entirely inappropriate. The VSL is based on the utility of life, and therefore, the costs of lockdown must also be based on

[19] The absurdity of such a conclusion points to the problem of using a marginal value of life to estimate a total value. If the entire economy of the US was actually closed for one year, the total loss of life would be in the hundreds of millions.

[20] Taken from Bureau of Economic Analysis: https://www.bea.gov/news/2021/.

the lost utility of lockdown. It has been understood from the very beginning of the pandemic that lockdown caused a broad range of costs through lost civil liberty, lost social contact, lost educational opportunities, lost medical preventions and procedures, increased domestic violence, increased anxiety and mental suffering, and increased deaths due to despair and inability to receive medical attention. If the value of lockdown is measured in utility, then the costs of lockdown must be measured in the same fashion. Excluding the value of lost non-market goods (goods not measured by GDP) grossly under-estimates the cost of lockdown.

To point out the distinction, assume that instead of using the VSL to measure the value of a life, the gain in GDP was used to measure the benefits of lockdown. Since the large majority of those who died of Covid-19 were retired, elderly, and sick they generally did not contribute to GDP.[21] Hence, using a GDP only measure for a cost *and* benefit study would imply virtually no benefits to lockdowns and massive costs. This conclusion would be inappropriate, but at least it compares apples to apples.

C. Reviewing Lockdown Cost/Benefit Studies

Early Theoretical Cost/Benefit Studies

Generally, the earliest cost/benefit studies done in spring 2020 suffered from each of the theoretical assumptions outlined above; assumptions that were either known, or turned out to be, incorrect, and which biased the results in favor of lockdown.[22] There were few empirical studies done in the earliest stages of the

[21] As of March 2021, 95.9% of deaths were to individuals over age 60, and 69.1% of deaths were to individuals over 80. Source: https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html.

[22] I ignore the issue of "homogeneity" in SIR models (the idea that everyone in the model is the same) because most empirical work ignored it. However, this is another significant shortcoming of many models. Acemoglu *et al.*, as early as May 2020, produced a SIR model where there were three different age cohorts, with age-increasing risks from Covid-19. Not too surprisingly, in such

pandemic, but those that were done often relied on mechanical SIR models for counterfactuals, and had very limited data to work with. At the very beginning of the pandemic "studies" were mostly casual, and simply guessed that benefits were likely greater than costs.[23]

By the late spring academic articles appeared that contained the same sentiments. Consider Thunstrom, *et al.* (May 2020) who concluded that:

> ... social distancing likely generates net social benefits. In our benchmark case, which we view as the most plausible case among those we examined, the present value of net benefits from social distancing amount to $5.16 trillion.

The Thunstrom, *et al.* article assumed that there was no private voluntary response to the virus, $R_t = 2.4$, the VSL=$10M, there was a fixed and unchanging hospital capacity, the IFR reached 1.5% at capacity, and costs only entailed a 6.2% fall in GDP. These assumptions generated $12.4T in the value of 1.24M lives saved, and $7.21T in lost GDP. As noted above, every one of these assumptions biased the model in favor of lockdown benefits and against lockdown costs.

To see how sensitive the Thunstrom, *et al.* conclusion is, consider making just *one* change: using the Robinson *et al.* age-dependent VSL numbers rather than the constant VSL of $10M. Now the 1.24M lives only have a value of $5.54T, and lockdown has a negative value of $-1.66T. One realistic change in assumptions flipped the cost/benefit conclusion.[24]

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a model a uniform, blanket lockdown is not optimal. By June of 2020 models started appearing where individuals could differ in many characteristics like transmissibility, locations, ages, occupations, etc. Both Ellison (June 2020), and Akbarpour *et al.* (June 2020) showed that introducing heterogeneity resulted in herd immunity being reached much faster, and which raised the costs of blanket lockdowns.

[23] See for example, this March 23, 2020 article: https://www.nationalreview.com/corner/a-covid-cost-benefit-analysis/ which assumed lockdown saved one million lives all valued at $9M each, and made no guess at costs, but concluded "I still think the benefits will easily prevail..." . Another article from March 31, 2020 (https://www.sciencemag.org/news/2020/03/modelers-weigh-value-lives-and-lockdown-costs-put-price-covid-19), assumed a constant value of life of $9.5M, and a loss of GDP caused by lockdown of 22%, argued that "even a yearlong lockdown makes economic sense."

[24] Almost all of the cost/benefits studies I found from the early spring suffered from the problems of

April–June: Early Challenging Results

Many of the early theoretical studies received wide media attention, no doubt triggered by the exceptional claims made about deaths and costs. However, even in the early months of April, May, and June 2020 challenges to the sudden conventional wisdom on both the theoretical and empirical front were common.[25]

On April 27, 2020, three economists at the University of Chicago published "Some basic economics of Covid-19 policy" (Mulligan, Murphy, and Topel). The title is very informative. Understanding optimal policy goes back to recognizing that total benefits and costs must be compared (and comparable), and that efforts to increase benefits involve costs. They pointed out what was mentioned above: the VSL is not constant, nor is is appropriate to consider trading off "lives for GDP.":

> The VSL for very old individuals is lower because they have fewer years of remaining life to lose, and because they are in generally poorer health than younger people. The value of a statistical life is a powerful tool because it allows us to assess some fundamental trade-offs between health and other aspects of people's lives. It is critical to remember that the trade-off here is not between "lives" and GDP — it is the trade-off between two things that people themselves value: health and other aspects of their lives.

Mulligan *et al.* go on to note that it is improper to consider models in which the individuals do not respond to the presence of a virus: "The fact that individuals put great value on their own health and longevity means that there are strong

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using a standard SIR model to estimate the counterfactual, constant and high VSL, high transmission and infection fatality rates, and costs based on GDP. These include Eichenbaum *et al.* (March, 2020), Bethune and Korinek (April 2020), Jones *et al.* (April, 2020), Baker *et al.* (April, 2020), Bloom *et al.* (March, 2020), Hall *et al.* (June, 2020), Basili and Nicita (August 2020), and Cutler and Summers (October, 2020). An interesting example is Rowthorn and Maciejowski (August 2020). Although it came out later in the summer, it still used a basic SIR model in its cost/benefit analysis. What makes it interesting is that the authors recognized how critical the VSL number was. When a life is worth £2m, then only a lockdown of 5.3 weeks was justifiable. When the VSL is £10m it still only justified a 10 week lockdown.

[25] These challenges came from professionals in public health as well as economics. Rangel *et al.* (May, 2020) pointed out very early that narrow models that only focused on a few outcomes would lead to terrible public health outcomes.

individual incentives to engage in self-protection." They also note: i) that isolation and suppression of the disease delays the development of herd immunity, which ultimately is the way a society comes out of a pandemic; ii) that since a vaccine takes time to develop, approve, and deliver, the costs of lockdown must be projected out over the entire period; and iii) that policy must evolve with new information.

Mulligan *et al.* use an average VSL of $4.2M, and given their calculations, a one year lockdown *reduced* net wealth "even ignoring other long-run costs from reduced values of human and physical capital and any intrinsic value of reduced civil liberties." They claimed that with the given knowledge of the time, "that broad lockdowns make the most sense when the level of infection is high. In the language of economists, the marginal product of mandatory social distancing is greatest when there are many infected individuals circulating." In other words, stay-at-home orders make little sense when the fraction of the population infected is less than 1–2% as it was in many places around the world.

Other studies in the early spring provided better empirical evidence about the virus. Lewis *et al.* (April 2020) found that there was a 6.19% fall in quarter GDP growth, and that this was attributed to the response to the virus (ie. lockdowns were having negative market consequences). Coibion *et al.* (May 2020) found that average individual income losses over the first wave in the U.S. were between $5000 –$33,000. Ravindrn and Manisha (July 2020) was an early paper showing that jurisdictions with lockdown saw in increase in violence against women.

Very early in the pandemic it was clear that predictions based on basic SIR models were wrong, and a major factor was the assumed infection fatality rate (IFR). Levin *et al.* (December 2020, but available in July 2020) was one example of an early meta-analysis that brought together a number of smaller studies from around the world to estimate the IFR. They found that the IFR for Covid-19 was extremely age-specific. Children and younger adults have a very low IFR, and this increases with age, and dramatically increases after age 70. They estimated that at age 55 the IFR is 0.4%, but by age 85 it is 14%. Thus, although younger people were

bearing the costs of reduced employment and education, any benefits of lockdown were received by much older cohorts.

These months also saw the first empirical studies on lockdown effects at the state level, with mixed results. Friedson *et al.* (April 2020) was an early study of shelter-in-place regulations, and found that in California this policy reduced cases by between 125–219 per 100,000 population, but each death delayed cost 400 jobs. Dhaval *et al.* (May 2020a) looked at a natural experiment in Texas where there was variation across the state in the timing of lockdowns. They found that urban lockdowns reduced cases by 19–26%, but that there was no overall effect at the state level. Lin and Meissner (May 2020), was one of the first empirical studies that showed that the lockdown effect was minimal and that lower workplace interactions invoked larger residential activity. They also found that common shocks across the U.S. had a larger effect than local lockdown shocks.[26] Chaudhry *et al.* (July 2020), examining the fifty most infected countries and exploiting the timing and degree of interventions, found no relation between border closures, full lockdowns, and testing on Covid-19 mortality.

