**Expert Report on the COVID-19 Response in Alberta, Canada**

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# **Does Covid-19 pose a real or imminent serious threat to the health of the population?**

The mortality danger from COVID-19 infection varies substantially by age and a few chronic disease indicators.[[1]](#footnote-1) For much of the population, including the vast majority of children and young adults, COVID-19 infection poses a small mortality risk. By contrast, for older populations – especially those with severe comorbid chronic conditions – COVID-19 infection poses a high risk of mortality, on the order of a 5% infection fatality rate.

The best evidence on the infection fatality rate from SARS-CoV-12 infection (that is, the fraction of infected people who die due to the infection) comes from seroprevalence studies. The definition of seroprevalence of COVID-19 is the fraction of people within a population who have specific antibodies against SARS-CoV-2 in their bloodstream. Seroprevalence studies provide better evidence on the total number of people who have been infected than do case reports or a positive reverse transcriptase-polymerase chain reaction (RT-PCR) test counts; these both miss infected people who are not identified by the public health authorities or do not volunteer for RT- PCR testing. Because they ignore unreported cases in the denominator, fatality rate estimates based on case reports or positive test counts are substantially biased upwards.

According to a meta-analysis[[2]](#footnote-2) by Dr. John Ioannidis of every seroprevalence study conducted to date of publication with a supporting scientific paper (74 estimates from 61 studies and 51 different localities around the world), the median infection survival rate from COVID-19 infection is 99.77%. For COVID-19 patients under 70, the meta-analysis finds an infection survival rate of 99.95%. A separate meta-analysis[[3]](#footnote-3) by scientists independent of Dr. Ioannidis’ group, reaches qualitatively similar conclusions.

A US CDC report[[4]](#footnote-4) found that there were between six and 24 times more SARS-CoV-2 infections than cases reported between March and May 2020. This study is based on serological analysis of blood samples incidentally collected by commercial laboratories in 10 cities nationwide, although the CDC does not provide the infection fatality rate estimate implied by their seroprevalence studies reviewed by Dr. Ioannidis above.

In September 2020, the CDC updated its current best estimate of the infection fatality ratio - the ratio of deaths to the total number of people infected - for various age groups.[[5]](#footnote-5) The CDC estimates that the infection fatality rate for people ages 0-19 years is 0.003%, meaning infected children have a 99.997% survivability rate. The CDC’s best estimate of the infection fatality rate for people ages 20-49 years is 0.02%, meaning that young adults have a 99.98% survivability rate. The CDC’s best estimate of the infection fatality rate for people age 50-69 years is 0.5%, meaning this age group has a 99.5% survivability rate. The CDC’s best estimate of infection fatality rate for people ages 70+ years is 5.4%, meaning seniors have a 94.6% survivability rate.

A study of the seroprevalence of COVID-19 in Geneva, Switzerland (published in the *Lancet*)[[6]](#footnote-6) provides a detailed age break down of the infection survival rate in a preprint companion paper[[7]](#footnote-7) 99.9984% for patients 5 to 9 years old; 99.99968% for patients 10 to 19 years old; 99.991% for patients 20 to 49 years old; 99.86% for patients 50 to 64 years old; and 94.6% for patients above 65.

I estimated the age-specific infection fatality rates from the Santa Clara County seroprevalence study[[8]](#footnote-8) data (for which I am the senior investigator). The infection survival rate is 100% among people between 0 and 19 years (there were no deaths in Santa Clara in that age range up to that date); 99.987% for people between 20 and 39 years; 99.84% for people between 40 and 69 years; and 98.7% for people above 70 years. In fact, in all of California[[9]](#footnote-9) through August 20, there have been only two deaths at all among COVID-19 patients below age 18. Also, 74.2% of all COVID-19 related deaths occurred in patients 65 and older.

Alberta Health has stated it is investing in four serology studies,[[10]](#footnote-10) but I am not aware that the results of these studies have been publicly released[[11]](#footnote-11), and it is clear that the age gradient in COVID-19 mortality found everywhere else applies. The overwhelming majority of deaths from COVID-19 in Alberta have occurred in ages 70 and older, with 886 deaths out of a total of 1,368 deaths occurring in ages 80 and older (see Figure 10 and Table 3 below).[[12]](#footnote-12)





In addition to the risk posed by old age, COVID-19 infection poses an elevated mortality risk for people with certain chronic conditions like diabetes. We now have good evidence on the relative risk posed by the incidence of chronic conditions, so we know that among common conditions, age is the single most important risk factor. For instance, a 65-year-old obese individual has about the same COVID-19 mortality risk conditional upon infection as a 70-year-old non-obese individual.

According to data from Statistics Canada[[13]](#footnote-13), “Of the over 9,500 COVID-involved deaths between March and July, the majority (90%) had at least one other cause, condition or complication reported on the certificate.”



Further, from the first wave of the pandemic until to the end of May 2020, 80% of the COVID-19 deaths in Canada occurred at long-term care facilities and retirement homes[[14]](#footnote-14). Dementia or Alzheimer’s disease were most often listed as comorbidities among Canadians aged 65 years or older whose deaths involved COVID-19—especially among those aged 85 or older.

According to Statistics Canada,[[15]](#footnote-15) “When a pre-existing condition is suspected of putting a person at higher risk of a severe course of COVID-19 resulting in death, the death is counted as a death due to COVID-19 rather than a death due to the pre-existing condition…It is also possible that the death may have been influenced by COVID-19 but caused by another disease or an unintentional injury event. In these situations, COVID-19 should still be recorded on the medical certificates of cause of death, but would not be considered a death due to COVID-19.” Pre-existing conditions can also put people at a higher risk of severe courses of influenza resulting in death, but to my knowledge, such deaths are not counted as influenza deaths. Such a discrepancy in counting COVID-19 deaths and influenza deaths makes comparisons between the two respiratory illnesses difficult and results in artificially elevated death statistics due to COVID-19.



This elevated mortality risk for people with certain chronic conditions is also reflected in the data specific to Alberta. Ten health conditions have been identified as comorbidities among COVID-19 deaths (see Table 4 below).[[16]](#footnote-16)



Only 2.8% or 37 of the COVID-19 deaths in Alberta are of someone with no comorbidity. For all the other deaths, the person had one, two or three or more comorbidities. The vast majority (75.7%) had three or more comorbidities (see Table 5 and Figure 14 below).[[17]](#footnote-17)



In summary, COVID-19 does not pose a real or imminent serious threat to the health of the population in general but only to the health of a specific part of the population – the elderly and a limited number of people with certain chronic conditions. Age is the single most important risk factor, with a worldwide 99.95% infection survival rate for people under 70 and 95% infection survival rate for people 70 and over.

Further, COVID-19 case fatality rates have been dropping steadily since the disease emerged. Peer-reviewed studies document these trends.[[18]](#footnote-18) One study in England found that “30-day mortality peaked for people admitted to critical care in early April… There was subsequently a sustained decrease in mortality risk until the end of the study period” in late June. This trend was found for people of all age groups, and survived adjustment for patient characteristics, which strongly suggests an improvement in treatment and patient management as the cause.[[19]](#footnote-19)

Ventilator protocols which were used during the early days of the epidemic were too aggressive, with physicians too quick to place patients on mechanical ventilation. In those early days, nearly 90% of all COVID-19 patients on mechanical ventilation died.[[20]](#footnote-20) New discoveries about the use of histamine blockers in conjunction with ventilators contribute to improved survival of hospitalized COVID-19 patients.[[21]](#footnote-21), [[22]](#footnote-22) Separately, there were particular problems in the care of elderly COVID-19 patients in state run nursing homes in Quebec, as an example, during the early days of the epidemic, where some COVID-19 patients were neglected and died from thirst and hunger.[[23]](#footnote-23) Quebec also did very poorly because the government failed to protect the vulnerable population in the CHSLD by sending COVID infected patients to nursing homes that were unable to isolate them from the rest of the population, greatly increasing patient mortality.[[24]](#footnote-24) Addressing this neglect certainly contributed to improved outcomes in Quebec.

The discovery that a deadly immune over-reaction to SARS-CoV-2 infection in some patients could be modulated by dexamethasone has greatly improved patient outcomes.[[25]](#footnote-25), [[26]](#footnote-26) There has also been an improved understanding of the pathophysiological reasons why some patients progress to more severe outcomes from SARS-CoV-2 infection, while others do not.[[27]](#footnote-27) So, the improvements in outcomes for COVID-19 patients derive from multiple sources. In summary, COVID-19 infection is less deadly than it was when it arrived in North America in winter 2020.

# **How common is the spread of the SARS-CoV-2 virus by individuals who are infected, but display no symptoms?**

Much of the infrastructure of COVID-19 lockdown policies is premised on the idea that the SARS-CoV-2 virus can spread from infected people who display no symptoms that are typical of COVID-19 infection (that is, asymptomatic individuals) to uninfected individuals. If asymptomatic or pre-symptomatic disease spread is uncommon, lockdown policies could be replaced with much less onerous policies, such as symptom checking in public venues and public health advice for people with symptoms to stay home and avoid public places, with little effect on infection transmission rates.

According to a comprehensive survey of the literature on reported cases through early June 2020, about 20% of COVID-19 cases are asymptomatic.[[28]](#footnote-28) Seroprevalence studies tend to report a larger fraction of infections (often not identified as cases) as asymptomatic.[[29]](#footnote-29) In any case, asymptomatic viral carriers clearly make up a large fraction of COVID-19 cases and infections, so a good understanding of how likely they are to transmit the disease to others should play an important role in the determination of COVID-19 infection control policies.

