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

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ABSTRACT

An examination of over 80 Covid-19 studies reveals that many relied on assumptions that were false, and which tended to over-estimate the benefits and underestimate 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. Research done over the past six months has shown 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 noncompliance, and non-lockdown jurisdictions benefited from voluntary changes in behavior that mimicked lockdowns. The limited effectiveness of lockdowns explains why, after one year, the unconditional cumulative deaths per million, and the pattern of daily deaths per million, is not negatively correlated with the stringency of lockdown across countries. Using a cost/benefit method proposed by Professor Bryan Caplan, and using two extreme assumptions of lockdown effectiveness, the cost/benefit ratio of lockdowns in Canada, in terms of life-years saved, is between 3.6–282. That is, it is possible that lockdown will go down as one of the greatest peacetime policy failures in Canada's history.

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I. Introduction

In my forty years as an academic, I've never seen anything like the response and reaction to Covid-19. The research response has been immense, with estimates of over 40,000 papers related to the topic produced in one year. This research covers every imaginable aspect of Covid-19, and over the course of the past year knowledge about the virus, the human reactions to it, and the consequences of these reactions has exploded. In one word, the Covid-19 information cascade has been "overwhelming."

In contrast, the ubiquitous media, public health, and political response to the pandemic has been one-sided, incomplete, and almost unchanging over the past year. 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 look up if you know where to look. Furthermore, when research results contrary to the official government response were shared on social media, they were often pulled from social media platforms. As a result, for average Canadians the public media and official public health news conferences have been the only source of Covid-19 information.

This review of a small segment of the literature is intended to give some guidance for those who would otherwise not have access to academic research. The focus is to only critically assess the cost/benefit studies that have been written over the past year on lockdown policies related to the Covid-19 pandemic.[1]

The report covers over 80 different academic studies and 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.

[1] The studies referred to are listed in the Reference section. Many papers and data sites have links to webpages. Because these links often "ran off the page" I often had to break them up by inserting a space. Hence, if the link does not work, check to make sure there are no spaces.

The term "lockdown" is used to generically refer to state actions that imposed various forms of non-pharmaceutical interventions. That is, the term will be 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.[2] Here I will only consider lockdown as it took place in Canada and most of the world; that is, within a country where the virus became established.

This is a complicated report because it covers a wide range of studies, and deals with a wide range of issues. Table 1 outlines the substance of the report. Sections II: A and B, discuss 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 models turned out to be false.

Section II: C, examines major cost/benefit studies completed over the first six months of the pandemic, and then focuses on what I believe to be the critical factor: distinguishing between mandated and voluntary changes in behavior. This section concludes with an interpretation of some unconditional death comparisons across countries that are typically reported in the media. Section II:D surveys the research done on the costs of lockdown. Finally, Section III. presents a simple alternative cost/benefit methodology to generate two cost/benefit ratios of lockdown.

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[2] Other island countries with this strategy include many Pacific island nations (like Samoa and Tonga), Caribbean islands (like Cuba and Jamaica), and Iceland. Some countries have been able to mimic being islands in border closings like South Korea, Finland, and Norway.

Table 1: Outline of the Main Body of Report

II. Cost Benefit Studies

A. Issues in Determining Lockdown Benefits
The Counterfactual Number of Cases/Deaths
The Exogenous Behavior Assumption
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B. An Issue in Lockdown Costs
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C. Reviewing Lockdown Cost/Benefit Studies
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Unconditional Cross-Country Covid-19 Comparisons

D. The Costs of Lockdown

III. An Alternative Cost/Benefit Methodology

The major conclusions of this report are:

a. A proper cost/benefit study of a specific policy must consider all costs and all benefits of that policy.

b. 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.

c. As a result of (b) most of the early cost/benefit studies arrived at conclusions that were refuted later by data, and which rendered their cost/benefit findings incorrect.

d. Advances in models and data over the past six months 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.

e. The limited effectiveness of lockdowns explains why, after one year, the unconditional cumulative deaths per million, and the pattern of daily deaths per million, is not negatively correlated with the stringency of lockdown across countries.

f. Using a cost/benefit method proposed by Professor Bryan Caplan, and using two extreme assumptions of lockdown effectiveness, the cost/benefit ratio of lockdowns in terms of life-years saved is between 3.6–282.

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.
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> [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 will necessarily provide a misdirection. 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."

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Over the course of the Covid-19 pandemic, there has been no public evidence that either the federal or provincial governments of Canada 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, variant transmissions, etc., there has seldom been any 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. Here, aside from going through some of the theoretical issues, I provide a summary of the major findings.

A. Issues in Determining Lockdown Benefits

Over the course of the first six months of the pandemic most of the "action" in cost/benefit studies came from the benefit side. That is, many studies reported enormous benefits to lockdown, and so little attention was given to the particulars of lockdown costs. Therefore, before going through a sequential review of studies to show the progression of understanding over the past year, I start by addressing some general theoretical and empirical issues of estimating Covid-19 lockdown benefits. Understanding these assumptions explains why the conclusions across studies are so different.

The Counterfactual Number of Cases/Deaths

The argument for lockdown benefits is intuitive. If a new virus enters a population with no immunity and spreads *exponentially*, causing an overwhelming of

hospitals and subsequent large numbers of deaths, then a physical 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 if a vaccine can be created in time. Lockdown is a formal, state-mandated "one size fits all" version of the social norm "keep your distance from people who are sick."

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?

Within the field of epidemiology it is common to model disease through what is called a SIRS model. This is a model that depends on number of people susceptible (S), infectious (I), or recovered (R). These models can vary in many ways, and can include many parameters and constraints. Early in the pandemic the Neil Ferguson *et al.* (March 2020) model (known as the Imperial College of London (ICL) model), appeared to drive many lockdown decisions, and certainly was widely covered in the media.

In these models the virus progresses through a population in a mechanical fashion. There are a number of parameters in the model, including the basic reproduction number, R_t. The basic reproduction number varies over time, and indicates the expected number of secondary infections in a vulnerable population that are generated by a single given infection. Lockdowns are often interpreted as a means of effectively altering the reproduction number.