Despite the mixed results, one early empirical paper on lockdown was widely cited and heavily influential: Flaxman *et al.* (June 2020) claimed lockdowns saved 3 million lives in Europe. This paper looked at lockdowns across 11 European countries in the spring of 2020. It inferred transmission rates based on observed deaths, assumed homogeneity across the countries, and critically assumed that the reproduction number $R(t)$ only changed because of the immediate response to the mandated lockdown. They concluded that (p. 260):

[26] Other early studies showing that lockdown reduced cases include Born *et al.* (July 2020), Courtemanche *et al.* (July 2020), Dehning *et al.* (May 2020), and Hannah *et al.* (2020) and Dhaval *et al.* (May 2020b). Most of the early studies are based on modeling exercises, which again, depend critically on the model's counterfactual prediction. An exception was Banerjee and Nayak (June 2020) who looked at county level mobility data in the U.S. and did a difference-in-difference analysis between counties with and without lockdown. They found a positive effect of lockdown, but their data only spanned February 1 – March 31 2020, and over this period most of the states without mandated lockdowns had almost no infections. Hence there is a serious endogeneity problem with the cross-section analysis. That is, the lack of response is being attributed to the absence of lockdown, when it likely reflects the absence of the virus.

> In our analysis, we find that only the effect of lockdown is identifiable, and that it has a substantial effect (81% (75–87%) reduction in R_t). Taking into account country-specific effects, the effect size of lockdown remains large across all countries

The Flaxman *et al.* paper received criticism on a number of fronts: they assumed homogeneous populations, they lumped vastly different country policies into single indicator variables, and they assumed exogenous human behavior.[27] Homburg and Kuhbandner (June 2020), focus on the fact that R_t, by definition within a fixed population, must decline over time as recovered individuals are no longer susceptible to infection. However, Flaxman *et al.* assumed that the reproduction number was fixed at $R_t = R_0$ up until the moment of lockdown, at which point it changed to a new fixed level. This forced the model to put all of the explanatory power on the lockdown indicator variable and grossly exaggerated the effect of lockdown. Homburg and Kuhbandner conclude that "... the results of Flaxman *et al.* are artifacts of an inappropriate model."[28]

Despite the modeling issues and structural econometric tricks, one other feature of Flaxman *et al.* needs to be highlighted: the problem of attributing the "total" effect on transmission to lockdown, and not breaking down the channels by which an effect might have happened. Flaxman *et al.* state that " Our parametric form of R_t assumes that changes in R_t are an immediate response to interventions rather than gradual changes in behaviour, ...". This means that the only interpretation possible for the empirical results is that lockdown mattered. Thus, even if the estimated effect was true, it raised the question: was it caused by the mandated lockdown or

[27] Even Flaxman *et al.* recognize the problem of exogenous behavior: "We do not account for changes in behaviour; in reality, even in the absence of government interventions we would expect R_t to decrease and therefore would overestimate deaths in the no-intervention model."

[28] Lewis (June 2020), and Lemoine (December 2020) both write devastating critiques of the Flaxman *et al.* paper. In analyzing the Flaxman *et al.* supplementary material these two critiques also point out that the study's findings related to Sweden refute the study's conclusion.

voluntary individual reactions to the virus?[29]

Four Stylized Facts About Covid-19

Atkeson *et al.*'s (August 2020) paper "Four Stylized Facts About Covid-19" was a watershed result that appeared six months into the pandemic. Using data from 23 countries and all U.S. states that had experienced at least 1000 cumulative deaths up to July 2020, it discovered important features of the progression of the virus across countries that cast serious doubt that any forms of lockdown had a significant large impact on transmission and death rates.

In particular, they found that across all of the jurisdictions there was an initial high variance in the daily death and transmission rates, but that this ended very rapidly. After 20–30 days of the 25^{th} death the growth rate in deaths fell to close to zero, and the transmission rate hovered around one.[30] Not only did Atkeson *et al.* find a dramatic drop and stability of the death and transmission rates, but the spread in these rates across jurisdictions was very narrow. That is, across all jurisdictions, after 20–30 days the virus reached a steady state where each infected person transmmited the virus to one other person, and the number of daily deaths from the virus became constant over time.

This finding contrasted with all of the early local, small sample, studies that found any effects of lockdown on cases and deaths. Across all jurisdictions the progression of the virus was the same, despite wide ranging differences in the degree and type of lockdown. In their words:

> Our finding in Fact 1 that early declines in the transmission rate of COVID-19 were nearly universal worldwide suggest that the role of region-specific NPI's implemented in this early phase of the pandemic is likely overstated .... Our

[29] Ibarra-Vega (August 2020) uses a similar approach where the counterfactual number of infections is determined by a SIR model with exogenous behavior, and then shows that in such an imaginary model lockdowns are effective.

[30] Evidence that the virus was not exponentially out of control was available very early on. Harris (April 2020) shows that after one month the case load was flattening in NY.

> findings in Fact 2 and Fact 3 further raise doubt about the importance in NPI's (lockdown policies in particular) in accounting for the evolution of COVID-19 transmission rates over time and across locations. Many of the regions in our sample that instigated lockdown policies early on in their local epidemic, removed them later on in our estimation period, or have have not relied on mandated NPI's much at all. Yet, effective reproduction numbers in all regions have continued to remain low relative to initial levels indicating that the removal of lockdown policies has had little effect on transmission rates.
>
> [pp. 15–16]

Atkeson *et al.* speculated on three reasons for their findings. First, unlike the assumptions made in the SIR models, individuals do not ignore risks, and when a virus enters a population people take mitigating or risky actions based on their own assessments of that risk.[31] Second, again in contrast to the classic SIR model where individuals uniformly interact with each other, actual human networks are limited and this can limit the spread of the virus after a short period. Finally, like other pandemics, there may be natural forces associated with Covid-19 that explain the rapid move to a steady state death and transmission rate.

Each of these reasons suggest that the early correlative findings between lockdowns and cases were not causal linkages. At best the early findings have to be considered with caution. As noted above, Atkeson (February 2021) continued pandemic modeling shows the critical importance of including seasonality, lockdown fatigue, and behavioral responses to the virus.

Voluntary versus Mandated Lockdown Channels

As the summer and fall of 2020 progressed Covid-19 research continued as academics studied finer details based on new data and modeling refinements. Perhaps most significantly a number of papers found strong evidence that changes in human

[31] See Eksin *et al.* (2019) for a study of the effect of human behavior on the progression of disease. Adding behavioral responses to SIR models in economics goes back at least to Philipson and Posner (1993). It is not a new idea. Dhaval *et al.* (July 2020) had shown early on that in the context of a large political rally local individuals recognized the increased risk of transmission and adjusted their behavior to mitigate this risk, leading to no change in transmission rates.

behavior significantly affected the progression of the virus, and that this channel was more important than mandated lockdowns for altering the number of cases, transmission rates, and deaths.

Bjørnskov (March 2021) exploited cross-country variation in European lockdown policy and found that (p. 7):

> Comparing weekly mortality in 24 European countries, the findings in this paper suggest that more severe lockdown policies have not been associated with lower mortality. In other words, the lockdowns have not worked as intended.

Eichenbaum *et al.* (October 2020) showed that elderly people in particular are more likely to reduce spending, time away from home, and the consumption of goods likely to involve high contact with other people. Hunt *et al.* (October 2020) exploited the variation in stay-at-home orders across the U.S. and found that lockdowns had only modest effects on Covid-19 transmission rates. Rather, they found that

> ...most social distancing is driven by voluntary responses. Moreover, we show that neither policy nor rates of voluntary social distancing explain a meaningful share of geographic variation. The most important predictors of which cities were hardest hit by the pandemic are exogenous characteristics such as population and density.

Large urban centers got hit harder by the virus, but consistent with the Atkeson *et al.* (August 2020) finding, the transmission rate of the virus depended on endogenous individual responses.[32]

Goolsbee, A., and C. Syverson (June 2020), using cellular phone location records, found that voluntary "self-lockdown" explained most of the enormous change in behavior in the spring, and that they "do not find evidence of large temporal or spatial shifting in response to shelter-in-place policies" (p. 12).

[32] Gupta *et al.* (November 2020) survey the literature on social distancing and claim that mandates have an effect, but the volunteer response is larger.