The scientific evidence now strongly suggests that COVID-19 infected individuals who are asymptomatic are more than an order of magnitude less likely to spread the disease to even close contacts than symptomatic COVID-19 patients. A meta-analysis of 54 studies from around the world found that within households – where none of the safeguards that restaurants are required to apply are typically applied – symptomatic patients passed on the disease to household members in 18% of instances, while asymptomatic patients passed on the disease to household members in 0.7% of instances.[[30]](#footnote-30) A separate, smaller meta-analysis similarly found that asymptomatic patients are much less likely to infect others than symptomatic patients.[[31]](#footnote-31)

A large study of 10 million residents of Wuhan, China, all tested for the presence of the virus, found a total of 300 cases, all asymptomatic. A comprehensive contact tracing effort identified 1,174 close contacts of these patients, none of whom tested positive for the virus.[[32]](#footnote-32) This is consistent with a vanishingly low level of asymptomatic spread of the disease. While theoretical modeling work from earlier in the epidemic (including some of my own published research[[33]](#footnote-33)) predicts some level of asymptomatic disease spread, the empirical evidence at this point later in the epidemic strongly shows very little evidence that this is an important empirical reality.

By contrast with asymptomatic patients, symptomatic patients are very likely to infect others with the virus during extended interactions, especially in the initial period after they develop symptoms. A careful review of 79 studies on the infectivity of COVID-19 patients found the even symptomatic patients are infectious for only the first eight days after symptom onset, with no evidence of live virus detected beyond day 9 of illness.[[34]](#footnote-34)

In summary, asymptomatic individuals are an order of magnitude less likely to infect others than symptomatic individuals, even in intimate settings such as people living in the same household where people are much less likely to follow social distancing and masking practices that they follow outside the household. Spread of the disease in less intimate settings by asymptomatic individuals – including religious services, in-person restaurant visits, gyms, and other public settings – are likely to be even less likely than in the household. The clear implication of this scientific fact is that many intrusive lockdown policies (including church and business capacity limitations and closures) could be replaced with less intrusive symptom checking requirements, with little or no detriment to infection control outcomes.

# **What are the principles governing good health policy and public health practice?**

The principles of good public health[[35]](#footnote-35) and health policy practice predate the epidemic. While the topic is voluminous, there are a few principles that are particularly relevant to COVID-19 policy making, including the following guidelines for decision makers:

* Consider both the costs *and* benefits of alternative policies, choosing policies that appropriately balance the two.
* Appropriately account for uncertainty in the projected costs and benefits of policy options.
* Account for the strength of the scientific evidence.
* Be constrained in policy making by democratic norms and ethical principles.
* Choose policies that treat people in society equitably, and in particular eschew policies that disproportionately favor richer members of society over poorer members.

Sound health policy decision making requires a careful evaluation of both the costs and benefits over both the long and short term. The nature of these costs and benefits considered should be broadly considered, including physical costs (such as enhanced risk of mortality and morbidity from all sources), psychological harms (such as increased rates of depression and suicidality), as well as the economic damage (such as increased joblessness, closed businesses, and reduced income).

The costs and benefits of every potential policy involves some degree of uncertainty, including lockdowns. In the face of uncertainty, public health decision making should be based on the best available evidence regarding the most likely outcomes from the imposition of the policy. Public health decision making should eschew decision making based on worst-case or best-case assumptions about the outcomes that may happen if alternate policies are adopted. It is particularly bad practice to make decisions that assume worst case scenarios regarding the costs of a policy and best-case scenarios regarding the benefits of a policy, or vice versa. So, for instance, it is poor public health practice to assume that lockdowns, if implemented will have a dramatic effect on disease transmission and mortality with no consideration of the harms associated with lockdowns.

In addition to the costs and benefits, public health policy must consider the strength of the scientific evidence regarding the measure in achieving the aims it proposes. Of course, without solid scientific evidence in favor of a policy – especially one with enormous costs – its imposition by a government on a population would be unethical. The greater the potential harms from the policy on some part of the population, the greater the evidentiary standard required to establish its necessity.

Finally, equity is a key principle of public health. Public health officials must consider whether the harms of a policy like lockdowns fall disproportionately on the poor, on minority populations, or on others who are of low socio-economic status. Similarly, policies that accrue benefits disproportionately to the rich, to majority populations, and to people of high socio-economic status should be redesigned to comport with the requirement for equity in public health decision making.

In summary, sound public health practice adheres to key principles aimed at grounding policy in good science, respecting human rights and democratic norms, appropriately accounting for costs and benefits of policies and uncertainty in outcomes, treating people equitably, as well as other principles not discussed here.

# **Are the lockdowns** (including, but not limited to, forced prolonged quarantines, the closure of most businesses, restrictions or prohibitions of personal care and wellness services, the restriction or prohibition of cultural and sporting events and religious services, restrictions on in-person schooling, restrictions or prohibitions of private gatherings, prohibitions on hosting friends and family at private residences, restrictions on travel outside the country, restrictions or prohibitions of outdoor gatherings, prohibitions on most athletic activities) **necessary to maintain and enhance the health and well-being of the general population?**

Since the available epidemiological literature often tends to group many of the items in the list above under the moniker of “lockdown” or “non-pharmaceutical intervention (NPI)” we will consider the evidence regarding the items together based on the criteria for good public health practice we discussed above.

**Theoretical Considerations.** The theoretical models used to justify lockdowns – compartment or SEIR models – do not predict a decrease in the total number of infected people but shift in the timing of infections.

Compartment models work by envisioning a population exposed to a new pathogen like the SARS-CoV-2 virus. In the simplest versions of these models, everyone in the population is initially susceptible to infection. The epidemic starts with one person being infected and in turn infecting other people in the pool of susceptible people. Many infected people recover from the disease and – because of immunity induced by infection – are no longer susceptible. Over time, the population of susceptible people diminishes to the point where a newly infected person infects one or fewer people, and the epidemic declines.

In models like this, which are in common use to forecast the COVID-19 epidemic, lockdowns play a role of dampening the number of interactions between susceptible people and infected people, slowing the growth of the epidemic. However, unless the number of infections is reduced to zero – a result clearly not in evidence in the COVID-19 epidemic – the disease continues to spread in the population.

The clear theoretical implication from these models is that lockdowns delay infections into the future, rather than prevent them from occurring altogether.[[36]](#footnote-36) But society-wide lockdowns are not a tool of disease eradication, and in fact have never in history eradicated a disease. This “benefit” – a theoretical delay in the incidence of cases – should be considered against the harms from lockdowns, some of which are described below.

What is the evidence that these theoretical models provide accurate forecasts of the future path of the pandemic? Unfortunately, their track record is poor. According to a comprehensive evaluation of the performance of these models by an international group of statisticians and mathematicians, their poor performance stems from a wide variety of problems, including:[[37]](#footnote-37)

Poor data input, wrong modeling assumptions, high sensitivity of estimates, lack of incorporation of epidemiological features, poor past evidence on effects of available interventions, lack of transparency, errors, lack of determinacy, looking at only one or a few dimensions of the problem at hand, lack of expertise in crucial disciplines, groupthink and bandwagon effects and selective reporting are some of the causes of these failures.

Given this poor track record in prediction, extreme caution should be exercised by public health decision makers in using compartment models to forecast the future direction of the pandemic and in predicting the effects of policy interventions such as lockdowns on COVID-19 outcomes such as mortality and hospitalization.[[38]](#footnote-38)

**Empirical Literature on Lockdown Benefits.** In the case of lockdowns and social distancing interventions, there is no existing randomized study – the gold standard study type in clinical therapeutics and public health interventions – that has evaluated the efficacy or costs of these measures. Scientific experts have argued for the necessity and feasibility of such randomized evaluation of restricting schools, universities, and workplaces, banning public gatherings, and the like.[[39]](#footnote-39) If one were to view these lockdowns and activity restrictions as a medical intervention, it would be unethical to implement them in the absence of randomized evidence in support of their efficacy.

In the absence of such evidence, scientists and public health officials tend to rely on studies that are less rigorous than randomized trials in establishing causal links between the intervention and outcomes, including event studies and other observational studies. In the case of the lockdowns, the evidence from these sources is decidedly mixed. Evidence from the draconian lockdown order in China – including home and centralized quarantine, severe travel restrictions, cordon sanitaire, mandated centralized symptom reporting, and other interventions inconsistent with democratic norms – suggests that lockdowns can “temporarily” reduce spread of the virus.[[40]](#footnote-40) Evidence from the early days of the epidemic (March and early April 2020) in the US found that states that imposed strict stay-at-home orders had a slower growth in the epidemic than states that did not over that short period of time.[[41]](#footnote-41)

The problem with these event studies is that they cannot be used to forecast the effect of imposing less strict lockdowns (such as restrictions on businesses and gatherings). Focused as they are on quarantine or stay-at-home orders and the draconian policies imposed during the early epidemic in China, they represent a best case for the effectiveness of lockdowns. More importantly, they only measure the effect of lockdown on the speed of disease spread in the short run and should not be used to forecast the effect of lockdown on long run epidemic outcomes, since the theoretical literature strongly cautions against it. Recall that in those models, lockdowns push cases into the future; they do not prevent them altogether.