Figure 1 reproduces a key figure of the Ferguson *et al.* paper, 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 SIRS model.

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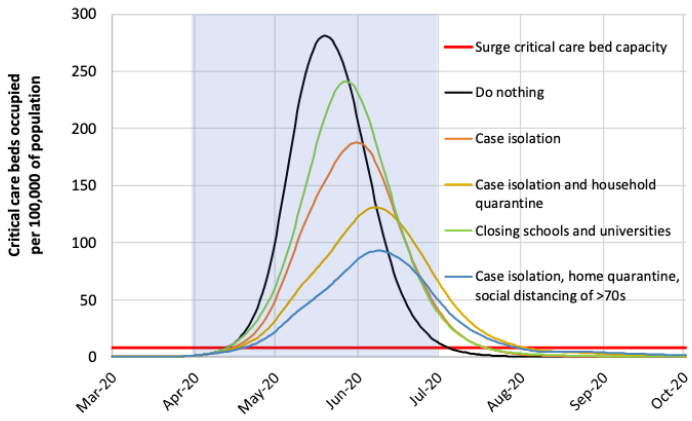

Figure 1: ICU Predictions in ICL Model

We can use Figure 1 to see the implications of the SIRS model for determining the counterfactual. Suppose, for the sake of argument that the blue line lockdown was enacted. Then, reading from the graph, on June 20th approximately 80 ICU beds would have been occupied. However, the counterfactual would be taken from the black "do nothing" line, and reading from the graph there would have been 200 ICU beds occupied. The blue lockdown would have reduced the number of ICU beds occupied by 120. Because SIRS models have an exponential growth characteristic until a population approaches herd immunity, the "do nothing" counterfactual can be enormous, and this automatically makes lockdown look better.

As a result, the ICL model made some dire predictions that saturated media coverage in the first wave of the pandemic. For instance: "In the (unlikely) absence of any control measures or spontaneous changes in individual behaviour ... In total, in an unmitigated epidemic, we would predict approximately 510,000 deaths in GB and 2.2 million in the US, not accounting for the potential negative effects of health systems being overwhelmed on mortality." (p. 7, 2020).

The authors also 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 a virus. However, given the large counterfactual numbers, presumably they felt no reasonable cost could justify not locking down.[3]

Problems with the ICL model were pointed out almost immediately. These problems included: 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.[4] However, the point to stress is that all of these assumptions have the effect of over-estimating the counterfactual number of cases, transmissions, and deaths.[5]

The Exogenous Behavior Assumption

As mentioned, a critical parameter in a SIRS model is the basic reproduction number, R_t. A typical SIRS model shows that 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. This pattern was shown in Figure 1, and this particular evolution of the virus happens because no individual in the model ever changes behavior.

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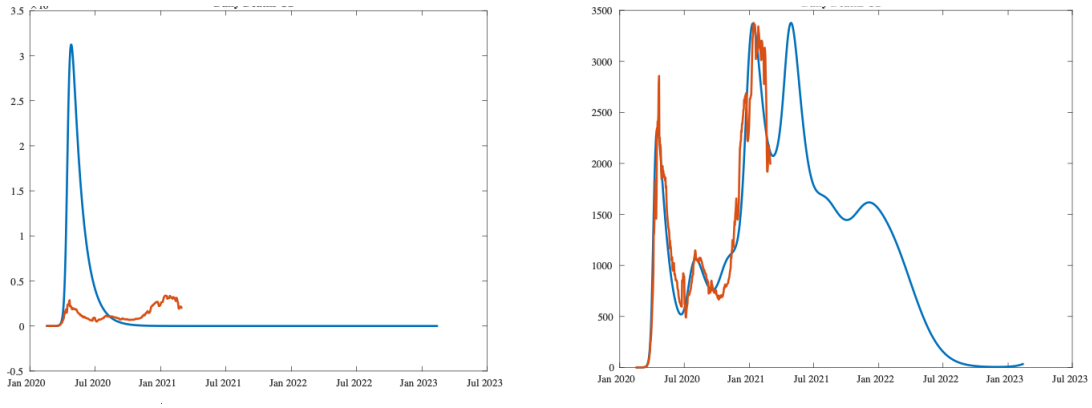
[3] To appreciate how far off the Ferguson *et al.* model predictions were, consider that the predicted number of deaths in the U.K. and the U.S. was to happen *by July of 2020.* Both the U.S. and U.K. have had relatively high death rates due to Covid-19, but as of March 12, 2021 the U.S. has experienced 536,914 deaths and the U.K. 125,927 deaths (OurWorldInData). The ICL model was off by a factor of four, over twice the time period.

[4] Estimates of the IFR have continued to fall over the year. The latest meta-study by Ioannidis (March 2021) estimates the average global IFR at 0.15%.

[5] 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 SIRS 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.

The implication of ignoring individual responses to a viral threat are dramatic. Atkeson (February 2021) uses a standard SIRS 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 are shown in panel (a) of Figure 2 by the blue line; the red line in panel (a) shows the actual daily deaths. The vertical axis is raised to the 10^4 power, so daily deaths are predicted to have peaked at 30,000 in July of 2020. Compared to the red line in panel (a), the standard model over estimated the peak number of deaths by a factor of about 12.



(a) (b)

Figure 2: Predicted and Actual Daily U.S. Deaths

Atkeson (February 2021) 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 is shown as the blue line in panel (b) of Figure 2. Adding the single behavioral response completely changed the model's predictive power. The model now tracks the actual progression of the daily deaths very closely. In correspondence with Atkeson he provided the reason 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. The point is, there is a dramatic change in predicted behavior once human reactions are included. A model lacking endogenous individual adjustment radically mis-estimates 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.[6] First, it influences how any counterfactual outcome is understood with respect to the lockdown. When no voluntary response is assumed, models predict the case load and deaths explode exponentially 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.[7] Therefore, not accounting for rational, voluntary individual responses within a SIRS model drastically overstates any benefit from lockdown.[8] When considering various cost/benefit

[6] The notion that epidemiological models need to contain endogenous human behavior was explained in a classic paper by Philipson (2000).

[7] 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.