There are, by my count, over twenty studies that distinguish between voluntary and mandated lockdown effects. Although they vary in terms of data, locations, methods, and authors, all of them find that mandated lockdowns have only marginal effects and that voluntary changes in behavior explain large parts of the changes in cases, transmissions, and deaths. Consider the following:

> This observational study, using a generalized phenomenological method based on official daily deaths records only, shows that *full lockdown policies of France, Italy, Spain and United Kingdom haven't had the expected effects in the evolution of theCOVID-19 epidemic.* Our results show a general decay trend in the growth rates and reproduction numbers two to three weeks before the full lockdown policies would be expected to have visible effects. Comparison of pre and post lockdown observations reveals a counter-intuitive slowdown in the decay of the epidemic after lockdown.
>
> [Meunier, p. 6, May 2020, emphasis added]

> Lockdowns are overall effective at curbing the spread of the disease and at reducing deaths (after about 30 days). *But the harsher is not the better: partial lockdowns are as effective as stricter ones,* but at a lower cost.
>
> [Bonardi *et al.*, June 2020, emphasis added]

> *We test and find wanting the popular notions that lockdowns with their attendant social distancing and various other NPIs confer protection.*
>
> [Nell, *et al.*, July 2020, emphasis added]

> ... our analysis shows that people voluntarily reduce their visits to workplace, retails, grocery stores, and limit their use of public transit when they receive information on a higher number of new cases and deaths. *This suggests that individuals make decisions to voluntarily limit their contact with others in response to greater transmission risks, leading to an important feedback mechanism that affects future cases and deaths.* Model simulations that ignore this voluntary behavioral response to information on transmission risks would over-predict the future number of cases and deaths.
>
> [Chernozhukov *et al.* p. 52, 2021, emphasis added.[33]]

> Lockdowns are ineffective at reducing Covid-19 deaths. Variation amongst counties in the United States, where over one-fifth had no lockdown, shows no impact of lockdowns. Specifically, *one cannot reject the hypothesis of zero difference in deaths between lockdown and non-lockdown counties.*
>
> [Gibson, p. 8, November 2020, emphasis added]

[33] This paper, which is likely the most sophisticated econometric causal study, found that lockdowns have a direct effect on cases and mortality. However, in a detailed analysis and replication Lemoine (July 2021) found that none of their results were robust.

These findings of the relative importance of voluntary responses relative to mandated lockdowns have continued to be confirmed.[34] A study by Bendavid *et al.* (January 2021) that distinguished between strong and weak lockdown countries concluded:[35]

> In the framework of this analysis, *there is no evidence that more restrictive non-pharmaceutical interventions ('lockdowns') contributed substantially to bending the curve of new cases* in England, France, Germany, Iran, Italy, the Netherlands, Spain or the United States in early 2020. By comparing the effectiveness of NPIs on case growth rates in countries that implemented more restrictive measures with those that implemented less restrictive measures, the evidence points away from indicating that [more restrictive] NPIs provided additional meaningful benefit above and beyond [light restrictive] NPIs. While modest decreases in daily growth (under 30%) cannot be excluded in a few countries, the possibility of large decreases in daily growth due to [more restrictive] NPIs is incompatible with the accumulated data.
>
> emphasis added

A reasonable conclusion to draw from the sum of lockdown findings on mortality is that a small reduction (benefit) cannot be ruled out for early and light levels of lockdown restrictions. There is almost no consistent evidence that strong levels of

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[34] Using a natural experiment methodology in Denmark, Kepp and Bjørnskov (January 2020) find that "efficient infection surveillance and voluntary compliance make full lockdowns unnecessary." A different type of study is Savaris *et al.* (March 2021) that uses mobility data to identify time spent at home, and looked at over 3700 pairwise jurisdictional comparisons, they found "... no evidence that the number of deaths/million is reduced by staying at home." Most notably, they were not studying lockdown stay-at-home orders, but actual stay-at-home behaviors. Elenev *et al.* (July 2021) show that people in neighboring jurisdictions voluntarily respond to stay at home orders elsewhere. Berry *et al.* (p. 1, April 2021) found that "shelter-in-place orders had no detectable health benefits, only modest effects on behaviro, and small but adverse effects on the economy. ... Many people had already changed their behaviors ...".

[35] This paper received a number of critical letters and comments to the journal. The authors responded in Bendavid *et al.* (March 2021), showing that the criticisms were invalid. They conclude in their reply:

> Given their many uncontestable harms to health and society, we believe that the extant literature does not provide strong support for their [NPI] effectiveness at reducing case spread, and should be subjected to careful, critical and rigorous evaluation. If the benefits of such measures are negligible (or worse), their perpetuation may be, on balance, detrimental to the health of the public.
>
> p. 3

lockdown have a beneficial effect, and given the large levels of statistical noise in most studies, a zero (or even negative) effect cannot be ruled out. Maybe lockdowns have a marginal effect, but maybe they do not; a reasonable range of the decline in Covid-19 mortality is 0–20%.

D. The Costs of Lockdown

Research on the cost of lockdowns has lagged that of the benefits, and even still is incomplete and piecemeal because there are several critical issues which will take time to sort out. First, lockdown costs depend on the expectations people have on how long they will last. These expectations have been constantly changing as lockdowns have been repeatedly extended from an initial two weeks to over sixteen months. Second, many costs will manifest over time, and estimates of these costs can not been done yet. Third, without lockdowns there still would have been negative consequences from the virus itself, and these must be separated from the costs of the lockdown reaction. Fourth, lockdowns take place in the context of other countries and there are general equilibrium and feedback effects that require sorting out. Finally, it is still unknown how permanent many of the effects will be.

Lost GDP

These issues have meant that all estimates of lockdown costs to date in cost/benefit studies have been limited and unsatisfactory. For example, Miles *et al.* provides a good discussion of cost estimation issues, but then settles on using different scenarios of lost GDP in the U.K. as a cost estimate. There is no question that lost GDP from lockdown is a cost. Lockdowns that close non-essential businesses, supply chains, and various service sector activities, must reduce the production of goods and services. Since these goods and services are valued, this loss is an obvious cost of lockdown.

Measures of GDP losses over the year abound. Miles *et al.* have different scenario losses attributed to lockdown that range from £200B – £550B for the U.K.

In terms of actual losses, Sweden had a -7.4% change in the second quarter of 2020, compared to -13.9% change for the EU in the same time period (Eurostat, February 2021). If we used Sweden (which had GDP fall 2.8% over the year) as a lockdown counterfactual, then perhaps one half of the EU fall in GDP could be contributed to lockdowns.[36] Applying this to a country like Canada, that experienced about an 11% fall in the second quarter GDP and overall a 5.1% fall in GDP, then Canada's lockdown cost about $89 billion dollars.[37]

When considering losses of GDP, it is important to note that these losses have not been evenly distributed. Canada, like most countries, borrowed to finance lockdown transfer payments, which transfers the debt burden to younger generations. Furthermore, GDP losses vary across industries. In Canada, for example, retail sales experienced a drop of 30% in the second quarter of 2020, but then mostly recovered. Full-service dining sales, on the other hand, dropped by 80% in the second quarter, but by the end of the year were still down 52%. Finally, international flights fell by an enormous 90% in the second quarter, and remained there for the rest of the year.[38]

As noted earlier in section II.B, only using GDP losses as a measure of lockdown costs grossly underestimates the costs. Despite this, it is often the case that studies with this methodology still find that costs of lockdown exceed any benefits. For example, Miles *et al.* find that costs exceed benefits for every one of their forty scenarios — even though they use the over-estimated Ferguson *et al.* counterfactual of lives saved. In other words, despite underestimating the costs and overestimating the benefits (and only for the first three months of lockdown) they still concluded:

[36] Sweden's GDP growth taken from: https://tradingeconomics.com/sweden/gdp-growth.

[37] Canada's GDP levels are from: https://tradingeconomics.com/canada/gdp.

[38] Data taken from Statistics Canada's economic dashboard: https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2020009-eng.htm.

> We find that the costs of the three-month lockdown in the UK are likely to have been high relative to benefits, so that a continuation of severe restrictions is unlikely to be warranted.
>
> [p. R75, August 2020]

Other Costs

From the beginning it has been recognized that costs involved both the lost goods and services from shutting down economic activity and the lost utility from restricting individual freedoms. Over the course of the year the list of costs beyond lost GDP has increased, and the reach of lockdowns in terms of suffering has turned out to be nuanced and long. Many of the costs will not be known for years as they work out in reduced graduation rates, increased structural unemployment, reduced future earnings, permanent changes to the workforce and organization of businesses, reduced social capital, and reduced long run health status. Here I provide a short list of some of the findings arrived at thus far.

a. **Lost educational opportunities.** Lost, delayed, or poor education leads to reduced human capital that has life long negative consequences.[39] Not only has lockdown reduced educational opportunities for the young, the distribution of the effects is not equal. Bonal and González (December 2020), find that children in low income families, with poor access to online resources, suffer more than others.

b. **Additional effects of school closures.**[40] Closing schools creates isolation for children, which is known to increase the risk of mental health con-

[39] The role of education in the formation of human capital and its importance for individual wellbeing and economic growth is well established in economics. See Becker (1994) for a classic treatment.