In fact, there are many possible reasons why the number of cases might change over time outside of lockdowns, and these should be accounted for in any accurate estimation of lockdown effects. Perhaps most importantly, these simple event studies do not account for the environmental, epidemiological, and economic factors that impact disease spread, imputing changes in the track of the epidemic almost entirely to policy interventions. There are many possible reasons why the number of cases might change over time outside of lockdowns, and these should be accounted for in any accurate estimation of lockdown effects. For instance, there is evidence that COVID-19 infection rates are increased during cold weather seasons.[[42]](#footnote-42), [[43]](#footnote-43) It is striking that the recent sharp rise in COVID-19 cases in California corresponds with colder weather, despite the continuing lockdowns. Even authors who favor lockdowns as a policy option in summarizing this evidence agree that seasonality plays an important role in case spread:[[44]](#footnote-44)

“A convincing argument that weather influences COVID-19 can be formulated in three parts: (1) experimental data suggest SARS-CoV-2 persistence on surfaces or in the air is sensitive to temperature, humidity, and ultraviolet light; (2) other environmentally sensitive respiratory viruses are seasonal, and more common in winter; and therefore, (3) climatic effects could be protective over space (hot, dry places might have less transmission) and time (summer might see reduced transmission compared to winter).”

This is not to say that other factors play no role, but rather that seasonality should be accounted for in any analysis of case spread. Studies decomposing lockdown effects should also account for the fact that, even in the absence of policy interventions, people change their behavior to protect themselves from disease risk if they perceive the danger from infection to be high.[[45]](#footnote-45)

The best studies, which account for environmental, epidemiological, and economic factors alongside policy interventions conclude that the mortality from COVID-19 infection in different regions is not primarily driven by policy decisions like lockdowns, but rather by other factors specific to each region.[[46]](#footnote-46) A comprehensive international cross-country study, analyzing data from the first eight months of the pandemic, conclude that:[[47]](#footnote-47)

Countries that already experienced a stagnation or regression of life expectancy, with high income and non-communicable disease rates, had the highest price to pay. This burden was not alleviated by more stringent public decisions. Inherent factors have predetermined the Covid-19 mortality: understanding them may improve prevention strategies by increasing population resilience through better physical fitness and immunity…The death rate appears not to be linked with the responses of governments.

In other words, countries that had a population predisposed to poor COVID-19 infection outcomes, especially countries that had an older population, tended to have worse outcomes irrespective of whatever lockdown policies they implemented.

A separate peer-reviewed study (on which I am a co-author) compares how Sweden and South Korea (neither of which adopted shelter-in-place orders or forced business closures, but did adopt other restrictions such as public gathering limitations) fared with regard to control of disease spread in Spring 2020 relative eight other countries (including France, Spain, the US, the UK) which adopted such restrictive measures.[[48]](#footnote-48) The major finding from the paper is that countries that adopted shelter in place orders and forced business closures tended to have *worse* outcomes in terms of disease spread though the difference was statistically indistinguishable from zero.

# **What are the harms of lockdowns and governmental actions aiming to slow down the propagation of the disease on the health of the population?**

While the evidence on the benefits of lockdowns is equivocal, the harms of the lockdowns are manifold and devastating. The effects on the health of populations, in particular, warrants careful attention, since they can be compared directly against the harms from COVID-19 infection. The COVID-19 lockdowns have often featured the cessation of elective and other medical services to keep hospital and health care systems available for COVID-19 patients. Naturally, patients who skip medical services will suffer adverse health consequences as a result. The empirical evidence supporting these ideas includes documentation for plummeting childhood vaccination rates[[49]](#footnote-49), worse cardiovascular disease outcomes (in part because patients delayed necessary cardiac care)[[50]](#footnote-50), less cancer screening[[51]](#footnote-51) [[52]](#footnote-52) and deteriorating mental health[[53]](#footnote-53) [[54]](#footnote-54) [[55]](#footnote-55).

Specifically regarding children’s surgeries, authors writing in the Canadian Medical Association Journal reported that, “although nearly 9000 emergency and urgent surgeries were completed in Canadian children’s hospitals between mid-March and June, there were an estimated 7600 surgery postponements with an additional estimated 4000 children not wait-listed owing to reduced access to consultation.”[[56]](#footnote-56) The Canadian Institute for Health Information reported that “[f]rom March to June 2020, overall surgery numbers fell 47% compared with 2019, representing about 335,000 fewer surgeries.”[[57]](#footnote-57)

In addition to the physical health harms from lockdown, there has been immense psychological harm. The social isolation induced by lockdown has led to a sharp rise in opioid and drug-related overdoses[[58]](#footnote-58) [[59]](#footnote-59) [[60]](#footnote-60), similar to the "deaths of despair" that occurred in the wake of the 2008 Great Recession.[[61]](#footnote-61) In the first six months of 2020 in Alberta, 449 people “died from an apparent opioid poisoning”.[[62]](#footnote-62) For comparison, in Alberta “[t]he number and per 100,000 rate of opioid poisoning deaths in the second quarter of 2020 was over 100 per cent higher compared to first quarter of 2020.”[[63]](#footnote-63)

Social isolation of the elderly has contributed to a sharp rise in dementia-related deaths around the country.[[64]](#footnote-64) For children, the cessation of in-person schooling since the spring has led to "catastrophic" learning losses[[65]](#footnote-65), with severe projected adverse consequences for affected students' life spans.[[66]](#footnote-66) According to a US CDC estimate, one in four young adults seriously considered suicide this past June.[[67]](#footnote-67) Among 25 to 44-year-olds, the US CDC reports a 26% increase in excess all-cause mortality relative to past years, though fewer than 5% of 2020 deaths have been due to COVID-19.[[68]](#footnote-68), [[69]](#footnote-69)

A recent study[[70]](#footnote-70) in *European Psychiatry* analyzed the psychological harms of the lockdowns in Switzerland and attempted to quantify citizens’ years of life lost as a result. The authors focused on deaths caused by “suicide, depression, alcohol use disorder, childhood trauma due to domestic violence, changes in marital status, and social isolation.” The authors find that the 2.1% of the population who suffered from one of these conditions would suffer nearly 9.8 years of life lost in expectation as a consequence of just a three-month lockdown. They emphasize that that their estimate is likely to be an underestimate because many of the outcomes they analyze will persist even after the lockdown ends. The authors conclude,

The literature suggests that increased duration of confinement is associated with worse outcomes for psychological health of those confined. While some of the stress-related problems ensuing from confinement may remit, an important portion of this damage may prove to be hard or impossible to reverse and the affected individuals may experience ongoing suffering. Our projection suggests that the Swiss population will incur a substantial increase in mortality as a consequence of confinement-related psychosocial stress, which should be considered in forming public health responses to the pandemic.

While the lockdowns result in direct harms for the health of populations where they are implemented, they also have enormous indirect consequences as a result of a collapse in worldwide economic outcomes, with a particularly large and negative effect on poor countries.[[71]](#footnote-71) This economic harm translates directly into health harm, as large populations are no longer able to feed themselves due to poverty. The UN estimates that an additional 130 million poor people will be at risk of starvation as a consequence of the economic collapse caused by the lockdowns – predicting a famine of “biblical” proportions.[[72]](#footnote-72) Estimates suggest that an additional 400,000 people will die from inadequate tuberculosis treatment as a consequence of diversion of resources away from TB identification and treatment.[[73]](#footnote-73) Vaccination campaigns in rich and poor countries that address diseases like diphtheria and polio have been suspended due to the lockdowns.[[74]](#footnote-74) According to a recent editorial in the journal *Nature*, COVID-19 is “fuelling a resurgence of AIDS, malaria, and tuberculosis” around the world.[[75]](#footnote-75)

# **What is the magnitude of the risk children pose in disease spread? Is there any rationale for lockdown related restrictions on children?**

The overwhelming weight of scientific data suggests that the risk of transmission of the virus from younger people aged 18 and below to older people is small or negligible, and the risk of transmission from people 18 to 25 to older people is small relative to the risk of transmission from people older than 25 to others older than 25.

The most important evidence on childhood spread of the disease comes from a study conducted in Iceland and published in the New England Journal of Medicine.[[76]](#footnote-76) The data for this study comes from Iceland’s systematic screening of its population to check for the virus. This is the most important study on this topic because it is the only study that definitively establishes the direction of spread of the virus from contact to contact. The study reports on both a population-representative sample and a sample of people who were tested because of the presence of symptoms consistent with COVID-19 infection. The study team isolated SARS-CoV-2 virus samples from every positive case, sequenced the genome of the virus for every case and tracked the mutation patterns in the virus. This analysis, along with contact tracing data, allowed the study team to identify definitively who passed the virus to whom. There have been hundreds of minor mutations of the virus identified, which typically do not alter the function of the virus much, but which provide a unique fingerprint, of sorts, that makes it possible to tell whether two patients could possibly have passed the virus to one another. From this analysis, the senior author of the study, Dr. Kari Stefansson, concluded[[77]](#footnote-77) that “[E]ven if children do get infected, they are less likely to transmit the disease to others than adults. We have not found a single instance of a child infecting parents. There is amazing diversity in the way in which we react to the virus.”