[8] Looking back on statements made in March/April 2020 by medical professionals and epidemiologist shows how far off their predictions were. Michael Osterholm, director of the Center for Infectious Disease Research and Policy at the University of Minnesota, stated on The Joe Rogan Experience in March 2020 that "We conservatively estimate that this could require 48 million hospitalizations, 96 million cases actually occurring, over 480,000 deaths that can occur over the next four to seven months with this situation.." (Quoted from https://nationalinterest.org/blog/buzz/scientist-480000-people-could-die-due-coronavirus-48-million-hospitalizations-132167). The reality was that as of July 16, 2020 there were 138,000 deaths, 250,000 hospitalizations, and 3,600,000 confirmed cases. Unabashed, Osterholm 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,

studies it is important to discount models that assume no individual response to a viral threat.

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. Both effects create a *total* change in behavior that is the result of these two channels. It is extremely important that the empirical work done on lockdown effects distinguish between the two channels of behavior to determine how much behavior changed because of mandated lockdowns and how much because of voluntary changes.[9]

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,

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2021 there were 428 cases per million people in the U.S. As of March 14, six weeks later, there were 163 cases per million. Cases did not rise to unprecedented hurricane levels, but rather fell by more than two times.

[9] 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.[10]

In economics, the concept of "value" is based on the idea of maximum sacrifice. How much one is willing to sacrifice, at most, for something determines that individual's economic value of the thing. 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 how much individuals are willing to sacrifice to extend their life a little bit by reducing some type of harm (called a 'marginal' value), and then use this to determine a total value of life.

Everyday people make decisions that directly and indirectly are based on their marginal value of life. The decisions to eat poor foods, smoke, accept dangerous employment, cross a street, drive a car, exercise, or engage with others all entail risks to life and therefore imply a value of life. Economists and policy makers in general use the notion of an individual's marginal value of life in determining what it is called "The Value of a Statistical Life" (VSL). The VSL concept was developed in the 1960s by Thomas Schelling, and is widely used in policy work.

The VSL is estimated by observing individual marginal tradeoffs. Thus, if we observed someone willing to pay \$1000 to reduce the chance of death by 1/10,000 over the next year, then this would imply a value of life of \$10,000,000 ($10,000 \times$ \$1000).

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.

[10] 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. I abstract from this philosophical and moral issue.

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.[11]

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.

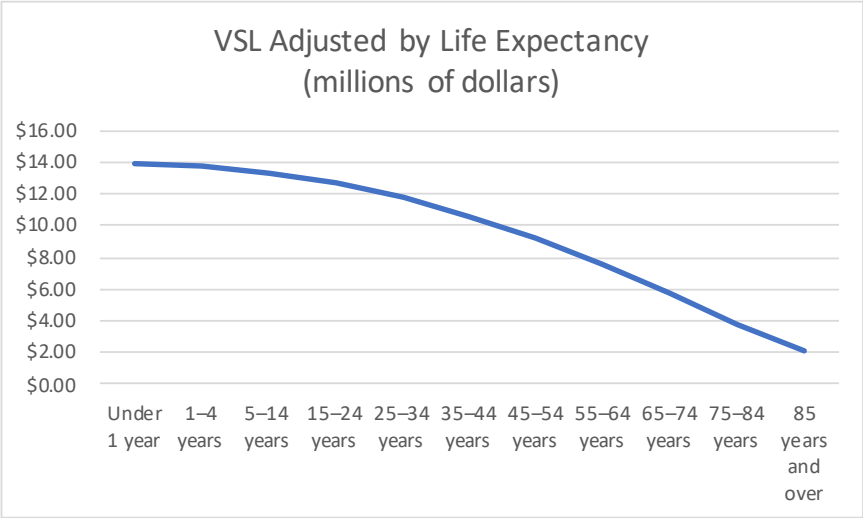

Figure 3: Age Related Estimates of VSL

To assume that the VSL is constant implies that individuals are indifferent between living one more day or eighty more years. Figure 3 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.[12]

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

[12] 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/

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. To take the extreme case, if the ICL model estimate implies that 200,000 Canadians would die from Covid-19 without lockdown, and each life lost was worth $10,000,000, then the benefit of lockdown would be $1 trillion dollars. In 2018 Canada's GDP was just $2.1 trillion dollars. At this estimate of death and VSL, it would make sense to shut down (not just lockdown) 50% of the Canadian economy for an entire year.

B. An Issue With Lockdown Costs

Comparing Apples to Oranges

One final theoretical issue needs to be dealt with before examining various cost/benefit studies. 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 marketed goods and services.

It is very common, in cost/benefit studies to simply use lost GDP as the measure for the cost of lockdown. That is, the reduction in the value of goods and services produced was attributed as the only cost of the lockdown. For example, Figure 4 shows Canada's GDP up to November 2020.[13] The estimated fall in GDP over

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.

[13] Taken from Stats Canada: https://www150.statcan.gc.ca/n1/daily-quotidien/210129/cg-a001-eng.htm.

the year is 5.1%, making it the worst year for economic growth since the great depression.

If 100% of the fall in GDP (approximately $107 billion) is attributed to the lockdown (that is, the virus directly had no effect on production), then compared to the trillion dollar savings in lives, the costs of lockdown are at most 10% of the value of the lives saved, and lockdown seems like a reasonable policy.

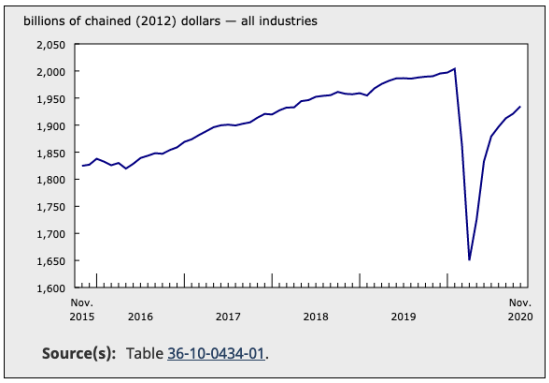

Figure 4: Canada's GDP Up to November 2020

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 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 of despair. 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 importance of the distinction, assume that instead of using the VSL to measure the value of a life, the gain (from fewer deaths) in GDP was used. If lockdown prevented the death of a 45 year old, fully employed person,

their market income could be used as a measure of their contribution to GDP. But the large majority of those who died of Covid-19 were retired, elderly, and sick.[14] The retired, elderly, and sick generally do not contribute to GDP. 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 it is still more appropriate than comparing utility based VSL estimates to lost GDP.