[40] Although not a research study, a Unicef bulletin contains a long list of lockdown and school closures on children. These include: lost days of education (especially for early education), food insecurity, lost access to health care, increased stress, increased risk of abuse at home, poorer infant and maternity care, failure to receive regular vaccinations, and increased mental health issues. See https://downloads.unicef.org.uk/wp-content/uploads/2020/04/Unicef-UK-Children-In-Lockdown-Coronavirus-Impacts-Snapshot.pdf

ditions.[41] Agostinelli *et al.* (December 2020) showed that school closures hurt students from low income families more. Baron *et al.* (August 2020) reported that school closures inhibit the reporting of child abuse. Green *et al.* (December 2020), using Canadian data found that closing schools and having children learn from home meant that parents reduced labor force participation. Lewis, *et al.* (February 2021) provide an extensive list of literature on the harm school closures have had on children and conclude: "School closures have been implemented internationally with insufficient evidence for their role in minimising covid-19 transmission and insufficient consideration of the harms to children." [42]

Perhaps the most startling education finding was from Christakis *et al.* (November 2020), who estimated the linkage between school, lost educational attainment, and life expectancy. Over the course of just the first wave of the pandemic their point estimate on the estimated effect of school closures on life expectancy was 13.8 million lost years of life. To put this in context, the average age of Covid-19 death in the US is about 75. A healthy 75 year old American has a 12 year life expectancy. Thus, the 13.8 million lost life years translates into 1,150,000 75 year old deaths. These lost life years took place over the first wave of the pandemic, and are more than twice the number of all U.S. Covid-19 deaths in the first year.

c. **Increased deaths expected from unemployment.** Life expectancy is a function of wealth levels.[43] McIntyre and Lee (August 2020) predict between 418–2114 excess suicides in Canada based on increased unemployment

[41] Loades *et al.* (November 2020) survey 80 studies related to isolation and children and conclude "... increased the risk of depression, and possibly anxiety at the time at which loneliness was measured...".

[42] For other effects of closing schools see also Fuchs-Schundeln *et al.* (September 2020), or Buonsenso *et al.* (December 2020).

[43] See Roelfs *et al.* (January 2011) and references that show this relationship has been understood for some time. Lindo (2011) also shows that unemployment contributes to higher infant death.

over the pandemic year. Bianchi *et al.* (December 2020), using time-series data on unemployment, life expectancy, and mortality, estimate the effect of Covid-19 unemployment shocks on future deaths. They find that for the U.S. over the next 15 years unemployment shocks caused by the lockdown reaction will increase deaths by 800,000. These deaths will disproportionately effect women and African-Americans. Since the authors do not distinguish between the effect of the pandemic and lockdowns, not all of the deaths can be attributed to lockdown. However, the link between lockdowns and unemployment is well established.

d. **Increased deaths from overdoses and other deaths of despair.** Lockdowns disrupt illegal drug channels, often resulting in a more contaminated drug supply. Lockdowns also increase human isolation, leading to increased depression and suicides.[44] As early has June 2020, Jia *et al.* reported substantial increases in depression, stress, and anxiety were linked to lockdown. Mulligan (December 2020) found that over the course of 2020 across the U.S. deaths of despair increased between 10–60%. Killgore *et al.* (November 2020) found that the number of people with thoughts of suicide in the U.S. states with lockdown increased with each passing month, but remained stable in states without lockdown.

e. **Increased domestic violence.** Chalfin *et al.* (March 2021) found that much of the increased domestic violence is related to increased alcohol which increased during lockdown.[45]

[44] This channel has been known for some time. See Steptoe *et al.* (April 2013) and references, or Holt-Lunstad *et al.* (March 2015) who showed that physical isolation and social loneliness increased mortality. The CDC reported in August 2020 (Czeisler *et al.* (August 2020) that there were elevated mental health conditions brought on by the pandemic, and Newlove-Delgado *et al.* (January 2021) found that lockdown contributed to increased mental health problems among U.K. youth and that this problem was most serious among young women.

[45] Awareness about the effect of lockdown on violence against women was available as early as March 2020 when the WHO released a statement: https://www.who.int/reproductivehealth/publications/emergencies/COVID-19-VAW-full-text.pdf. Binge drinking is strongly associated with stay at home orders (Weerakoon *et al.* (December 2020).)

f. **Lost non-Covid-19 medical service.** In the spring lockdown hospitals cancelled scheduled appointments for screenings and treatments (e.g., London *et al.* (July 2020); Garcia *et al.* (April 2020)), this created fear among individuals who required emergency treatments and, ironically, although emergency calls for treatment often fell, things like deaths from Cardiac arrest increased (e.g., Holland *et al.* (August 2020)). Woolf *et al.* (July 2020)) estimate that in the U.S. about 1/3 of the excess deaths over 2020 are not Covid-19 deaths. Maringe *et al.* (July 2020) estimate that approximately 60,000 years of lost life will result in England from increased cancer deaths resulting from suspended screenings. (see also Lai *et al.* (June 2020)). These results are supported by Williams *et al.* (2021) who find that during the first wave of the pandemic in England and Wales the non-Covid-19 related excess mortality caused by lockdowns "more than offset" any decrease in Covid-19 deaths attributed to lockdown.[46]

The opportunity costs of lockdown are widespread across societies, and everyone has faced some type of lockdown consequence. These costs are often non-market and in the future, making them difficult for third parties to measure. They are also unevenly distributed onto the young and the poor who have been unable to mitigate the consequences of lockdown. These characteristics contribute to the lack of attention given to them, and stand in sharp contrast to Covid-19 case loads and deaths that are measured, highly concentrated, and widely reported.

In light of the nature and measurement problems associated with the costs of lockdown, as of July 2021 no true, standard, cost benefit study has been conducted. All efforts have rested on assumptions and guesses of things not yet known. It will still take time for a systematic, ground-up, attempt to determine the total lost

[46] See also Agrawal *et al.* (June 2021) for similar findings of increased excess deaths, using data from 43 countries and all US states. Other effects range from increased major amputations, longer wait list times, fewer organ transplants (Manara *et al.* (August 2020)). Many primary care appointments switched to telephone and online appointments, which are often inferior substitutes for in-person treatments.

quality of life brought about by lockdown. Even though such studies do not exist, there is still weight to the economic logic that, with negligible benefits and obvious high costs, lockdown is an inefficient policy.

III. An Alternative Cost/Benefit Methodology

Professor Caplan (2020) has suggested a thought experiment that provides a solution for the cost measurement issue. Rather than attempt to measure a long list of costs and add them up, Caplan proposes a method that exploits our willingness to pay to avoid the harms of lockdown. If lockdown imposed net costs of $1000 on a person, then that person would be willing to pay up to $1000 to avoid lockdown. Caplan, however, poses the matter in terms of time rather than dollars. His (paraphrased) thought experiment is the following:

> Suppose you could either live a year of life in the COVID era with lockdowns (e.g., like what happened in the U.K.), or $12 - X$ months with the virus but no lockdowns (e.g., like what happened in Sweden or Florida). What value of X would make the AVERAGE person indifferent?

Professor Caplan's thought experiment addresses the total costs of all covid prevention as *perceived* by each person living under it, and therefore is an appropriate utility based cost measure to hold up against the value of lives saved through lockdown: X is the number of months a person is willing to pay to avoid lockdowns, other things equal. To make this more explicit, let y_0 be the set of behaviors one would engage in during the Covid-19 pandemic year *without* lockdown (Swedish case), and y_1 be the set of behaviors engaged in with *actual* lockdown (UK case). Let $U(y_0, 12 - X months)$ be the utility of the former, and $U(y_1, 12 months)$ be the utility of the latter. Professor Caplan is asking: what value of X makes the two utilities equal?

For any *random* individual, X could take on a wide range of values. For some this past year has been horrific, and perhaps they would have preferred it never

happened. Perhaps they suffered violence or abuse that was fueled by frustration and alcohol while locked down during a long stay-at-home order. Or perhaps they lost a business, a major career opportunity, or struggled over a long period of unemployment and induced depression. For these people, X equals 12 — they would have paid 12 months of their life to have avoided this past year. Others might have been willing to pay even more. For the vast majority of populations, Covid-19 was not a serious health risk. Lockdowns provided no benefits and only costs. Thus, for the vast majority, X likely takes on a value in the order of a few months.

On the other hand, consider the case of an elderly person in relatively poor health. Such a person, as we know from the research done on voluntary responses, will very likely isolate and lockdown voluntarily. Mandated lockdowns impose no marginal costs on them, and as a result, this person would set $X = 0$. That is, they would pay *nothing* to have avoided mandated lockdowns. There are others for whom lockdown was also just a minor inconvenience. Those who are professional and have no children at home; who have access to Amazon, Zoom, and the internet; who live in a large house with a garden, dislike travel (and travelers), and have poorer health are also likely to pay very little to avoid lockdown. These folks might be willing to sacrifice only a week or two (e.g., $X = .25$) to avoid lockdown.

The question is: how many months would be sacrificed on *average*? Professor Caplan argues that $X = 2$ months is a conservative estimate. That is, on average, two months would be sacrificed to have avoided lockdown. For the sake of demonstration, I will use this value of two months, in the context of Canada, to calculate the costs of lockdown.

As of March 2021 the pandemic had lasted one year, and by assumption the average Canadian had lost two months of normal life due to lockdown. The population of Canada is 37.7 million people, which means that 6,283,333 years of life were lost due to Canada's lockdown policy. This number of years can be converted into "lives" using average life expectancy.