Although the Iceland study is the only definitive study, there are a number of other studies that use contact tracing methods to investigate the role of children in disease spread. The bulk of such studies conclude that children play a small role, consistent with the Iceland data. A French study,[[78]](#footnote-78) conducted by scientists at the L’Institut Pasteur, examined data from late April 2020 on schoolteachers, students, and their parents in Crepy-en-Valois in France. The schools in France were closed from the end of January on, at first because of a February holiday and then the late February lockdown. The authors found three cases among kids in January using antibody tests but found no evidence of virus spread to other kids or teachers from those early cases. Any spread between the end of January and the end of April (when the authors collected samples) must have occurred during the lockdown. The kids who tested antibody positive at the end of April, because of the circumstances of the lockdown, must have become positive from a source other than their school. The main contacts of the young children were their parents, of whom 61% were positive, which is consistent with parent to child spread. Also consistent is the fact that only 6.9% of parents tested positive in April for the virus among the kids who were antibody negative. The authors’ main conclusion[[79]](#footnote-79) from these facts is that parents were the source of infections in school children; children were not the source. This finding mirrors the conclusion from the Icelandic study that the disease spreads less easily from children to adults than it does from adults to adults.

Researchers in Ireland conducted a similar study[[80]](#footnote-80) which analyzed 1,160 children and adults in Ireland who were physically present in a school at some time between March 1st and March 13th where a COVID-19 case was identified. (Schools were closed in Ireland on March 12th). The authors found 3 children (all between 10 and 15 years old) and 3 adults who had COVID-19 infections. Their study followed students and families after the school closures to see if there was any evidence of disease spread from these identified cases. All six patients had confirmed cases of COVID-19 disease but were found to have contracted the virus from contacts outside of the school setting. Despite identifying a total of 722 contacts, the study authors reported finding no instance of an infected child infecting another child. The infected adults, by contrast, had many fewer contacts – 102 – but did pass on the infection to a few adult contacts.

A report[[81]](#footnote-81) by the ministry of health in the Netherlands, based on contact tracing data, finds almost no disease spread by infected patients 20 and under at all, and only limited spread by adults 20-25 to others outside their own age category. The authors of the study concluded: “Data from the Netherlands also confirms the current understanding: that children play a minor role in the spread of the novel coronavirus. The virus is mainly spread between adults and from adult family members to children. The spread of COVID-19 among children or from children to adults is less common.”

A German[[82]](#footnote-82) study reports a strikingly similar finding on the likelihood of pediatric disease spread. The German Society for Pediatric Infectious Diseases collected on all children and adolescents admitted to a hospital for COVID-19 treatment between mid-March and early May 2020 – 128 patients in all, admitted to 66 different hospitals. The authors were able to find the source of infection for 38% of these patients, which turned out to be a parent 85% of the time. Though the authors document a limitation of small sample size, they conclude that “In contrast to other epidemic viral respiratory infections, the primary source of infection with SARS-CoV-2 appears not to be other children.” The authors reported a single death among these 128 pediatric patients.

One of the largest studies in the world on coronavirus in schools, carried out in 100 institutions in the UK, recently confirmed that “there is very little evidence that the virus is transmitted” in schools.[[83]](#footnote-83) Indeed, the president of the Royal College of Pediatrics and Child Health and a member of the government advisory group Sage confirmed that “there is very little evidence that the virus is transmitted in schools” based on this extensive study.

A study of 23 family disease clusters in Greece, published on Aug. 7th in the *Journal of Medical Virology*, found that in 91% of the clusters, an adult was the first person to be infected. Their contact tracing effort attempted to clarify the direction of disease spread by careful questioning about the relative timing of the development of symptoms. They found no evidence of either child to adult spread, or even of child to child spread. They concluded that “[w]hile children become infected by SARS‐CoV‐2, they do not appear to transmit infection to others. Furthermore, children more frequently have an asymptomatic or mild course compared to adults.”[[84]](#footnote-84)

A study by the Federal Office of Public Health of Switzerland analyzed 793 cases reported by Swiss doctors in late July 2020.[[85]](#footnote-85) The reports included the place where each patient most likely contracted the infection. The most common source of infection was at home, with 27.2% tracing their disease there. School, by contrast, consisted of only 0.3% of the infections; exactly two of the 793 cases could be tracked to a school. There are some limitations though of this study: first, it is a contact tracing study without genetic sequencing verification so the usual caveat applies; and second, the report provides no details about the age of the cases, so it is not possible to separately glean the disease acquisition frequencies for children and adults; and third, only summer schools were in session during this time period. Nevertheless, the results strongly suggest that schools are a minor source of community spread of the infection.

A recent South Korean contact tracing study[[86]](#footnote-86) was cited in the New York Times as providing evidence that “Older Children Spread the Coronavirus Just as Much as Adults.” Contrary to the interpretation of the NYT headline, the pattern of evidence reported in the study does not imply that older children spread the coronavirus as much as adults. A follow-on paper on South Korean case study, reanalyzing the same data set, the same patients, and published in the *Archives of Disease in Childhood*, clarified the direction of transmission of disease by focusing only on cases without “shared exposure” to a positive case.[[87]](#footnote-87) The idea in this reanalysis paper is to exclude from consideration situations where two people who are infected share a third contact who is also infected, since it is possible that third contact infected both the original two people. Using this method, the authors found a single case (out of 107 pediatric index cases and 248 household members who also tested positive) of a child passing on the disease to another household member – another child. They find no instances of a child passing the disease to an adult.

This reanalysis of the South Korean paper is instructive, and the lesson should be clear. Correlation studies and anecdotes that do not distinguish the direction of spread of disease provide no information whatsoever about the safety (or lack thereof) of school reopening. In every single instance, when a more careful analysis that identifies the direction of spread (such as this South Korean study) is conducted, the analysis finds that children pose a negligible risk of spreading the disease to adults, both at school and at home.

There are other contact tracing-based studies that have attempted to reach conclusions about the role of children in spreading the epidemic that suffer from the same problem as the original South Korean study referenced above. For instance, a pre-print study from the Italian province of Trento[[88]](#footnote-88) reported on 2,812 cases who reported 6,690 contacts. Though there were only 14 children among these cases, the authors nevertheless conclude that they transmitted the disease at a high rate, infecting 11 of their 49 contacts, nearly all within the same household. This represents only a small fraction of cases and contacts the authors analyzed, so numerically it is incorrect to conclude that children played a key role in the spread of the epidemic. Furthermore, unlike the Icelandic study, the Italian study cannot distinguish a child infecting a contact from the contact infecting the child. To my knowledge, nearly every contact-tracing based study of the role of children in the epidemic – with the Icelandic study and reanalysis of the South Korean study cited above as notable exceptions – suffers from this same problem.

A recent report, published in the *Journal of Pediatrics* and entitled “Pediatric SARS-CoV-2: Clinical Presentation, Infectivity, and Immune Responses”, measured the concentration of the SARS-CoV-2 virus in the nasopharynx of children who showed symptoms consistent with COVID-19 infection.[[89]](#footnote-89) The report found that the viral load in pediatric patients with symptoms (typically mild symptoms) was higher than adult hospitalized patients with severe COVID-19 disease. This is consistent with reports from earlier in the epidemic, which found similarly high viral loads in children.[[90]](#footnote-90) Many news media reports of the *Journal of Pediatrics* study extrapolated beyond the results of the study, with alarming headlines saying that children are “silent spreaders” of SARS-CoV-2.[[91]](#footnote-91)

These media reports are misleading because the presence of virus in the nasopharynx is not synonymous with the transmissibility of the virus. The PCR test which checks for the presence of the virus registers false positive results in the presence of non-viable, non-infectious, viral particles.[[92]](#footnote-92),[[93]](#footnote-93),[[94]](#footnote-94) So even a high viral load is not evidence of infectivity.[[95]](#footnote-95) The *Journal of Pediatrics* study itself appropriately lists the fact that their study does not assess the transmissibility of the virus as a limitation of the study. The only way to check for infectivity is to conduct a careful study of actual transmission of the virus, of the sort reported in the Icelandic contact tracing/viral mutation analysis referenced earlier.[[96]](#footnote-96)

Another approach to this topic involves analyzing the effect of actual school closures on the spread of the epidemic within a country. If children play a role as a key vector of the epidemic, then one would expect that countries that closed schools would see a significant effect of this policy on disease spread. In fact, the opposite is the case. Studies from around the world that have examined school closures (including Japan[[97]](#footnote-97), New South Wales[[98]](#footnote-98), and Sweden/Finland[[99]](#footnote-99)) find little or no effect of school closure on disease spread. The studies encompass closures of both elementary schools and high schools. A study[[100]](#footnote-100) analyzing the Swedish experience concluded that there was there was no additional risk to elderly people cohabiting with school age children up to age 16, despite the fact that Swedish schools were kept open throughout the epidemic. A systematic review of this evidence[[101]](#footnote-101) concluded that even though it may be possible for children to be infected with the virus and even transmit it, “[o]pening up schools and kindergartens is unlikely to impact COVID-19 mortality rates in older people.”

One purported counterexample to this evidence that has received widespread attention involves the reopening of school in Israel in the early summer.[[102]](#footnote-102) While the Israeli opening of schools is cited as a counter-example to the many other studies showing the negligible risk of transmitting COVID-19 by children, the Israeli reports suggest it was a unique circumstance, with children crowded into a small closed space and few precautions taken against disease spread. The New York Times story cited above provides an illustrative anecdote of symptomatic teachers passing the virus to their students. And the primary source of disease spread at the Gymnasia Rehavia high school was a single symptomatic teacher infecting colleagues and students. Contemporary reports, which emphasize the success of Israel in controlling the epidemic, suggest that Israelis reduced adherence to other mitigation measures as well. The cases that arose in Israeli schools are more likely a reflection of pre-existing community spread of the virus than a cause.