Summary of Theoretical Issues

Cost/Benefit studies are based on assumptions. These assumptions are often hidden in the mathematics of the theoretical or statistical model. I have pointed out four major sets of assumptions and their implications.

a. Models that use large (incorrect) values for the SIRS model parameters (e.g., R_t, IFR) over-estimate the counterfactual number of cases and deaths.

b. Models that assume human behavior is exogenous and independent of the virus over-estimate the counterfactual number of cases and deaths.

c. Studies that use an age independent VSL of $10,000,000 over-estimate the value of any lives saved.

d. Studies that use only lost GDP as a measure of the cost of lockdown under-estimate costs.

These four sets of assumptions bias the benefits of lockdown upwards and the costs of lockdown downwards. Below it is shown that all four of these assumptions were present in many of the earliest cost/benefit studies.

[14] 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.

C. Reviewing Lockdown Cost/Benefit Studies

Early Theoretical Cost/Benefit Studies

I direct my attention mostly to economic studies directly related to cost/benefit studies or issues related to estimating costs and benefits. I have examined, to various degrees, the relevant studies located on the NBER webpage, but I have also gone through the relevant studies at the Society for Benefit-Cost Analysis, and studies from various areas that received large amounts of attention.[15]

My general opinion of the earliest theoretical studies done in spring 2020 is that they were often based on assumptions that were either known, or turned out to be, incorrect, and which biased them to conclude that the benefits of lockdown exceeded the costs.[16] There were few empirical studies done in the earliest stages of the pandemic, but those that were done often relied on mechanical SIRS models for counterfactuals, and had very limited data to work with. At the very beginning of the pandemic "studies" were mostly casual, and used "back of the envelope" methods. Consider this conclusion from a March 23, 2020 article:[17]

> ... assume we save a million lives [by lockdown] and value everyone's life equally. In this case we've preserved $9 trillion in value, more than 40 percent of a year's GDP — before we try tallying all the health-care costs of an uncontrolled pandemic and

[15] The Society webpage is located at: https://www.benefitcostanalysis.org/covid-19_benefit_cost_analysis.php

[16] I ignore the issue of "homogeneity" in SIRS 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 SIRS model where there were three different age cohorts, with age-increasing risks from Covid-19. Not too surprisingly, in such 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.

[17] Source: https://www.nationalreview.com/corner/a-covid-cost-benefit-analysis/. Another article from March 31, 2020 (https://www.sciencemag.org/news/2020/03/modelers-weigh-value-lives-and-lockdown-costs-put-price-covid-19), assuming 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."

> the suffering we avert among nonfatal cases. Starting with these numbers I suspect it would be very, very difficult to make the costs add up to more than the benefits. The other is to assume we save a million lives, but on average each person only had, say, a decade to live ... In this case we're preserving only $1.25 trillion. I still think the benefits will easily prevail ...

By the late spring academic articles were being produced 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.[18]

[18] Almost all of the early cost/benefits studies I found from the early spring suffered from the problems of using a standard SIRS 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), 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 SIRS 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.

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 and May challenges to the sudden conventional wisdom on both the theoretical and empirical front were common.

On April 27, 2020, three economists at the University of Chicago (Mulligan, Murphy, and Topel) published "Some basic economics of Covid-19 policy" in the Chicago Booth Review. 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 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% as it is in many places in Canada.

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 on in the pandemic it was clear that the theoretical predictions based on the ICL and other basic SIRS models, in terms of numbers of cases and deaths, were wrong. There were a number of reasons for this, but one factor was the assumed infection fatality rate (IFR). The IFR is the fraction of those who become infected who die of Covid-19. It is a difficult number to calculate because the total number of infected individuals is not easily known. Levin *et al.* (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 had by much older cohorts.

The months of April–June also saw the first empirical studies on the effect lockdown had on case loads at the state level. Although most of the early studies

had found that lockdown reduced case loads, these results were mixed. 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.[19]

Perhaps the most widely cited and influential early empirical paper on lockdown was Flaxman *et al.* (June 2020) that argued lockdowns saved 3 million lives in Europe, and which according to the *Nature* webpage has almost 350,000 online accesses as of March 2021.[20] This paper looked at lockdowns across 11 European countries in the spring of 2020. It infered 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):

> 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

[19] 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.

[20] Public Health Ontario provided an online synopsis of the paper on June 6, 2020 (https://www.publichealthontario.ca/-/media/documents/ncov/research/2020/06/research-nature-estimating- effects-of-non-pharmaceutical.pdf?la=en), but without any critical commentary.

country-specific effects, the effect size of lockdown remains large across all countries

The Flaxman *et al.* (June 2020) paper has received criticism on a number of fronts, and these include the fact that they assumed homogeneous populations, they lump vastly different country policies into single indicator variables, and they assumed exogenous human behavior.[21] 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."[22]

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

[21] 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."

[22] 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?[23]

Four Stylized Facts About Covid-19

In my opinion, the Atkeson *et al.* (August 2020) paper "Four Stylized Facts About Covid-19" was a watershed paper among those written on Covid-19 within the first six months of the pandemic. It discovered an important feature 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. The paper used data from 23 countries and all U.S. states that had experienced at least 1000 cumulative deaths up to July 2020.

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$^{\text{th}}$ death the growth rate in deaths falls to close to zero, and the transmission rate hovers around one.[24] This is summarized in Figure 5 which reproduces their Figure 2 in it entirety.

The black line is the median posterior estimate of the relevant rate. Both graphs show the dramatic drop and stability of the death and transmission rates. This finding means that after 20 days the virus reached a steady state where each infected person transmits the virus to one other person, and the number of daily deaths from the virus became constant over time.

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

[24] 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.