The average age of reported Covid-19 deaths in Canada over the first year of the pandemic was 80.[47] In Canada an average 80 year old has a life expectancy of 9.79 years.[48] This means that the 6,283,333 million years of lost life is equivalent to the deaths of 643,513 80 year olds.[49] As of March 22, 2021 Canada had a total of 22,716 deaths due to Covid-19 (or 222,389 lost years of life).

The question is, however, how many lost years of life would have resulted from Covid-19 deaths if there had been no lockdown? Within the econometric evidence, one of the highest counterfactual upper bounds on the number of Covid-19 deaths was found by Chernozhukov *et al.* (p. 51) at 50%; that is, deaths would have been, at most, 50% higher had there been no lockdown.[50] Given that most of the literature finds a zero effect of lockdowns on deaths, perhaps a mid-point estimate between zero and the Chernozhukov *et al.* upper bound would be a 20% increase in the number of deaths. In the table below I will calculate benefits for both scenarios.

Therefore, in the two cases of an increase of 20% or 50% in deaths with no lockdown, Canada would have experienced an additional 4543 or 11,358 deaths. Meaning there would have been additional 44,430 or 111,081 years of lost life due to Covid-19 deaths. The benefit of lockdown, therefore, was the avoidance of these extra years of lost life. As noted, the cost of lockdown was 6,283,333 years of lost life, and therefore, the cost/benefit ratio of lockdown is 141 (6,283,333/44,430) or 56 (6,283,333/111,081).

Table 2 below shows nine different cost-benefit ratios using the same procedure, but with different assumptions. In terms of lockdown costs the table considers two extremes. The first is that $X = .5$ or two weeks. In other words, lockdowns were

[47] https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html

[48] https://knoema.com/atlas/Canada/topics/Demographics/Age/Life-expectancy-at-age-80-years

[49] The life expectancy of a 25 year old Canadian is 55.2 years, so the 6.3m lost life years is the equivalent of losing 114,130 25 year olds

[50] This upper bound was not statistically significant, and Lemoine (July 2021) later showed that it was not robust.

little more than an inconvenience for the average Canadian. The second is that $X = 5$, in which case the average Canadian was willing to sacrifice almost half of a year to avoid lockdowns. In terms of the benefits of lockdown the table uses three cases: the 20% mid-point estimate, the 50% upper bound, and the apocalyptic values of the Ferguson *et al.*, Imperial College of London (ICL) model. [51] All three of these benefit estimates are on the high side, and so the cost/benefit ratios are conservative.

Table 2: Cost/Benefit Ratios

X	**(i) 20%**	**(ii) 50%**	**(iii) ICL**
.5	35	14	1.19
2	**141**	56	4.79
5	7355	140	11.95

The cost/benefit ratios based on the Ferguson *et al.* model are presented only to show that even under that nonsense scenario lockdown is a failure as a policy by cost/benefit standards. The review of the literature suggests that lives saved likely ranged between 0-20% of actual deaths. Thus, even under the assumption that lockdowns were little more than a minor inconvenience on average ($X = .5$), the costs were at least thirty-five times higher than the benefits. The reasonable conservative case is that the cost/benefit ratio is around 141, which means that by any cost/benefit standard, lockdown has been a public policy disaster.

This analysis only considers the *number* of years of lost life. A proper cost/benefit analysis would consider the *value* of these lost years. As noted above, the value of life

[51] As noted in Table 1, the Ferguson *et al.* model predicted that lockdowns saved 134,054 lives (266,741-132,687) until the end of July 2020, which was presumably to be the end of the pandemic.

is not constant across age. Since the life years lost to Covid-19 deaths were mostly among those older than 60, and since the years of lost life because of lockdown have mostly been among the young, adjusting the the above cost/benefit ratios for the value of life will make lockdown an even worse policy.[52]

IV. Conclusion

After more than a year of gathering aggregate data, a puzzle has emerged. Lockdowns were brought on with claims that they were effective and the only means of dealing with the pandemic. However, across many different jurisdictions this relationship does not hold when looking at the raw data.

A casual examination of lockdown intensity and the number of cumulative deaths attributed to Covid-19 across jurisdictions shows no obvious relationship.[53] Indeed, often the least intensive locations had equal or better performance. For example, using the *OurWorldInData* stringency index (SI) as a measure of lockdown, Pakistan (SI: 50), Finland (SI: 52), and Bulgaria (SI: 50) had similar degrees of lockdown, but the cumulative deaths per million were 61, 141, and 1023. Peru (SI: 83) and the U.K. (SI: 78) had some of the most stringent lockdowns, but also experienced some of the largest cumulative deaths per million: 1475 and 1868.[54]

Using information from *OurWorldInData*, the cumulative deaths per million on March 28, 2021 in North America were 1351 and for the European Union 1368. Sweden had light restrictions, but cumulative deaths were 1327; while the UK had heavy lockdowns and 1868 cumulative deaths per million. This stands in sharp

[52] Lally (July 2021) performs a cost benefit study for New Zealand and compares the cost per QALY to estimates of lost GDP and other costs of lockdown. He concludes these costs "... to be at least 13 times the generally employed figure of $62,000 for health interventions in New Zealand; the lockdowns were therefore not justified."

[53] Whether these deaths were actually caused by Covid-19 is an important matter, but one that I have not dealt with in this paper.

[54] All numbers from *OurWorldInData* are as of March 28, 2021. https://ourworldindata.org/grapher/covid-stringency-index

contrast to the dire predictions that were made about Sweden in the first six months of the pandemic.[55]

Similar findings arise when comparing various US states. Florida and California were often compared because they are similar in terms of size and latitude, but had different lockdown policies. Florida locked down in the spring but then started lifting restrictions, on September 25th, 2020 all restrictions were lifted. California has had various mandates throughout 2020, but in early December issued stay-at-home order that remained in place until January 25th, 2021.[56] However, the cumulative deaths per 100,000 people are practically indistinguishable: 152 for Florida and 143 for California.[57]

It is easy to find counter examples when using unconditional counts on deaths across different jurisdictions. That is, one can find cases where lockdown states had fewer deaths per million than some non-lockdown states (e.g., Ireland and Germany had high stringency indexes and below average deaths per million). However, it remains the case that lockdown is not associated with fewer deaths per million, but

[55] Gardner, *et al.* (April 2020), claimed the following about Sweden: "This individual-based modelling project predicts that with the current mitigation approach approximately 96,000 deaths (95% CI 52,000 to 183,000) can be expected before 1 July, 2020." The original ICL model, Report 12 (appendix) also predicted 90,157 deaths in Sweden by the end of July, 2020. On March 28, 2021 the total number of deaths in Sweden was 13,402. Klein *et al.* (August 2020) pointed out 16 different factors for Sweden compared to other Nordic countries that explained their worse experience with the virus. The most important factor was the "dry tinder" situation; that is, Sweden had a light flu season in the year prior to Covid-19 which meant that it had a large number of elderly people who would have normally died in the previous year. The lower excess deaths in 2019 was then made up by the higher than average excess deaths in the spring of 2020. Overall, the excess deaths for Sweden in 2020 was just 1.5% higher than average. Source: https://www.cebm.net/covid-19/excess-mortality-across-countries-in-2020/ This dry tinder effect accounted between 25–50% of the difference in death rates across the Nordic countries.

[56] See John Hopkins Coronavirus Resource Center for lockdown information: https://coronavirus.jhu.edu/data/state-timeline/.

[57] Texas, which removed all lockdown restrictions on March 10, 2021, is another very public case. The reaction to opening up was overwhelmingly negative: the California Governor called it "absolutely reckless," Dr. Fauci said "It just is inexplicable why you would want to pull back now," and President Joe Biden said it was "a big mistake" and the result of "Neanderthal thinking." However, cases and deaths continued to fall after the removal of lockdown restrictions.

(likely) more.[58]

These unconditional observation puzzles are resolved by the research done over the past year. The preconceived success of lockdowns was driven by theoretical models that were based on assumptions that were unrealistic and often false. The lack of any clear and large lockdown effect is because there isn't one to be found.

The consideration of any policy must consider all costs and all benefits of that policy. All estimates of costs and benefits depend on various assumptions of parameters and structural model forms, and many of the studies examined (especially the early ones) relied on assumptions that were false, and which tended to over-estimate the benefits and under-estimate the costs of lockdown. As a result, most of the early cost/benefit studies arrived at conclusions that were refuted later by data, and which rendered their cost/benefit findings incorrect.

Advances in models and data over the past year have showed that lockdowns have had, at best, a marginal effect on the number of Covid-19 deaths. Generally speaking, the ineffectiveness of lockdown stems from voluntary changes in behavior. Lockdown jurisdictions were not able to prevent non-compliance, and non-lockdown jurisdictions benefited from voluntary changes in behavior that mimicked lockdowns.