Thus, with no careful study to back it, and several lines of evidence that complicate any causal inference, the role of school opening in the resurgence of COVID-19 cases in Israel is not established. If there is a lesson to be learned, it is that schools can be opened safely for in-person learning if reasonable precautions – specific to the circumstances of each school – are taken. In the Israeli case, as with much of the anecdotal evidence cited, no viral sequencing analysis was conducted to verify the direction of disease spread. A report in *Science* emphasizes that no causal connection should be inferred from the correlation between Israeli school openings and the rise in cases there: “In Israel, infections among children increased steadily after schools opened. That paralleled a rise in cases nationwide, but it’s not clear whether the country’s rising caseload contributed to the increase within schools or vice versa.”

A large study of 1,900 children attending an urban summer schools in Barcelona, Spain over a five-week period found only 39 new index cases (30 pediatric).[[103]](#footnote-103) The setting was chosen because the investigators viewed it as a model for what to expect from school openings in the fall. These kids had 253 contacts in total, of whom, only 12 developed an infection – a secondary attack rate of 4.7%. The low secondary attack rate was similar for children of all ages attending the programs, ranging up to 17 years-old. The investigators attributed the success in controlling the spread of the disease to frequent hand washing by the children and to organizing the children into “bubbles” so that the kids interacted with the same group of children all day long.

A recent and comprehensive official report by Public Health England of the role of English schools, which were reopened on June 1, 2020 despite high community case numbers, in spreading the pandemic.[[104]](#footnote-104) The author of this report found that cases and outbreaks were “uncommon across all educational settings” and that “[s]taff members had an increased risk of SARS-CoV-2 infections compared to students in any educational setting, and the majority of cases linked to outbreaks were in staff.” In response to this study, UK education minister Gavin Williamson said “The latest research, which is expected to be published later this year – one of the largest studies on the coronavirus in schools in the world – makes it clear there is little evidence that the virus is transmitted at school.”[[105]](#footnote-105)

The overwhelming bulk of scientific studies that have examined the topic – including the best studies, which take pains to distinguish correlation from causation – find that children play a limited role in spreading COVID-19 infection to adults and that children themselves face minimal risk of poor outcomes if they should become infected.

In summary, Canadian responses to the epidemic have included many limitations on the activities of children, including but not limited to closures of schools, limitations to in class teaching, restrictions on Bible camps and Bible studies, suspension or limitations of sports and activities, and limitations to contacts with friends. Given the evidence cited here, these policies are inconsistent with the principle that public health decisions must be grounded in good scientific evidence.

# **Do Restrictions on the Activities of Young Adults Play an Important Role in Disease Spread? Do Young adults face particular harms from the lockdown restrictions?**

Unlike children, young adults who are infected – especially early in infection – spread disease as efficiently as older adults. However, they are harmed by infection much less than older adults. Young adults face a very low mortality risk from COVID-19 infection – an infection survival rate of 99.98% for people aged 20-49, according the US CDC.[[106]](#footnote-106)

By contrast, young adults face enormous harm from lockdowns. Indicators of psychological harm have also increased sharply in prevalence in this group. According to a US CDC survey, one in four young adults aged 18 to 24 seriously considered suicide.[[107]](#footnote-107) Similarly, a Canadian Mental Health Association survey found that nearly 1 in 5 (19%) young adults in that age group had suicidal thoughts.[[108]](#footnote-108) The survey also found that 60% of young adults aged 18 to 24 surveyed said that their mental health had seriously deteriorated since March 2020. Other harms include lost educational opportunities with colleges and universities shutting down or providing only online classes and catastrophically high unemployment and economic dislocation.[[109]](#footnote-109) Ironically, the lockdowns themselves have thus increased the risk of COVID-19 faced by older populations by increasing the number of households where young adults who have lost their jobs co-reside with vulnerable older parents[[110]](#footnote-110), which increases the risk of COVID-related death.[[111]](#footnote-111)

For young adults then, the harms from lockdowns are substantially greater than the harms from COVID. Viewed as a medical treatment, lockdowns imposed on younger populations violates the ethical principle that medical actions should do no harm to the patient. Unlike, chemotherapy for cancer, which induces a short-term harm to a patient in exchanges for a potential longer-term benefit, lockdowns cause long lasting harm to young adults with little to no long-lasting benefit.

# **Can religious services be held safely? Are there particular benefits that derive from communal singing?**

Religious activity is essential to a meaningful life for many Canadians, and the free exercise of religion is guaranteed by the Canadian Constitution. Because assembly for religious practice is so important to so many, rather than recommending that religious assembly be canceled during the pandemic, the World Health Organization has provided guidance for religious assembly in the context of COVID-19.[[112]](#footnote-112) The US CDC provides similar guidance and is instructive in the North American context.

The CDC guidance for communities of faith starts by recognizing the particular importance that religious communities should be permitted to gather for worship.[[113]](#footnote-113) The CDC document cites the US First Amendment right to the free exercise of religion and reminds state and local authorities to account for this right in decision making about permitting religious communities to meet. Similar guarantees are present in the Canadian Constitution, as these involve fundamental human rights.

The Public Health Agency of Canada cites this CDC document as an additional resource for community gathering spaces, which includes places of worship.[[114]](#footnote-114)

The recommendations in the CDC guidance include: (1) communication with local public health authorities regarding in person service plans; (2) protection for staff who are at higher risk for severe illness, including older staff members and those with underlying medical conditions; (3) encouragement of the congregation and staff to engage in hygienic hand washing practices; (4) encourage the congregation and staff to wear masks when social distancing is difficult, (5) promote six-foot social distancing during worship and reduce physical contact (shaking hands, hugging); (6) disinfection and cleaning of the worship space before and after each service; (7) minimize sharing of worship materials and shared food; (8) encourage staff and congregants with symptoms consistent with COVID-19 infection or at high mortality risk given infection (e.g. elderly congregants and those with relevant comorbid conditions) to stay home; and (9) post signs and messages to communicate information about practices that can lead to disease spread. The CDC document is pointedly silent on singing during worship and does not make any explicit recommendations regarding communal singing. These guidelines require social distancing, which can reduce the likelihood of disease spread, but do not require a limitation to a fixed number of people in a service regardless of the size of the church, which has no scientific justification.

By following these guidelines, churches, mosques, synagogues, and other religious assemblies can safely hold indoor worship services, with minimal effect on the spread of COVID-19 disease.

The overwhelming evidence that church attendance provides psychological benefits for attendees should be considered against the cost of a marginal increase in disease spread (a harm that can be mitigated by following safety protocols). A comprehensive meta-analysis of the literature found evidence of improved mental health from religiosity (typically defined to encompass church attendance).[[115]](#footnote-115) This is consistent with the broader literature on the psychological benefits of membership in voluntary associations as way to alleviate psychological distress.[[116]](#footnote-116) The evidence suggesting psychological benefits of church attendance (including reductions in rates of depression) are particularly strong for adolescents.[[117]](#footnote-117) Church attendance reduces stress and allostatic load (a term indicating stress endured over a long period of time),[[118]](#footnote-118) which can cause both psychological and physical harms, including higher incidence of chronic disease and higher mortality.[[119]](#footnote-119) There is also evidence in the medical literature regarding the particular psychological benefits provided by communal singing in the process of worship.[[120]](#footnote-120) Communal singing provides a sense of belonging and connectedness that is crucially important in the life of many believers, with measurable effects on mental health.[[121]](#footnote-121),[[122]](#footnote-122),[[123]](#footnote-123)

Of course, the spiritual benefits of in-person religious observance are personal to every member of the religious communities and should not be discounted even if they are not discretely measurable in terms of health benefits. For many believers, faith provides purpose in life.

# **Can restaurants and bars be opened safely to customers? Are there particular benefits that derive from eating in community?**

Alberta is home to a vibrant restaurant and food service industry, including countless eateries, bars, and cafes. It is an important industry that provides entrepreneurial and employment opportunities that benefit the people of Alberta in many ways, including providing psychologically important opportunities to eat together with friends and family. At various points, these facilities have been forced to close in-person dining or have had mandated hours of when to stop selling liquor and closure hours. These facilities currently remain closed (at the time of writing) throughout Alberta despite Alberta’s chief medical officer of health previously stating in an interview that only 1% of cases are linked to restaurants[[124]](#footnote-124) and also that transmission was occurring outside of the formal business environment.[[125]](#footnote-125) These closure orders are not scientifically justified.

If restaurants, bars, etc. adhere to basic safety protocols promulgated by public health agencies throughout Canada (the protocols in summer/fall 2020 in Alberta are a typical example[[126]](#footnote-126)), they can operate with in-person service safely. The recommendations include the following (among other items not listed here): (1) discourage patrons from congregating together while waiting for seating; (2) limit party size at tables and require a 2 metre distance between each dining party; (3) provide for physical barriers between tables when 2 metre distance is impossible; (4) use contactless payments and avoid cash payments where possible; (5) clean menus between uses or use paper menus; (6) avoid singing, or provide physical distancing between singers and patrons; (7) all employees must wear acceptable face covering at all times; (8) frequent sanitizing of surfaces, (9) encourage symptom checking of potential patrons and do not serve patrons who have symptoms consistent with COVID-19 disease.

In New York City, where a similar set of recommendations was in place for restaurants and bars, restaurants which were permitted to operate for in-person dining (until a new closure order[[127]](#footnote-127) was put in place effective Dec. 14, 2020), a detailed contact tracing report found that restaurants and bars in New York City only account for 1.4% of the COVID spread. In that study, private gatherings at home account for 74% of the COVID spread.[[128]](#footnote-128)

This finding should not be surprising. The evidence on the sharply lower frequency of disease spread by asymptomatic individuals (see Section B above) means that the vast majority of people visiting a restaurant pose no risk whatsoever for spreading the disease to fellow restaurant patrons, even if they happen to carry the virus. The main set of people who pose a risk of disease spread are symptomatic patients during the first eight days of infection. Requiring a symptom check at the restaurant door is a much less onerous imposition than banning in-person dining altogether and will have about the same impact on disease spread.