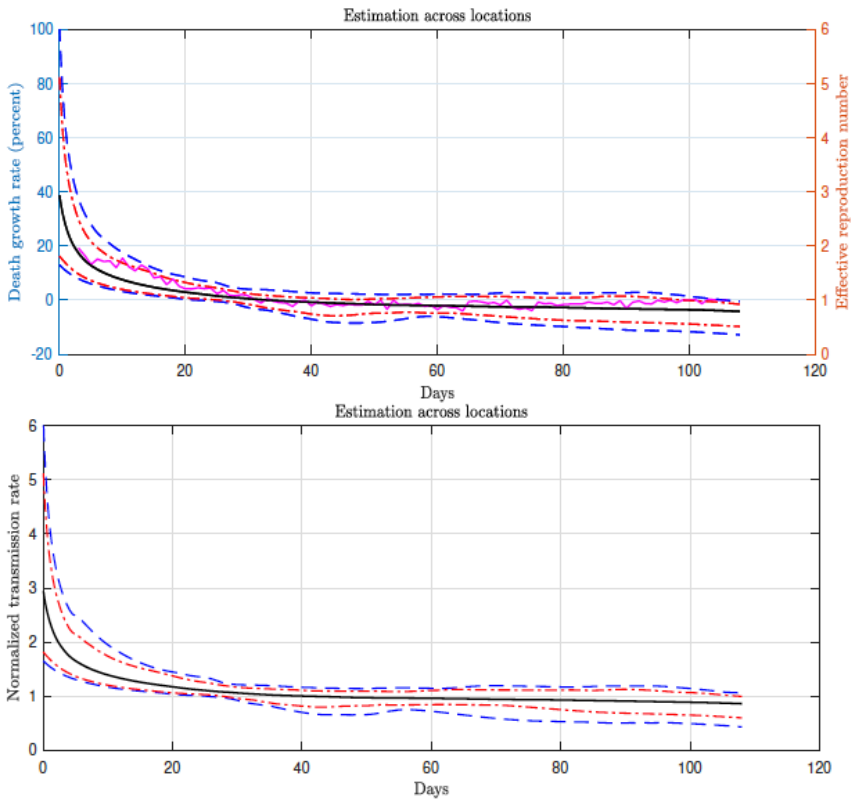

Figure 2: Location and sampling uncertainty. The black solid line in both charts represents the median posterior estimate. The solid magenta line in the top chart represents the median growth rate of 7-day smoothed daily deaths for all 50 locations and corresponds only to the left scale. The two dash-dotted bands in both charts contain two thirds of the posterior probability at each point in time and the two dashed bands, 0.90 of the posterior probability. The growth rates of death is estimated according to the fitted Weibull function. Effective reproduction numbers and normalized transmission rates are based on the SIR model. Day 0 is the earliest date when the cumulative death toll reached 25 in each location.

Figure 5: Atkeson et al. Estimated Transmission and Death Rates

The Atkeson *et al.* (August 2020) findings cast serious doubt on all of the early local, small sample, studies that found large effects of lockdown on cases and deaths.[25] 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

[25] Barro (April 2020), showed early on in the 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.

> implemented in this early phase of the pandemic is likely overstated .... Our 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 instated 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.* (August 2020) speculated on three reasons for their findings (reasons that were not unknown from previous research on pandemics). First, unlike the assumptions made in the SIRS 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.[26] Second, again in contrast to the classic SIRS 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.

Any of these reasons suggest that the early findings of a correlation between lockdowns and cases may not have found a causal linkage. 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

[26] See Eksin *et al.* (2019) for a study of the effect of human behavior on the progression of disease. Adding behavioral responses to SIRS 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.

most significantly a number of papers found strong evidence that changes in human 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 (August 2020) 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.[27]

Goolsbee, A., and C. Syverson (June 2020), using cellular phone location records, find that voluntary "self-lockdown" explains 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).

[27] 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, close to 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 quotes:

> 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. 40, July 2020, emphasis added.[28]]

> 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]

[28] This paper also finds that lockdowns have a direct effect on cases and mortality.

These findings of the relative importance of voluntary responses relative to mandated lockdowns have continued to be confirmed.[29] An excellent study by Bendavid *et al.* (January 2021) that distinguished between strong and weak lockdown countries concluded:[30]

> 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

Unconditional Cross-Country Covid-19 Comparisons.

One year after the pandemic started we now know the number of cumulative deaths that have been attributed to Covid-19.[31] We also know now that there

[29] 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.

[30] 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

[31] Whether these deaths were actually caused by Covid-19 is an important matter, but one that I abstract from.

was wide ranging differences in the extent of lockdown intensity, and we know that jurisdictions with limited to no lockdowns did not systematically have death rates that exceeded hard lockdown jurisdictions. Not only did they not exceed, but often they had equal or better performance. 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 1847.[32] If lockdowns had the enormous beneficial effects many have claimed, then there should be an obvious correlation between deaths and lockdowns across country comparisons. In this section, I want to simply point out some remarkable cross country comparisons, and suggest that it is reasonable to explain them by the findings that lockdown only has (at best) a marginal impact on deaths.

Consider Figure 6 below, created using the *OurWorldInData* webpage application that compares the cumulative number of deaths between Europe and North America. North American cases are dominated by the United States, and during 2020 President Trump came under heavy fire for mishandling the pandemic. Still, despite having different policies across the two continents, after one year the number of Covid-19 deaths per million people is practically identical.

[32] Numbers as of March 28, 2021. https://ourworldindata.org/grapher/covid-stringency-index

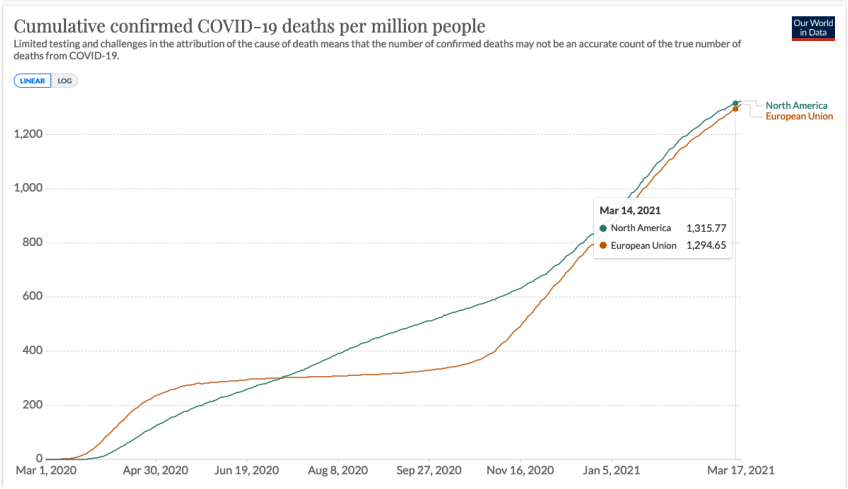

Figure 6: Cumulative Deaths, North America v. European Union.