Using a cost/benefit method proposed by Professor Bryan Caplan the most reasonable cost/benefit ratio of lockdowns in terms of life-years saved in Canada is 281. However, given their limited effectiveness, lockdowns still fail under extremely conservative estimates of costs. Furthermore, if the fall of 2021 results in many cases

[58] Simply regressing cumulative deaths per million on lockdown stringency across the 36 countries available with information from *OurWorldInData*, produces:

$$\begin{array}{rl} \text{Cum. Death/M} = & 352.66 + 10.64 \\ & (0.80) \quad (1.59) \end{array}$$

where the t-statistic is in the parentheses. The small positive correlation is the wrong sign for lockdown efficacy and is not statistically significant. One should not put too much stock in such a simple cross section regression, my point is only that a simple correlation isn't found.

resulting from the more transmissible delta variant among a shrinking number of unvaccinated people, then the expected benefits of lockdown policies become even smaller. Lockdowns are not just an inefficient policy, they must rank as one of the greatest peacetime policy disasters of all time.

References

Abouk, R. and B. Heydari. "The Immediate Effect of COVID-19 Policies on Social Distancing Behavior in the United States." *MedRxiv*, April, 2020. https://doi.org/10.1101/2020.04.07.20057356.

Acemoglu D., V. Chernozhukov, I. Werning, and M. Whinston. "Optimal Targeted Lockdowns in a Multi-Group SIR Model", *NBER* May 2020.

Agostinelli, F., M. Doepke, G. Sorrenti, F. Zilibotti. "When the Great Equalizer Shuts Down: Schools, Peers, and Parents in Pandemic Times", *NBER* WP: 28264, December 2020. doi = 10.3386/w28264

Agrawal, V., J. Cantor, N. Sood, and C. Whaley. "The Impact of the Covid-19 pandemic and policy responses on excess mortality." *NBER* WP: 28930. DOI 10.3386/w28930

Akbarpour, M., C. Cook, S. Marzuoli, S. Mongey, A. Nagaraj, M. Saccarola, P. Tebaldi, S. Vasserman, Shoshana and H. Yang. "Socioeconomic Network Heterogeneity and Pandemic Policy Response", *NBER* WP: 27374 June, 2020. doi = 10.3386/w27374

Ambikapathy, B. and K. Krishnamurthy. "Mathematical modelling to assess the impact of lockdown on COVID-19 transmission in India: model development and validation." *JMIR Public Health Surveillance* 6(2) Mayl 2020. doi:10.2196/19368

Atkeson, A., K. Kopecky, and T. Zha. "Four Stylized Facts about COVID-19", *NBER* WP: 27719, August, 2020. doi = 10.3386/w27719

Atkeson, A. "A Parsimonious Behavioral SEIR Model of the 2020 Covid Epidemic in the Unisted States and the United Kingdom." *NBER* WP: 28434, February, 2021.

Baker, S., N. Bloom, S. Davis, and S. Terry. "COVID-Induced Economic Uncertainty", *NBER* WP: 26983, April 2020. doi = 10.3386/w26983

Banerjee, T. and A. Nayak. "U. S. County level analysis to determine If social distancing slowed the spread of COVID-19." Pan American Journal of Public Health 44 June 2020. https://doi.org/10.26633/RPSP.2020.90

Baron, E. J., E. Goldstein, and C. Wallace. "Suffering in silence: How COVID-19 school closures inhibit the reporting of child maltreatment." *Journal of public economics,* 190, (2020). https://doi.org/10.1016/j.jpubeco.2020.104258

Barro, R. "Non-Pharmaceutical Interventions and Mortality in U.S. Cities during the Great Influenza Pandemic, 1918-1919", *National Bureau of Economic Research* WP,27049, April 2020. doi=10.3386/w27049.

Basili, M. and A. Nicita, "The Covid-19/SARS-CoV-2 pandemic outbreak, the risk of institutional failures and a coherent health policy," Department of Economics University of Siena 838, Department of Economics, University of Siena, August 2020.

Becker, G. *Human capital: A theoretical and empirical analysis with special reference to education.* (Chicago: The University of Chicago Press, 1994).

Bendavid, E., C. Oh, J. Bhattacharya, and J. Ioannidis. "Assessing Mandatory Stay-at-Home and Business Closure Effects on the Spread of COVID-19" *European Journal of Clinical Investigation,* January, 2021.

Bendavid E, C. Oh, J. Bhattacharya, J. Ioannidis. "Response to Letters Re: 'Assessing mandatory stay-At-Home and business closure effects on the spread of COVID-19'." *European Journal of Clinical Investigation* April 2021. https://doi.org/10.1111/eci.13553

Berry, C. R., A. Fowler, T. Glazer, S. Handel-Meyer, and A. MacMillen. "Evaluating the effects of shelter-in-place policies during the Covid-19 pandemic" *PNAS* 118(15) April 2021, https://doi.org/10.1073/pnas.2019706118

Bethune, Z., and A. Korinek. "Covid-19 Infection Externalities: Trading Off Lives vs. Livelihoods", *NBER* WP: 27009, April 2020. doi = 10.3386/w27009

Bianchi, F., G. Bianchi, D. Song. "The Long-Term Impact of the COVID-19 Unemployment Shock on Life Expectancy and Mortality Rates", *NBER* WP: 28304, December, 2020. doi = 10.3386/w28304

Bjørnskov, C. "Did Lockdown Work? An Economist's Cross-Country Comparison." *CESifo Economic Studies.* March 2021: 1–14.

Bloom, N., P. Bunn, P. Mizen, P. Smietanka, and G. Thwaites. "The Impact of Covid-19 on Productivity", *NBER* WP: 28233, December 2020. doi = 10.3386/w28233

Boettke, P. and B. Powell. "The political economy of the Covid-19 pandemic." *Southern Economic Journal* 87, 2021.

Bonal, X., and S. González. "The impact of lockdown on the learning gap: family and school divisions in times of crisis." *International Review of Education* 66, December 2020. https://doi.org/10.1007/s11159-020-09860-z

Born, B., A. Dietrich, and G. Mueller. "The Lockdown Effect: A Counter-factual for Sweden." *CEPR Discussion Paper*, 32, July, 2020. https://cepr.org/active/publications/discussion_papers/dp.php?dpno=14744.

Bonardi, J.P., Q. Gallea, D. Kalanoski, and R. Lalive. "Fast and Local: How Lockdown Policies Affect the Spread and Severity of Covid-19." *CEPR Covid Economics*, 27, 2020. https://cepr.org/sites/default/files/CovidEconomics23.pdf.

Buonsenso, D., D. Roland, C. De Rose, P. Vsquez-Hoyos, B. Ramly, J. Nandipa, J. Chakakala-Chaziya, A. Munro, S. Gonzlez-Dambrauskas, "Schools Closures during the COVID-19 Pandemic: A Catastrophic Global Situation." Preprints 2020, doi: 10.20944/preprints202012.0199.v1.

Caplan, B. "Life years lost: the quantity and the quality." November 24, 2020. https://www.econlib.org/life-years-lost-the-quantity-and-the-quality/

Chalfin, A., S. Danagoulian, M. Deza. "COVID-19 Has Strengthened the Relationship Between Alcohol Consumption and Domestic Violence", *NBER* WP: 28523, March, 2021.

Chaudhry, R., G. Dranitsaris, T. Mubashir, J. Bartoszko, and S. Riazi. "A country level analysis measuring the impact of government actions, country preparedness and socioeconomic factors on COVID-19 mortality and related health outcomes." *EClinicalMedicine* 25, July 2020. doi.org/10.1016/j.eclinm.2020.100464

Chernozhukov, V., H. Kasahara, P. Schrimpf. "Causal Impact of Masks, Policies, Behavior on Early Covid-19 Pandemic in the U.S." *Journal of Econometrics* 220, 2021: 23–62.

Chin, V. J. Ioannidis, M. Tanner, S. Cripps. "Effect estimates of Covid-19 non-pharmaceutical interventions are non-robust and highly model-dependent." *Journal of Clinical Epidemiology* 136, 2021: 96–132.

Christakis, D. A., W. Van Cleve, and F. J. Zimmerman. "Estimation of US Children's Educational Attainment and Years of Life Lost Associated With Primary School Closures During the Coronavirus Disease 2019 Pandemic." *JAMA Network Open*, 3(11), November 2020. doi.org/10.1001/jamanetworkopen.2020.28786

Coase, R. "The Problem of Social Cost" *Journal of Law and Economics* III 1960: 1–44.

Coibion, O., Y. Gorodnichenko, M. Weber. "The Cost of the Covid-19 Crisis: Lockdowns, Macroeconomic Expectations, and Consumer Spending", *NBER* WP: 27141, May 2020, doi = 10.3386/w27141

Courtemanche, C., J. Garuccio, A. Le, J. Pinkston, and A. Yelowitz. "Strong Social Distancing Measures In The United States Reduced The COVID-19 Growth Rate." *Health Affairs* 39(7), May 2020: https://doi.org/10.1377/hlthaff.2020.00608.