Against these data regarding the negligible risks of COVID-19 transmission in indoor dining (in a restaurant following guidelines) should be considered the substantial evidence that social eating provides significant and tangible psychological and physiological benefits for diners that are lost through the imposition of such scientifically and epidemiologically unjustified blanket and untargeted bans. Those who eat socially more often feel happier and are more satisfied with life, are more trusting of others, are more engaged with their local communities, and have more friends they can depend on for support; path analysis suggests that the causal connection runs from eating together to bondedness rather than the other way around.[[129]](#footnote-129) And a comprehensive survey of 17,612 men and 19,581 women over the age of 65 found that eating alone has been linked to a higher incidence of depression among adults, particularly those who live alone.[[130]](#footnote-130) Eliminating the possibility of indoor dining, no matter the precautions taken, reduces or eliminates these important benefits.

# **Can gyms, martial arts studios, and other venues offering opportunities for physical activities open with minimal risk of disease spread? Are there particular benefits to health that derive from access to such facilities?**

Gyms, martial arts studios, dance studios, and other venues offering opportunities for physical activities are essential to many Canadians as a way of staying physically fit and healthy. Despite the importance of these venues to public health, in much of Canada, Alberta included, the lockdown orders have ordered them to stay closed for extended periods during the past months. These orders are unjustified.

There are two reports of outbreaks linked to Alberta gyms[[131]](#footnote-131)[[132]](#footnote-132), but it is unclear how many cases were contracted at the gym. To my knowledge the public health authorities in Alberta have provided no studies – based on contact tracing or other data – to document that gyms and other such venues pose a risk of disease spread. There is one report of a “super-spreader” event that occurred in a gym in Ontario in October.[[133]](#footnote-133) In that case, there was a spinning class, with stationary bicycles with wheels that in theory could aerosolize the virus. If that is true, the right remedy is to limit indoor spin classes or require physical barriers between bicycles, not to shutter gyms and fitness venues altogether. The CBC story reporting on this event cited one infectious disease expert who admitted that gyms are not high-risk environments:

Dr. Ilan Schwartz, an infectious disease expert with the University of Alberta, said spin classes may pose more risk than other group settings because of the bikes themselves. In theory, the rapidly spinning wheels could aerosolize droplets by flinging them farther distances.

"I haven't seen any studies of this, but theoretically it makes sense," he said.

"I think going to the gym isn't necessarily high-risk, unless individuals are close together and there's poor ventilation. But there might be specific circumstances that could make it higher-risk, where something with fast, moving parts [or] a rapidly moving fan can generate aerosols as well."

Compared with this sort of anecdotal evidence, there are more systematic data from other localities that suggest that physical fitness centers play a limited role in disease spread.[[134]](#footnote-134) In a study published in *Nature* analyzing the association between mobility of populations, super-spreader events and disease risk, the authors conclude that restricting occupancy in public venues is the best approach to limiting the risk of disease spread, while lockdowns aimed at general mobility restrictions work less well.[[135]](#footnote-135) They find that fitness centers do not pose a very high risk of disease spread relative to other public venues.

Second, guidelines disseminated by public health agencies around Canada provide discrete steps that fitness centers can take to reduce the risk of spread of the disease at these centers.[[136]](#footnote-136) These steps include physical distancing requirements, physical barriers, ventilation requirements, symptom checking, cleaning requirements, and face masks when physical distancing is impossible. Given the findings in the scientific literature, these requirements – if implemented appropriately – are sufficient to limit the probability of disease spread at fitness centers.

Third, closing fitness centers reduces the ability of the population to engage in activities that maintain physical fitness, and thus increase the risk of poor outcomes if a COVID-19 infection were to occur. For example, obesity is a risk factor for mortality from COVID-19 infection. Regular exercise is essential for patients with type 2 diabetes[[137]](#footnote-137) or cardiovascular disease[[138]](#footnote-138) to maintain their health. Exercise also provides people with anxiety, depression, and stress-related disorders with an important avenue to address these problems.[[139]](#footnote-139), [[140]](#footnote-140) The negligible benefits of closing fitness centers in terms of slowing disease spread should be balanced against the health benefits of these centers for people who frequent them.

In summary, if fitness centers take standard precautions as recommended by Canadian public health agencies (symptom checking, good ventilation, physical barriers, etc.) the risk of COVID-19 disease spread from their operation is small. The most comprehensive studies confirm that fitness centers play a small role in disease spread. And finally, there are considerable harms to health – both physical and psychological health – from reducing the availability of venues for physical fitness for the population.

# **Do other measures exist that would achieve the goal of the government to protect the population from Covid-19, but that would have less or no impairments on the freedoms and liberties of the population? If yes, what are they?**

Yes. The Great Barrington Declaration, of which I am a primary coauthor, describes an alternate policy of focused protection. This policy would lead to less COVID-related death and less non-COVID related deaths than the current government policy. The co-authors of the Declaration include Prof. Martin Kulldorff of Harvard University and Prof. Sunetra Gupta of Oxford University. Over 12,000 epidemiologists and public health professionals, and 35,000 medical professionals have co-signed the declaration. The text of the Great Barrington Declaration is copied immediately below.[[141]](#footnote-141)

“As infectious disease epidemiologists and public health scientists we have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies, and recommend an approach we call Focused Protection.

Coming from both the left and right, and around the world, we have devoted our careers to protecting people. Current lockdown policies are producing devastating effects on short and long-term public health. The results (to name a few) include lower childhood vaccination rates, worsening cardiovascular disease outcomes, fewer cancer screenings and deteriorating mental health – leading to greater excess mortality in years to come, with the working class and younger members of society carrying the heaviest burden. Keeping students out of school is a grave injustice.

Keeping these measures in place until a vaccine is available will cause irreparable damage, with the underprivileged disproportionately harmed.

Fortunately, our understanding of the virus is growing. We know that vulnerability to death from COVID-19 is more than a thousand-fold higher in the old and infirm than the young. Indeed, for children, COVID-19 is less dangerous than many other harms, including influenza.

As immunity builds in the population, the risk of infection to all – including the vulnerable – falls. We know that all populations will eventually reach herd immunity – i.e.  the point at which the rate of new infections is stable – and that this can be assisted by (but is not dependent upon) a vaccine. Our goal should therefore be to minimize mortality and social harm until we reach herd immunity.

The most compassionate approach that balances the risks and benefits of reaching herd immunity, is to allow those who are at minimal risk of death to live their lives normally to build up immunity to the virus through natural infection, while better protecting those who are at highest risk. We call this Focused Protection.

Adopting measures to protect the vulnerable should be the central aim of public health responses to COVID-19. By way of example, nursing homes should use staff with acquired immunity and perform frequent testing of other staff and all visitors. Staff rotation should be minimized. Retired people living at home should have groceries and other essentials delivered to their home. When possible, they should meet family members outside rather than inside. A comprehensive and detailed list of measures, including approaches to multi-generational households, can be implemented, and is well within the scope and capability of public health professionals.

Those who are not vulnerable should immediately be allowed to resume life as normal. Simple hygiene measures, such as hand washing and staying home when sick should be practiced by everyone to reduce the herd immunity threshold. Schools and universities should be open for in-person teaching. Extracurricular activities, such as sports, should be resumed. Young low-risk adults should work normally, rather than from home. Restaurants and other businesses should open. Arts, music, sport and other cultural activities should resume. People who are more at risk may participate if they wish, while society as a whole enjoys the protection conferred upon the vulnerable by those who have built up herd immunity.”

The Great Barrington Declaration provides concrete suggestions for a strategy of focused protection. This includes a (non-comprehensive) suite of policies aimed at protecting people who are particularly vulnerable (e.g. the elderly) to mortality from COVID-19 infection. These policies differ depending on the particular living situation of vulnerable people. The current policies have failed to protect the vulnerable, as is evidenced by the large fraction of the COVID-19 deaths among the elderly in Canada. There have been many unnecessary deaths, and especially among the urban working class and poor.[[142]](#footnote-142) Concrete examples of these failures include:

* Requiring older “essential” workers and members of the working class that cannot afford not to work to be put in work situations where they may be exposed to the virus.
* Failure to protect [nursing home residents](https://www.usatoday.com/story/news/investigations/2020/06/01/coronavirus-nursing-home-deaths-top-40-600/5273075002/) from exposure to the virus from staff members, visitors, and other residents.[[143]](#footnote-143)
* No provision for elderly people living in multi-generational homes to be shielded should a family member be exposed to the virus.

**Focused protection of the vulnerable provides a better alternative to lockdown to protect the vulnerable. Below, in Section M, I outline ideas for focused protection.**

In summary, the Great Barrington Declaration offers a policy alternative to lockdowns that reduces COVID-19 related mortality among the vulnerable via overwhelming resources devoted to focused protection where they live. For the non-vulnerable, the lifting of lockdowns provides an enormous benefit for physical and psychological health – including mortality risk – that offsets the harm from potential COVID-19 infection.

# **Is there immunity obtained after being infected and cured from Covid-19?**

The scientific evidence is overwhelming that there is lasting immunity after SARS-CoV-2 infection among people who recover from the infection.