Perhaps the identical result in Figure 6 is due to simple averaging; that is, on average the policies across the two continents were the same. Consider Figure 7 which contrasts Sweden, that had "light" restrictions to the European Union. As of March 16, 2021, the cumulative deaths per million in Sweden is the same as in the EU. This stands in sharp contrast to the dire predictions that were made about Sweden in the first six months of the pandemic.[33]

[33] Gardner, *et al.* (April 2020), using a standard SIRS model, 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." On March 16 2021 the total number of deaths in Sweden was just 13,228.

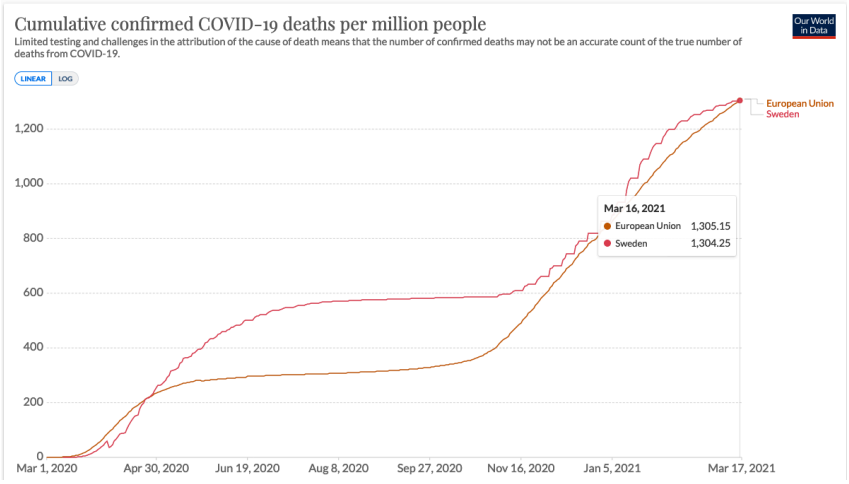

Figure 7: Cumulative Deaths, Sweden v. European Union.

Figure 8 looks at the daily Covid-19 deaths per million people between Sweden (light lockdown) and the UK (harsh lockdowns). The cumulative deaths per million were higher in the UK, but the figure shows that the general progression of deaths over the past year is very similar across the two countries.

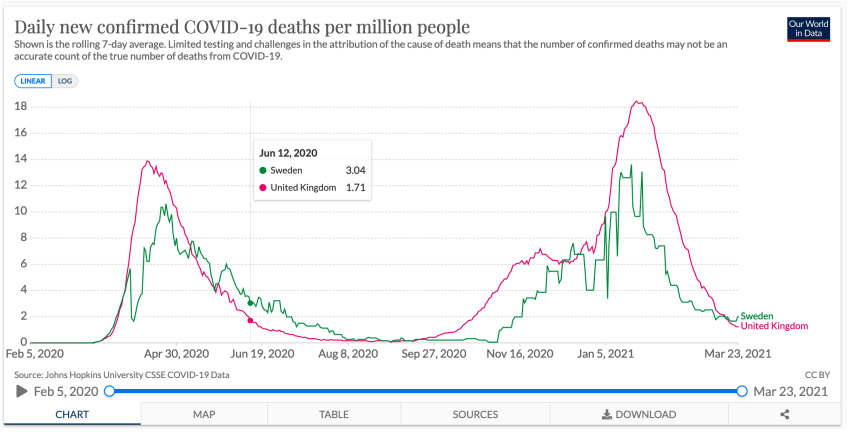

Figure 8: Daily Deaths, Sweden v. United Kingdom.

Different countries have obviously had different experiences with Covid-19; how-

ever, these differences are more related to country specific demographics than lockdown policy. 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.[34] This dry tinder effect accounted between 25–50% of the difference in death rates across the Nordic countries.

Using the CDC Data Tracker (https://covid.cdc.gov/covid-data-tracker/) similar graphs can be made comparing U.S. states. Florida and California were often compared because they are similar in terms of size and latitude, but had such different lockdown policies. Florida locked down in the spring but then started lifting restrictions, on September 25th 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.[35] Figure 9 shows daily deaths per 100,000 in each state. The cumulative deaths per 100,000 people are practically indistinguishable: 152 for Florida and 143 for California. However, the relative experience in the second wave does not seem consistent with lockdowns having an effect. Unlocked Florida did better in the second wave than lockdown California.

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[34] Source: https://www.cebm.net/covid-19/excess-mortality-across-countries-in-2020/

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

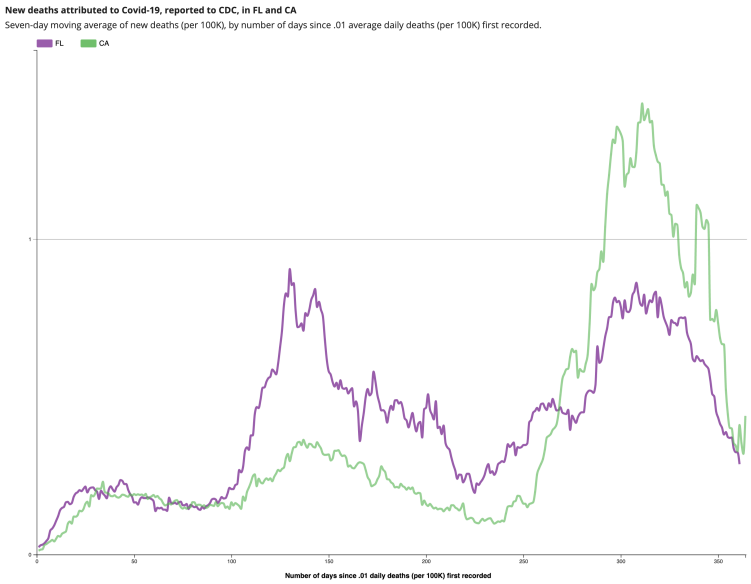

Figure 9: Daily Deaths: California v. Florida

Figure 10 shows one final case that has recently been covered widely in the news. Texas removed all lockdown restrictions on March 10, 2021. The reaction 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." The red vertical line in Figure 10 shows the March 10th date. Cases and deaths have continued to fall since the removal of lockdown. This is not to say that the removal caused the fall, it only points to the fact that the simple view of lockdowns is wrong.