Cutler D. and L. Summers. "The COVID-19 Pandemic and the $16 Trillion Virus." *JAMA* October 2020 doi:10.1001/jama.2020.19759

Czeisler, M., R. Lane, E. Petrosky, *et al.*, "Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24–30, 2020." *Morbidity and Mortality Weekly Report* August 14, 2020: 69(32):1049–1057. DOI: http://dx.doi.org/10.15585/mmwr.mm6932a1external icon.

Dehning, J. J. Zierenberg, F. P. Spitzner, M. Wibral, J. P. Neto, M. Wilczek, and V. Priesemann. "Inferring change points in the spread of covid-19 reveals the effectiveness of interventions." *Science*, 369(160) May 2020.

Dhaval, D. A. Friedson, K. Matsuzawa, and J. Sabia. "When Do Shelter-in-Place Orders Fight COVID-19 Best — Policy Heterogeneity Across States and Adoption Time", *NBER* WP: 27091, May, 2020b doi = 10.3386/w27091

Dhaval, D., A. Friedson, K. Matsuzawa, D. McNichols, C. Redpath, and J. Sabia. "Risk Aversion, Offsetting Community Effects, and COVID-19: Evidence from an Indoor Political Rally", *NBER* WP: 27522, July 2020a doi = 10.3386/w27522

Dhaval, D., A. Friedson, K. Matsuzawa, J. Sabia, S. Safford. "Were Urban Cowboys Enough to Control COVID-19? Local Shelter-in-Place Orders and Coronavirus Case Growth", *NBER* WP: 27229, May, 2020. doi = 10.3386/w27229

Eichenbaum, M., M. de Matos, F. Lima, S. Rebelo, and M. Trabandt. "How do People Respond to Small Probability Events with Large, Negative Consequences?", *NBER* WP: 27988, October, 2020.

Eichenbaum, M., S. Rebelo, and M. Trabandt. "The Macroeconomics of Epidemics", *NBER* WP: 26882, March 2020.

Eksin, C., K. Paarporn, and J. Weitz. "Systematic biases in disease forecasting ? The role of behavior change." *Epidemics*, 27, June 2019.

Elenev, V., L. Quintero, A. Rebucci, E. Simeonova. "Direct and spillover effects from staggered adoption of health poloicies evidence from covid-19 statey-at-home orders" *NBER* WP: 29088, July 2021.

Ellison, G., "Implications of Heterogeneous SIR Models for Analyses of COVID-19", *NBER* WP: 27373, June 2020. doi = 10.3386/w27373

Eurostat. "GDP down by 0.7% in the euro area and by 0.5% in the EU." *Euroindicators* February, 2021.

Farboodi, M., G. Jarosch, and R. Shimer. "Internal and external effects of social distancing in a pandemic." *NBER* WP: 27059, July 2020.

Ferguson, N., D. Laydon, G. Nedjati-Gilani *et al.* "Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand." Imperial College London, March 2020. doi:https://doi.org/10.25561/77482.

Flaxman, S., S. Mishra, A. Gandy, H. Juliette T. Unwin, T. Mellan, H. Coupland, C. Whittaker, *et al.* "Estimating the Effects of Non-Pharmaceutical Interventions on COVID-19 in Europe." *Nature* 584 June 2020. https://doi.org/10.1038/s41586-020-2405-7.

Friedson, A., D. McNichols, J. Sabia, D. Dhaval. "Did California's Shelter-in-Place Order Work? Early Coronavirus-Related Public Health Effects", *NBER* WP: 26992, April 2020. doi = 10.3386/w26992

Fuchs-Schndeln, N., D. Krueger, A. Ludwig, I. Popova. "The Long-Term Distributional and Welfare Effects of Covid-19 School Closures", *NBER* WP: 27773, Sept. 2020. doi = 10.3386/w27773

Garcia, S., M. Albaghdadi, P. Meraj, C. Schmidt, R. Garberich, F. Jaffer, S. Dixon, J. Rade, M. Tannenbaum, J. Chambers, P. Huang, and T. Henry. "Reduction in ST-Segment Elevation Cardiac Catheterization Laboratory Activations in the United States During COVID-19 Pandemic" *Journal of the American College of Cardiology*, 75(22), April 2020. https://doi.org/10.1016/j.jacc.2020.04.011

Gardner, J., W. Van Der Wijngaart, L Kamerlin, N. Brusselaers, and P. Kasson. "Intervention strategies against COVID-19 and their estimated impact on-Swedish healthcare capacity" *MedRxiv* April 15, 2020, https://doi.org/10.1101/2020.04.11.20062133

Gibson, J. "Government mandated lockdowns do not reduceCovid-19 deaths: implications for evaluating the stringent New Zealand response," *New ZealandEconomic Papers*, Nov.(2020): DOI: 10.1080/00779954.2020.1844786.

Goolsbee, A., and C. Syverson. "Fear, Lockdown, and Diversion: Comparing Drivers of Pandemic Economic Decline¿ (University of Chicago, Becker Friedman Institute for Economics) June 2020 https://ssrn.com/abstract=3631180 or http://dx.doi.org/10.2139/ssrn.3631180

Green, D., A. Karimirad, G. Simard-Duplain, H. Siu. "COVID and the Economic Importance of In-Person K-12 Schooling", *NBER* WP: 28200, December 2020. doi = 10.3386/w28200

Gupta, S., K. Simon, C. Wing. "Mandated and Voluntary Social Distancing During The COVID-19 Epidemic: A Review", *NBER* WP: 28139, November, 2020.

Hall, R., C. Jones, and P. Klenow. "Trading Off Consumption and COVID-19 Deaths," *NBER* WP: 27340, June 2020. doi = 10.3386/w27340.

Hammitt, J., "Valuing Mortality Risk in the Time of COVID-19" *SSRN* June 2020, https://ssrn.com/abstract=3615314 or http://dx.doi.org/10.2139/ssrn.3615314

Harris, J. "The Coronavirus Epidemic Curve is Already Flattening in New York City", *NBER* WP:26917, April, 2020. doi = 10.3386/w26917

Holland, M., J. Burke, S. Hulac, M. Morris, G. Bryskiewicz, A. Goold, K. McVaney, L. Rappaport, and B. Stauffer. "Excess Cardiac Arrest in the Community During the COVID-19 Pandemic." *JACC. Cardiovascular interventions*, 13(16), August, 2020. https://doi.org/10.1016/j.jcin.2020.06.022

Holt-Lunstad, J. T. Smith, M. Baker. "Loneliness and Social Isolation as Risk Factors for Mortality: A Meta-Analytic Review" *Perspectives on Psychological Science*, March 11, 2015 https://doi.org/10.1177/1745691614568352.

Homburg, S. and C. Kuhbandner. "Comment on Flaxman et al.'The Illusory Effects of Non-Pharmaceutical Interventions on COVID-19 in Europe.' " *Nature* June 2020: https://doi.org/10.1038/s41586-020-2405-7.

Hsiang, S., D. Allen, S. Annan-Phan, K. Bell, I. Bolliger, T. Chong, H. Druckenmiller, L. Huang, A. Hultgren, E. Krasovich, P. Lau, J. Lee, E. Rolf, J. Tseng, and T. Wu. "The effect of large-scale anti-contagion policies on the COVID-19 pandemic." *Nature* 584, August 2020: 262–267.

Hunt, A., L. Boxell, J. Conway, B. Ferguson, M. Gentzkow, and B. Goldman. "What Explains Temporal and Geographic Variation in the Early US Coronavirus Pandemic" *NBER* WP: 27965, October, 2020. https://doi.org/10.3386/w27965.

Ibarra-Vega, D. Lockdown, one, two, none, or smart. Modeling containing covid-19 infection. A conceptual model. *Science of the Total Environment.* 730, August 2020. https://doi.org/10.1016/j.scitotenv.2020.138917

Ioannidis, J., "Reconciling estimates of global spread and infection fatality rates of COVID?19: an overview of systematic evaluations" *European Journal of Clinical Investigation* March 2021. https://doi.org/10.1111/eci.13554

Ioannidis, J., "Infection fatality rate of COVID-19 inferred from seroprevalence data" *Bulletin of the World Health Organization* October 2020.

Jia, R., K. Ayling, T. Chalder, A. Massey, E. Broadbent, C. Coupland, and K. Vedhara. "Mental health in the UK during the COVID-19 pandemic: cross-sectional analyses from a community cohort study", *BMJ Open* 10(9), June, 2020. doi = 10.1136/bmjopen-2020-040620

Jones, C., T. Philippon, and V. Venkateswaran. "Optimal Mitigation Policies in a Pandemic: Social Distancing and Working from Home", *NBER* WP: 26984, April 2020. doi = 10.3386/w26984

Kepp, K. and C. Bjørnskov. MedXriv, January 4, /2021. "Lockdown Effects on Sars-CoV-2 Transmission — The evidence from Northern Jutland." *MedRxiv* Pre-print January 4, 2021. doi: https://doi.org/10.1101/2020.12.28.20248936

Killgore, W., S. Cloonan, E. Taylor, M. Allbright, N. Dailey, "Trends in suicidal ideation over the first three months of COVID-19 lockdowns," *Psychiatry Research*, Vol. 293, 2020.