First, SARS-CoV-2 is a coronavirus and humans have been exposed to coronaviruses for millennia. Immunologists reviewing this evidence of immunity after coronavirus infection argue that we should use this knowledge to set prior expectations about human immune response to SARS-CoV-2 infection, and these priors suggest a robust and long-lasting immune response. In the *Journal of Immunology*, immunologist Nicole Baumgarth and her colleagues write:[[144]](#footnote-144)

“[W]e argue that the normal cadence by which we discuss science with our colleagues failed to properly convey likelihoods of the immune response to SARS-CoV-2 to the public and the media. As a result, biologically implausible outcomes were given equal weight as the principles set by decades of viral immunology. Unsurprisingly, questionable results and alarmist news media articles have filled the void. We suggest an emphasis on setting expectations based on prior findings while avoiding the overused approach of assuming nothing. After reviewing Ab-mediated immunity after coronavirus and other acute viral infections, we posit that, with few exceptions, the development of protective humoral immunity of more than a year is the norm. Immunity to SARS-CoV-2 is likely to follow the same pattern.”

The direct evidence in favor of a robust and long-lasting immune response is also overwhelming. In a paper published in the journal *Immunity*, immunologist Deepta Bhattacharya (no relation) and his colleagues show that recovered COVID-19 patients show “durable antibody production for at least 5-7 months after infection.”[[145]](#footnote-145) Several other studies, published in prominent immunology journals, confirm this report and show that the vast majority of people who are infected produce specific antibodies in response to the infection, which confer immunity or substantial protection against reinfection.[[146]](#footnote-146), [[147]](#footnote-147)

Over time, as is the normal course of an infection, the specific antibodies to SARS-CoV-2 infection fade. The immune memory persists in dormant or resting cells, called memory cells, who do not actively secrete antibodies, but nevertheless continue to provide lasting protection against SARS-CoV-2 infection. This is entirely consistent with a typical immune response to a challenge by a virus like SARS-CoV-2. Viral infections are most often addressed through CD8 T cells, which do not produce antibodies, but rather directly eliminate virus-infected cells to shortcut viral replication. Indeed, SARS-CoV-2 specific CD4 and CD8 T cells have been detected in convalescent patients.[[148]](#footnote-148)

This T-cell mediated immunity is also long lasting. A preprint study released last month documents this fact, and the title of the piece summarizes its result: “Robust SARS-CoV-2 specific T-cell Immunity is Maintained at Six Months Following Primary Infection.”[[149]](#footnote-149) Another pre-print released last month identifies long-lasting protection after SARS-CoV-2 infection from memory B-cells, which can produce specific antibodies in response to reinfection by the virus.[[150]](#footnote-150)

Finally, it is apparently the case that many individuals who have not been infected by SARS-CoV-2 possess T-cells that recognize it and can neutralize cells infected by the virus. The hypothesized mechanism involves infection by other coronaviruses, which share some molecular structural properties with SARS-CoV-2. A separate study published in Nature found both CD4 and CD8 T cells which provide recognize (and hence attack) regions of the SARS-CoV-2 virus in both convalescent patients and patients who had previously been infected with other coronaviruses including SARS-CoV-1, seventeen years after infection.[[151]](#footnote-151) Summarizing this evidence, Francis Collins (Director of the National Institutes of Health) writes:

Much of the study on the immune response to SARS-CoV-2, the novel coronavirus that causes COVID-19, has focused on the production of antibodies. But, in fact, immune cells known as memory T cells also play an important role in the ability of our immune systems to protect us against many viral infections, including—it now appears—COVID-19…This might potentially explain why some people seem to fend off the virus and may be less susceptible to becoming severely ill with COVID-19.

All these conclusions are well reflected in the fact that that despite millions of people infected worldwide to date after 10 months living with the virus, we have seen only a handful of patients who re-tested positive after being discharged, all of whom showed no evidence of being contagious and all presented milder symptoms. Scientific evidence strongly suggests that recovery from SARS-Cov-2 infection will provide lasting protection against reinfection, either complete immunity or protection that makes a severe reinfection extremely unlikely.

# **What is herd immunity? What is the most effective way to reduce harm until endemic equilibrium?**

Herd immunity – also known as endemic equilibrium – occurs when enough people have immunity so that most infected people cannot find new uninfected people to infect, leading to the end of the epidemic/pandemic. This means that the epidemic/pandemic will end before everyone is infected, although it will continue in endemic form with low rates of infections.  Herd immunity is a scientifically proven phenomenon. Sooner or later, herd immunity will be reached either through natural infection or through a combination of vaccinations and natural infection.

**To protect the vulnerable elderly living in nursing homes and other care settings, a** focused protection strategy would include frequent testing of nursing home staff members who are not already immune, testing of visitors, and less staff rotation so that residents only interact with a limited number of staff people. Rapid antigen tests could be used to avoid the problem of a delay between sample collection and the development of test results and to reduce the possibility of functional false positive results in PCR testing (see Section N below). COVID-19 infected individuals should not be sent to nursing homes, and all new residents should be tested. Sequestering of care home residents who have COVID-19 is also important.

**To protect older people living at home, d**uring high transmission times, older people should be offered home delivery of groceries and other essentials. When seeing friends and relatives, it is best to do it outdoors. Testing should be available for relatives and friends who want to visit. Free N95 masks should be provided for when they cannot avoid potential exposure.

**Focused protection requires protecting protect older people still in the work force.** People in their 60s are at somewhat high risk, and many are still in the workforce. Those that can work from home should be allowed to do so. For example, teachers in their 60s could teach online courses, or help fellow teachers with grading exams, essays and homework. Those that cannot work from home should be funded to take a 3 to 6-month sabbatical. In addition, workplace disability laws should require employers to provide reasonable accommodations to protect high COVID-19 risk workers without losing their jobs.

Focused protection requires protecting elderly people living in multigenerational homes. University closures and the economic displacement caused by [lockdowns has led millions of young adults](https://nationalinterest.org/blog/increasing-numbers-young-adults-are-living-their-parents-bad-170628) to live with older parents, increasing regular close interactions across generations. We know that older people living with working-age adults have [higher COVID-19 risk](https://su.figshare.com/articles/preprint/Residential_Context_and_COVID-19_Mortality_among_the_Elderly_in_Stockholm_A_population-based_observational_study/12612947/1) than older people living with other older people. There is [no further excess risk](https://su.figshare.com/articles/preprint/Residential_Context_and_COVID-19_Mortality_among_the_Elderly_in_Stockholm_A_population-based_observational_study/12612947/1) if also living with children though. This is the toughest challenge, and family specific solutions must be found. If the working-age household members can work from home, they can isolate together. If that is not possible, the older family member might temporarily be able to live with an older friend or sibling, with whom they can self-isolate together during the height of community transmission. As a last resort, empty hotel rooms could be used for temporary housing.

Focused protection also requires protecting younger people with chronic conditions like diabetes, severe asthma, or obesity that place them at higher mortality risk should they become infected. The focused protection plan for these individuals is the same as that for the elderly and will vary depending upon their living circumstance.

The deployment of a safe and effective SARS-CoV-2 vaccine – if people who are most vulnerable are prioritized for inoculation -- offers an opportunity for near perfect focused protection. For this population, the harms from COVID-19 infection are far greater than the possible harms from vaccination.

Effective focused protection reduces the number of people who will need hospitalization for COVID-19 infection, since hospitalization risk, like mortality risk, rises sharply with patient age.[[152]](#footnote-152) Thus, if effective focused protection is implemented, the probability of overcrowded hospital systems is greatly reduced.[[153]](#footnote-153)

Lockdowns actually extend the time that the vulnerable are at risk of infection. By delaying infections into the future, lockdowns delay the establishment of herd immunity in a population. Focused protection of the vulnerable is possible but without an effective vaccination campaign, requires vigilance which cannot be maintained forever.

In summary, replacing a lockdown policy with a policy of focused protection of the vulnerable would greatly reduce the lockdown harms for less vulnerable populations, while protecting the vulnerable from COVID-19 risk. The concrete suggestions outlined here are not comprehensive, and with the advent of a safe and effective vaccine in December 2020, there should be no controversy over whether this policy is possible. It is a failure of public health officials in Alberta that they have not engaged in developing strategies like those listed here. Reducing the risk of harm to the vulnerable and non-vulnerable alike from infectious (COVID-19 related) and non-infectious (lockdown related) causes should be the goal of public health policy. An aim that focuses solely on slowing disease spread – lockdown – ultimately increases both COVID-19 related and lockdown harms relative to a policy of focused protection.

# **What are RT-PCR tests? What is a Cycle Threshold and What is the Likelihood of Infection with Covid-19 with a CT over 30? How Does a Positive PCR Result Correlate to Alberta’s Definition of a “Case” of Covid-19?**

The RT-PCR test for the SARS-CoV-2 virus is at the heart of the testing system adopted by Canada. The RT-PCR tests, as used in most laboratories in Alberta, likely registers a positive test result even for non-infectious viral fragments. The RT-PCR test amplifies the virus – if present – by a process of repeatedly doubling the concentration of viral genetic material. If the viral load is small, many doublings are required before it is possible to detect the virus.

The problem arises from the fact that the implementation of the RT-PCR test for COVID-19 requires that clinical laboratories decide in advance how many doublings of the genetic material they will require before deciding that a sample is negative for the presence of the virus. This threshold, known as the “cycle time” of the test, determines both the rate at which a positive test result will be returned when the original sample does not include viral concentrations in sufficient amount to be infectious (hereafter, the functional false positive rate), and the rate at which a negative test result will be returned when the original sample does include viral concentrations in sufficient amount to be infectious (hereafter, the functional false negative rate).