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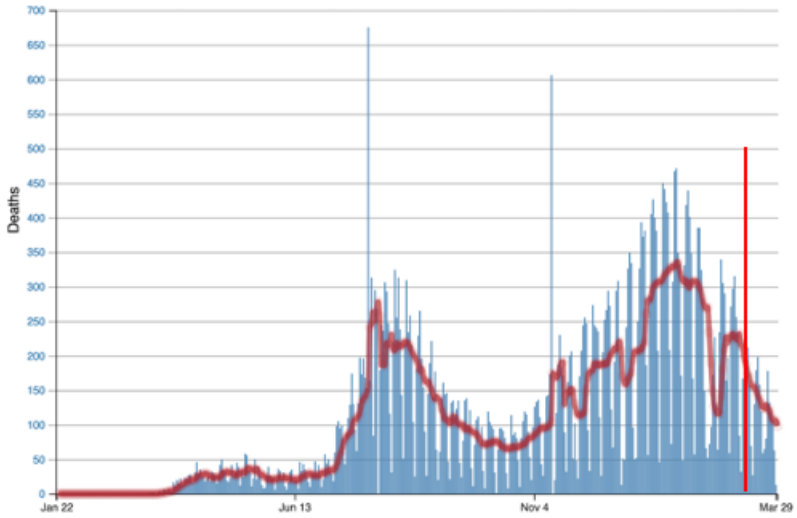

Figure 10: Daily Deaths in Texas

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).

Table 2 provides a less *ad hoc* method of considering the relationship between cumulative deaths and lockdown. Table 2, uses information from *OurWorldInData*, and provides the coefficients and t-statistics from a simple OLS regression where the dependent variable is Cumulative Deaths per Million and the main regressor is the country's Stringency Index. The sample is all countries in North American and Europe (N=36) for which *OurWorldInData* reported data.

Column (1) is a simple one variable regression between cumulative deaths per million and the stringency index. It shows a small positive correlation that is not statistically significant. A one point increase in lockdown stringency is associated with 10.6 more deaths per million. Both the t-statistic and the F statistic show that this estimate is imprecise: there is too much noise to statistically claim a correlation.

Column (2) simply adds a dummy variable equal to 1 if the country is an island.

Now the country index variable is slightly larger and statistically significant. There are about 45 stringency points from the least stringent country (Russia: 40.28) to the most stringent (Ireland: 84.26). Over this range, moving from the least to most stringent lockdown increases the cumulative deaths per million by 630 deaths. Contrary to the popular understanding, lockdown is not associated with fewer deaths per million, but more.

Table 2: OLS Regression
Dependent Variable: Cumulative Deaths per Million

Variable	(1)	(2)
Country Index	10.64	14.06
	(1.59)	(2.51)
Island		−932.58
		(−4.07)
Constant	352.66	288.60
	(0.80)	(0.79)
N	36	36
F	2.53	10.14
R^2	0.06	0.38

Table 2 only presents correlations, and it is *not* intended to substitute for the many sophisticated econometric papers that were reviewed above, and which exploited the timing and severity of lockdowns to infer or test a causal linkage. Table 2 is presented to point out that Figures 6–8 are not a matter of cherry-picking, and to drive home the point that if lockdowns had the effect that supporters claimed they had, it should show up in a simple cross country comparison.

The empirical work reviewed above provides the explanation for why lockdowns are not negatively correlated with cumulative deaths: voluntary actions, not mandated actions, account for a major portion of the evolution of the virus. Jurisdictions that locked down could never enforce the rules completely and so there was some non-compliance. Furthermore, there is some evidence that lockdown increased transmissions and deaths in inter-generational households. Jurisdictions that did

not lockdown still had many people (especially those at risk) change their behaviors to reduce risk. Liability law also likely induced many firms to enact "lockdown" like procedures at their outlets in non-lockdown jurisdictions to reduce liability risk. At the end of the day, it was close to a wash, and mandated lockdowns had little direct effect. Other differences in countries (how close they are to being an "island" in terms of border control, average income, relative humidity, age distributions, obesity, etc.) explain most differences in levels of infection and deaths.

The conclusion I draw from the research on actual outcomes over the past year is that at best lockdowns had some marginal effect on the reduction of cases, transmissions, and deaths. This means that the benefits of lockdown in terms of numbers of deaths is likely small. If these lives are valued at appropriate VSL numbers, the total benefits of lockdown are even smaller.

D. The Costs of Lockdown

Research on the cost of lockdowns has lagged that of the benefits, and even still is very piecemeal. 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 costly effects has increased, and the reach of lockdowns in terms of suffering has turned out to be nuanced and almost endless. Many of the costs will not be known for years as they work out in reduced graduation rates, reduced future earnings, and reduced long run health status. Here I provide a short list of some of the findings arrived at thus far.