Klein, D. B., J. Book, and C. Bjørnskov. "16 Possible Factors for Sweden?s High COVID Death Rate among the Nordics" (August 14, 2020). *GMU Working Paper in Economics No. 20-27*, https://ssrn.com/abstract=3674138 or http://dx.doi.org/10.2139/ssrn.3674138

Kniesner, T. J., R. Sullivan. "The Forgotten Numbers: A Closer Look at Covid-19 Non-Fatal Valuations" *Journal of Risk and Uncertainty* 61(2), 2020: 155–176.

Lai, A. *et al.* "Estimating excess mortality in people with cancer and multimorbidity in the COVID-19 emergency." *medRxiv* June 2020. doi.org/10.1101/2020.05.27.20083287

Lally, M. "The Costs and Benefits of Covid-19 Lockdowns in New Zealand" *medRxiv* July 2021; doi: https://doi.org/10.1101/2021.07.15.21260606

Leeson, P. and L. Rouanet. "Externality and Covid-19" *Southern Economic Journal* 87, April 2021.

Lemoine, P. "Lockdowns, science and voodoo magic." https://necpluribusimpar.net/lockdowns-science-and-voodoo-magic/, December 2020.

Lemoine, P. "Lockdowns, econometrics and the art of putting lipstick on a pig." https://cspicenter.org/blog/waronscience/lockdowns-econometrics-and-the-art-of-putting-lipstick-on-a-pig/, July 2021.

Levin, A., W. Hanage, N. Owusu-Boaitey, K. Cochran, S. Walsh, G. Meyerowitz-Katz. "Assessing the Age Specificity of Infection Fatality Rates for COVID-19: Systematic Review, Meta-analysis, & Public Policy Implications", *European Journal of Epidemiology* December 35(12), 2020. doi = 10.1007/s10654-020-00698-1

Lewis, N. "Did lockdowns really save 3 million Covid-19 deaths, as Flaxman et al. claim?" https://judithcurry.com/2020/06/21/did-lockdowns-really-save-3-million-covid-19-deaths-as-flaxman-et-al-claim/

Lewis, D., K. Mertens, J. Stock. "U.S. Economic Activity During the Early Weeks of the SARS-Cov-2 Outbreak", *NBER* April 2020. doi = 10.3386/w26954

Lewis, S., A. Munro, G. Smith, A. Pollock, Allyson. "Closing schools is not evidence based and harms children." *BMJ* 372, February 2021. https://www.bmj.com/content/372/bmj.n521

Lin, Z. and C. Meissner. "Health vs. Wealth — Public Health Policies and the Economy During Covid-19", *NBER* WP: 27099, May 2020. doi = 10.3386/w27099

Lindo, J. "Parental job loss and infant health." *Journal of Health Economics* 30(5), September 2011.

Loades, M., E. Chatburn, N. Higson-Sweeney, S. Reynolds, R. Shafran, A. Brigden, C. Linney, M. McManus, C. Borwick, and E. Crawley. "Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19," *Journal of the American Academy of Child & Adolescent Psychiatry*, 59(11) 2020. https://doi.org/10.1016/j.jaac.2020.05.009.

London, J., E. Fazio-Eynullayeva, M.. Palchuk, P. Sankey, and C. McNair. " Effects of the COVID-19 Pandemic on Cancer-Related Patient Encounters." *JCO Clinical Cancer Informatics* 4, June 2020. DOI: 10.1200/cci.20.00068

Luther, W., "Behavioral and Policy Responses to COVID-19: Evidence from Google Mobility Data on State-Level Stay-at-Home Orders" *AIER Sound Money Project Working Paper No. 2020-06*, May 8, 2020). https://ssrn.com/abstract=3596551 or http://dx.doi.org/10.2139/ssrn.3596551

Manara, A., L. Mumford, D. Callaghaan, R. Ravanan, and D. Gardiner. "Donation and transplantation activity in the UK during the COVID-19 lockdown.. *Lancet* 396(10249), August 2020. doi.org/10.1016/S0140-6736(20)31692-5

Maringe, C., J. Spicer, M. Morris, A. Purushotham, E. Nolte, R. Sullivan, B. Rachet, A. Aggarwal. "The impact of the COVID-19 pandemic on cancer deaths due to delays in diagnosis in England, UK: a national, population-based, modelling study" *The Lancet Oncology* 21(8), August, 2020.

McIntyre, R. S., and Lee, Y. "Projected increases in suicide in Canada as a consequence of COVID-19." *Psychiatry research*, 290, (2020) https://doi.org/10.1016/j.psychres.2020.113104

Meunier, T. "Full lockdown policies in Western Europe countries have no evident impacts on the COVID-19 epidemic" *MedRxiv* Pre-print May 1, 2020.

Miles, D., M. Stedman, and A. Heald. "Living with Covid-19: Balancing costs against benefits in the face of the virus." *National Institute Economic Review* 253 August 2020.

Mulligan, C., K. Murphy, R. Topel. "Some basic economics of COVID-19 policy A look at the trade-offs we face in regulating behavior during the pandemic" *Chicago Booth Review* April 2020. https://review.chicagobooth.edu/economics/2020/article/some-basic-economics-covid-19-policy#_ftnref1

Mulligan, C. "Deaths of Despair and the Incidence of Excess Mortality in 2020", *NBER* WP: 28303, December 2020. doi = 10.3386/w28303

Mulligan, C. "The Backward Art of Slowing the Spread? Congregation Efficiencies during COVID-19" Becker Friedman Institute, WP: 2021-51, April 2021.

Newlove-Delgado, T., S. McManus, K. Sadler, S. Thandi, T. Vizard, C. Cartwright, and T. Ford "Child mental health in England before and during the COVID-19 lockdown", *The Lancet Psychiatry* Jan. 2021

Philipson T. "Chapter 33, Economic epidemiology and infectious diseases." *Handbook of Health Economics.* (Vol 1. Elsevier; 2000).

Philipson, T. J. and Posner, R. A. *Private Choices and Public Health.* (Cambridge, Mass.: Harvard University Press, 1993).

Rangel, J.C., S. Ranade, P. Sutcliffe, E. Mykhalovskiy, D. Gastaldo, and J. Eakin. "Covid-19 policy measures — Advocating for the inclusion of the social determinants of health in modelling and decision making." *Journal of Evaluation in Clinical Practice* 26, May 2020. DOI: 10.1111/jep.13436

Ravindran, S. and S. Manisha. "Unintended Consequences of Lockdowns: COVID-19 and the Shadow Pandemic", *NBER* WP: 27562, July 2020. doi = 10.3386/w27562

Robinson, L., R. Sullivan, and J. Shogren. "Do the Benefits of COVID?19 Policies Exceed the Costs? Exploring Uncertainties in the Age–VSL Relationship" *Risk analysis: An International Journal* July 2020. https://doi.org/10.1111/risa.13561

Roelfs, D. E. Shor, K. Davidson, J. Schwartz. "Losing life and livelihood: a systematic review and meta-analysis of unemployment and all-cause mortality." *Social Science Medine* 72(6) January 2011: 840–854.

Rowthorn R, and J. Maciejowski. "A cost-benefit analysis of the COVID-19 disease." *Oxford Review of Economic Policy* August 2020. doi:10.1093/oxrep/graa030

Savaris, R., G. Pumi, J. Dalzochio, and R. Kunst. "Stay-at-home policy is a case of exception fallacy: an internet-based ecological study." *Scientific Reports* 11, March 2021. https://doi.org/10.1038/s41598-021-84092-1

Sjödin, H., A. Wilder-Smith, S. Osman, Z. Farooq, and J. Rockĺov. "Only strict quarantine measures can curb the coronavirus disease (COVID-19) outbreak in Italy," Euro Surveillance¿ 25(13) April 2020. https://doi.org/10.2807/1560-7917.ES.2020.25.13.2000280

Steptoe, A., A. Shankar, P. Demakakos, and J. Wardle. "Social isolation, loneliness, and all-cause mortality in older men and women." *Proceeding of the National Academy of Sciences* 110(15), April 2013. https://doi.org/10.1073/pnas.1219686110

Thunstrm, L., Newbold, S., Finnoff, D., Ashworth, M., and Shogren, J. (2020). The Benefits and Costs of Using Social Distancing to Flatten the Curve for COVID-19. Journal of Benefit-Cost Analysis, 11(2), 179-195. doi:10.1017/bca.2020.12

Weerakoon, S. M., K. Jetelina, and G. Knell "Longer time spent at home during COVID-19 pandemic is associated with binge drinking among US adults," *The American Journal of Drug and Alcohol Abuse*, (2020), DOI: 10.1080/00952990.2020.1832508

Williams, S. A. Crookes, K. Glass, and A. Glass. "Covid-19 mortalities in England and Wales and the Peltzman offsetting effect." *Applied Economics* 2021: 1–17. https://doi.org/10.1080/00036846.2021.1955089

Woolf, S., D. Chapman, R. Sabo, D. Weinberger, L. Hill, D. Taylor. "Excess Deaths From COVID-19 and Other Causes," *JAMA* 324(15), March-July 2020 doi:10.1001/jama.2020.19545