A higher cycle time threshold – requiring more doublings before declaring a negative test result – increases the functional false positive rate of the RT-PCR test because even if a non-infectious viral load is present in the sample obtained from the patient, a large number of permitted doublings could amplify whatever is present such that test result is positive. In such a case, this positive test result would not mean that the individual was infectious or contagious.

The RT-PCR test is commonly known in the literature as the gold standard to check for the presence of the SARS-CoV-2 virus. This is true, but beside the point. The important question is not whether RT-PCR is a “gold standard” test for viral presence, but rather whether it is a gold standard test for determining whether a patient is infectious, which it is not. Rather, the gold standard test for infectivity involves checking whether a sample taken from the nasopharynx of a patient can infect, in vitro, a cell culture. Infectious samples are known as “culture positive”, while non-infectious samples are known as “culture negative”. From an epidemiological point of view, infectivity measurement is more important than a measurement of whether the virus is present, since it is possible for a patient to have non-viable viral fragments present, a positive PCR test, and yet not be infectious.

The relevant question then, is whether the RT-PCR test is sufficiently accurate to use as a tool to decide whether to sharply curtail the normal activities of over a million people living in Alberta, imposing untold harm on them related to the lockdown, and the unfortunate answer is no.

A systematic review of the literature on cycle time thresholds for the SARS-CoV-2 RT-PCR tests (encompassing 25 different published studies on the topic) concludes that “The evidence is increasingly pointing to the probability of culturing live virus being related to the amount of viral RNA in the specimen and therefore, inversely related to the cycle threshold. Thus, detection of viral RNA per se cannot be used to infer infectiousness.”[[154]](#footnote-154) In other words, the scientific evidence now shows that the RT-PCR test for the presence of the SARS-CoV-2 virus will often generate a positive result even when an individual is not infectious (that is, does not pose a danger of infecting other people). The difficulty is that the RT-PCR test permits too many doubling cycles of viral particles before declaring a negative test. The functional false positive rate increases with the number of cycles (known as a Ct value) required to produce a positive result. The review recommends requiring clinical evidence of infection alongside a PCR result with a low cycle time count before designating a patient as a COVID-19 case.

Similar results were observed in a study[[155]](#footnote-155) published in the *European Journal of Clinical Microbiology & Infectious Diseases*. The study aimed to determine when it would be safe to discharge COVID-19 patients in Marseille, France. The authors observed a significant relationship between Ct value and culture positivity rate (see Fig. [1](https://link.springer.com/article/10.1007/s10096-020-03913-9#Fig1)). Samples with Ct values of 13–17 all led to positive culture. Culture positivity rate then decreased progressively according to Ct values to reach 12% at 33 Ct. No culture was obtained from samples with Ct > 34.

**Fig. 1**



Percentage of positive viral culture of SARS-CoV-2 PCR-positive nasopharyngeal samples from Covid-19 patients, according to Ct value (plain line). The dashed curve indicates the polynomial regression curve

The study concluded that patients with Ct values equal or above 34 did not excrete infectious viral particles.

Further, according to a careful study published in *Eurosurveillance* (a top journal in the field of epidemiology), if 27 cycles are needed for a positive test, the false positive rate is 34%; if 32 cycles are needed for a positive test, the false positive rate is 72%, and if 37 cycles are needed for a positive test, the false positive rate is 92%.[[156]](#footnote-156) If more than 40 cycles are needed for a positive test, the functional false positive rate is nearly 100%.

Twenty-two top international scientists came to a similar conclusion in respect of false positive test results and cycle thresholds. On November 27, 2020, they submitted a retraction request letter[[157]](#footnote-157) to the *Eurosurveillance* editorial board, requesting that the paper published by *Eurosurveillance* on January 23, 2020, entitled, “Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR”[[158]](#footnote-158) (the “Corman-Drosten paper”) be retracted due to its severe flaws. (It was this paper that led to the worldwide usage of PCR tests to diagnose COVID-19.) In addition to their letter, these scientists submitted a Review report[[159]](#footnote-159) of the Corman-Drosten paper outlining 10 fatal flaws in the paper. One of the flaws they listed was with the recommended cycle time value:

In case of virus detection, >35 cycles only detects signals which do not correlate with infectious virus as determined by isolation in cell culture; if someone is tested by PCR as positive when a threshold of 35 cycles or higher is used (as is the case in most laboratories in Europe & the US), the probability that said person is actually infected is less than 3%, the probability that said result is a false positive is 97%.

Even the World Health Organization recently published an Information Notice[[160]](#footnote-160) warning users of PCR tests that it had “received user feedback on an elevated risk for false SARS-CoV-2 results when testing specimens using RT-PCR reagents on open systems.” An updated guidance from the WHO suggests that retesting when the number of duplication cycles needed for a positive test is sufficiently high or a positive test is inconsistent with clinical evidence about a patient’s infection status.[[161]](#footnote-161)

This error in the test is a major problem for Alberta, since the public health authority tracks “cases” per capita and percent positivity of test results to measure the spread of the disease in the population.[[162]](#footnote-162) Both of these measures depend on the accuracy of the RT-PCR tests to determine whether an individual is infected with the virus. The text of Alberta’s COVID-19 case definition from its Public Health Disease Management Guidelines as of January 14, 2020, is reproduced below:[[163]](#footnote-163)

Confirmed Case

A person with confirmation of infection with the virus (SARS-CoV-2) that causes COVID-19 by:

 •Detection of at least one specific gene target by a validated nucleic acid amplification tests (NAAT) (e.g. real-time PCR or nucleic acid sequencing) performed at a community, hospital or reference laboratory (NML or a provincial public health laboratory)

 OR

 •A positive result on a validated rapid/point-of-care (POC) NAAT-based assay or antigen test(A)that has been deemed acceptable to provide a final result (i.e. does not require confirmatory testing)

(A)The performance characteristics of commercial testing kits such as the Simplexa®, GeneXpert®, Aptima or BD Max™ NAT are similar to the COVID-19 lab-developed test being usedat Alberta Precision Laboratories (APL) and additional confirmatory testing is not necessary. For more information refer to Rapid COVID-19 Tests. Positive results by the Abbott ID NOW COVID-19 molecular test or the RapidAntigentests such as the Abbott PanBioare considered valid and additional confirmatory testing is not required if administered through an Occupational Health and Safety program or by a trained regulated health care professional AND completed under the conditions outlined by Health Canada and in accordance with the manufacturer’s instructions. (See Section 2: Testing Modality, Recommendations, Interpretation and Management)

Probable Case(B)

•A person (with NO laboratory testing done) with clinical illness(C)who in the last 14 days had close contact with a lab-confirmed COVID-19 case while the confirmed case was infectious

OR

•A person (with laboratory testing done) with clinical illness(C)who meets the COVID-19 exposure criteria AND in whom laboratory diagnosis of COVID-19 is inconclusive(D)

B)All symptomatic contacts should be tested where feasible to confirm diagnosis. The probable case definition should only be used in the rare circumstances when the laboratory testing cannot be done or is inconclusive but clinical suspicion is high.

(C) Clinical illness: Any one or more of the following: fever (over 38 degrees Celsius), new onset/exacerbation of following symptoms: cough, shortness of breath (SOB)/difficulty breathing, sore throat, loss of taste and/or smell or runny nose. NOTE: Individuals may present with other symptoms that qualify them to be tested. Refer to Section 2: Testing Modality, Recommendations, Interpretation and Management and Table 2a: Symptom List for COVID-19 Testing for more information.(

D)Inconclusive is defined as an indeterminate test on a single or multiple real-time PCR target(s) without sequencing confirmation or a positive test with an assay that has limited performance data available .Ideally, individuals with an indeterminate result will be offered repeat testing and should be isolated at least until test results are available. For any questions or concerns regarding interpreting repeat test results, consult with the MOH/VOC.

Since nucleic acid sequencing is uncommon, Alberta diagnoses a confirmed case of COVID-19 with a positive result on a PCR test without the requirement for a clinical diagnosis by a qualified medical practitioner. It is problematic as without a clinical diagnosis of symptoms related to COVID-19, a positive PCR test alone is too unreliable to conclude that an individual is infectious with COVID-19, especially if that test is run at a high cycle threshold.

Another problem is that Alberta counts “Probable cases” as “cases” for its official case surveillance, and a probable case can include an “un-tested person” who was in close contact with a confirmed case of COVID-19[[164]](#footnote-164). As previously stated, the method for confirming a case of COVID-19 using PCR tests is highly unreliable, so that un-tested person may be counted as a COVID-19 case in error.

The PCR test’s inaccuracies imply that the criteria for reopening do not reflect the risk of community spread of the virus because a “high case count” or positivity rate may be due instead to functional false positive outcomes (that is, people who test positive for the virus at a high cycle threshold, but who are not infectious). Given this scientific evidence, it is certain that lockdowns are being imposed – along with their attendant costs– even when the risk of community spread of COVID-19 does not warrant it.

In summary, the scientific literature establishes the importance of cycle time thresholds in interpreting RT-PCR SARS-CoV-2 results to establish the infectivity of the samples;[[165]](#footnote-165) A reliance on a test that is run up to 40 cycles, (or any number of cycles higher than 30) –– is certain to produce a very large proportion of false positive outcomes. Lockdowns that are imposed on the basis of “case” counts derived from PCR tests will be only marginally related to the threat posed by the spread of the SARS-CoV-2 virus.

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