Lockdowns that close non-essential businesses, supply chains, 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 the GDP losses over the year abound. In Europe, 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). As noted in Figure 4 above, Canada experienced about an 11% fall in the second quarter GDP, and overall GDP fell by 5.1% according to Stats Canada. If we used Sweden (which had GDP fall 2.8% over the year) as a lockdown counterfactual, then close to half of the fall in Canada's GDP could be attributed to lockdown.[36] This would amount to about $89 billion dollars attributed to the lockdown.[37]

The financial costs of lockdown are well known to not be evenly distributed. Figure 11 shows the twelve month percentage change in sales across three different Canadian industries.[38] The left figure shows that retail sales experienced a drop (30%) in the second quarter of 2020, but then mostly recovered. The middle graph shows that full-service dining sales dropped by 80% in the second quarter, but by the end of the year were still down 52%. The last figure on the right shows that international flights fell by an enormous 90% in the second quarter, and have not recovered over the year.

Figure 11: 12 Month %Change in Retail, Dining, and Int. Air flight Sales.

Other research over the past year has documented the various costs of lockdown that went beyond lost goods and services.

a. **Lost educational opportunities.** Lost, delayed, or poor education leads to reduced human capital that has life long negative consequences.[39] Not

[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.

[39] The role of education in the formation of human capital and its importance for individual

only has lockdown reduced educational opportunities for the young, the distribution of the effects is not equal. Bonal, X., and S. 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 conditions.[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]

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

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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

[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) find 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) showing that physical isolation and social loneliness increases 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)), this created fear among individuals who required emergence 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.

III. An Alternative Cost/Benefit Methodology

To my knowledge, as of March 2021, no one has calculated the sum of Covid-19 lockdown losses into dollar costs, nor has there been any systematic attempt to determine the total lost quality of life brought about by lockdown. Therefore, economic arguments against lockdown have run along the lines that the benefits are negligible and the costs are obviously high.

Professor Bryan Caplan at George Mason University has proposed an interesting thought experiment that provides a solution for this issue.[46] Professor Caplan proposes the following question:

> Suppose you could either live a year of life in the COVID era, or X months under normal conditions. What's the value of X that makes the AVERAGE American indifferent?

Professor Caplan's thought experiment addresses the perceived costs of lockdown for each person living under it. For some this past year has been horrific. 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. How many months of 2020 would these people have been willing to sacrifice to have

[46] See https://www.econlib.org/life-years-lost-the-quantity-and-the-quality/.

avoided the negative consequences of lockdown? Many might be willing to give up years, others several months.

On the other hand, for others who are older, professional, have no children at home, live in a large house with a garden, dislike travel, and have poorer health, lockdown might have given them comfort and been no inconvenience. These folks might sacrifice nothing to avoid lockdown.

The question is: how many months would be sacrificed on average? Professor Caplan argues that $X = 10$ months is a conservative estimate. That is, on average, two months would be sacrificed to have avoided lockdown. For the sake of argument, suppose this is the true number for the average Canadian.

As of March 2021 the pandemic has lasted one year. That means that the average Canadian has lost two months of normal life. The population of Canada is about 37.7 million people, which means that 6.3 million years of life have been lost due to lockdown.

The average age of reported Covid-19 deaths in Canada is about 80.[47] In Canada an average 80 year old has a life expectancy of 9.79 years.[48] This means that the 6.3 million years of lost life is equivalent to the deaths of 643,513 80 year olds.[49] As of March 22, 2021 Canada has had a total of 22,716 deaths due to Covid-19. That amounts to 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? Consider two extremes:

a. Assume that the number of Covid-19 deaths would have been 10% higher had there been no lockdown. Then Canada would have experienced an additional 2,271 deaths, which means there would have been additional 22,333

[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

years of lost life due to Covid-19 deaths. The benefit of lockdown, therefore, was the avoidance of this extra 22,333 years of lost life. However, the cost of lockdown, as noted, was 6,300,000 years of lost life. The cost/benefit ratio of lockdown is $282 = 6,300,000/22,333$.

b. Assume that the initial ICL model forecasts were correct and without a lockdown Canada would have experienced 200,000 deaths. This would mean that Canada's lockdown policies prevented $177,281 (200,000 - 22,716)$ deaths. Under the same age and life expectancy assumptions lockdown prevented the loss of 1,735,580 life years. The cost/benefit ratio of lockdown is $3.6 = 6,300.000/1,735,580$.

Case (b) is highly unrealistic and nothing close to this rate of death happened anywhere in the world. However, even in this extreme case, lockdown is a failure as a policy by cost/benefit standards.

The review of the literature suggests that Case (a) is closer to reality. If lockdown only had a marginal effect on deaths, then by cost/benefit standards, lockdown has been a public policy disaster.[50]

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 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.

[50] This thought experiment can be turned around. What would be the amount of the year the average Canadian would have to give up to make the costs of lockdown equal to the benefits? Under assumption (a) where lockdowns only save 2,271 lives, the average Canadian would have to give up approximately 6 hours of the year. Under assumption (b) where lockdown saved 200,000 lives, the average Canadian would have to give up 2.5 weeks of the year.

IV. Conclusion

A review of the Covid-19 lockdown cost/benefit literature shows that the early cases made for lockdown rested on several unrealistic assumptions. These assumptions included that the virus continues to spread exponentially until herd immunity is reached, that individuals never change behavior in light of a viral threat, and that the value of lives lost is independent of age and around $10M.

Over the course of the last year research has revealed that simple SIRS models fail to predict the progression of the virus, that individual reactions to the virus are important, and that the costs of blanket lockdowns are far reaching and large. Lockdowns have some effect on cases, transmissions, and deaths, but these effects are marginal. As a result, lockdowns fail to pass a cost/benefit test.

One could argue that the Covid-19 lockdown policy was only wrong *ex post*. Hindsight is 20/20, and looking back is unfair. In March of 2020, faced with an unknown virus and expert advice that millions of people would die without lockdown and isolation, politicians and public health officials made the correct decision at the time.

Such an argument is reasonable for March of 2020, and even possibly for April 2020. However, as noted in the literature review, by late April it was already known that i) the empirical predictions of the SIRS based models were wrong, ii) that the models made a number of questionable assumptions, iii) that the deaths were highly skewed to the elderly, and iv) that the costs were large.

The progression of understanding about the virus has improved over time, but it has not fundamentally changed. By August there was enough information available to show that any reasonable cost/benefit analysis would show that lockdown was creating more harm than good. It is unreasonable to suggest that a proper decision could not have been made in the fall when the second wave of infections hit.

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