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Original Research: Philosophical Perspectives on Covid-19

When Is Lockdown Justified?

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Abstract

How could the initial, drastic decisions to implement "lockdowns" to control the spread of Covid-19 infections be justifiable, when they were made on the basis of such uncertain evidence? We defend the imposition of lockdowns in some countries by, first, looking at the evidence that undergirded the decision (focusing particularly on the decision-making process in the United Kingdom); second, arguing that this provided sufficient grounds to restrict liberty, given the circumstances; and third, defending the use of poorly empirically constrained epidemiological models as tools that can legitimately guide public policy.

1. Introduction

The initial months of the SARS-CoV-2 pandemic posed an extraordinary challenge to policymakers. By March 2020, just two months after the virus was first detected, governments around the world were faced with a drastic decision: implement far-reaching, often unprecedented restrictions on the entire populace, or risk exponential viral growth and, potentially, significant numbers of deaths and the collapse of healthcare systems? The difficulty of these decisions was exacerbated by the fact that the implications—on both sides—were highly uncertain. The nature of the threat posed by the pandemic, the degree to which restrictions would be effective, and the costs that these restrictions might exact were all estimated on the basis of emerging and uncertain evidence. This was further complicated by the fact that proposed mitigation measures involved severe restrictions upon liberty—restrictions that we generally only regard as justifiable under a very narrow set of circumstances.

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Decisions concerning pandemic control can now, more than eighteen months in, be evaluated by utilizing something more akin to a cost-benefit analysis.[1] Questions about the justifiability or necessity of restrictions upon liberty and economic activity (among other measures) can be subject to inclusive and sustained deliberation. But although we remain in an extraordinary situation, the degree of uncertainty and seeming urgency that marked the beginning of the pandemic posed a distinctive challenge. Is it possible, under these distinctive circumstances, to justify such drastic interventions at all?

In this article, we mount a defense of the initial imposition of lockdowns, focusing particularly on the United Kingdom (whose decision-making process was particularly well documented), but which should extend to countries with similar features. By "lockdowns" we mean combinations of policies aimed at slowing viral spread, by reducing contact between members of the population. These might include bans on gatherings; the closure of businesses, workplaces, schools, or universities; restrictions upon when and for what purpose individuals may leave their place of residence; and so on. A common feature of these measures is that they apply to the population as a whole, and that non-compliance can be penalized.[2]

We proceed with our defense, first, by briefly presenting the available evidence in the lead-up to the time when the initial decision to lock down was made, focusing particularly on the evidence supporting three key propositions: first, that the viral reproduction number (R) must remain below 1 to avoid exceeding healthcare capacity; second, that lockdown was required in order to keep R below 1; and third, that an initial period of lockdown would not generate damages exceeding any benefit. We then address two objections to the imposition of lockdowns on the basis of this emerging evidence: first, that it was not justifiable to limit people's liberty on these grounds and, second, that the mathematical modeling evidence that played a central role in motivating the imposition of lockdowns was so poor that it could not undergird policy decisions.

We cannot, of course, climb inside the heads of policymakers to discern the exact extent to which the initial decision to institute a lockdown was based on the available evidence (although, as we shall see in the next section, the rapidity with which the government changed their policy when certain key pieces of evidence emerged suggests, at least, that this evidence was a central factor in their decision to institute lockdowns). We cannot tell the extent to which other, perhaps more political, factors entered into the decision-making process of politicians (although it is certainly clear that scientific advice was not the sole influence on these policy decisions—see, for example, Farrar and Ahuja 2021). What we want to claim is this: the available evidence at the time that the government of the United Kingdom first instituted a lockdown constituted sufficient grounds to believe that a lockdown was the best option available at the time, and was sufficient to justify a *short-term,* drastic restriction of liberty. Insofar as the government did indeed act on the basis of this evidence, this decision was justified.

2. March 2020: Lead-up to Lockdown

On 5 January 2020, the World Health Organization (WHO) first reported an increase in cases of pneumonia, of unknown cause, in Wuhan, China, linked to a wholesale seafood and

[1] Or the contractualist approach suggested by Stephen John and Emma Curran (2021), in which the claims of various parties are weighed against each other.

[2] We go into more detail about the measures actually implemented in the United Kingdom below.

live animal market (WHO 2020b). Samples from these patients confirmed that the cause of these cases was a previously unknown coronavirus, of probable bat origin (Zhou et al. 2020; Zhu et al. 2020). By the end of January, there were 2,794 laboratory-confirmed infected individuals in Wuhan, 80 of whom had died (Zhou et al. 2020). The fatality rate of a new virus is always difficult to gauge, because of selection bias—the cases initially identified tend to be the more serious ones. But once further data became available, in early March (based on cases among expatriates on flights out of Wuhan, and passengers of the *Diamond Princess* cruise ship), the infection fatality rate was estimated to be 0.66%—substantially higher than that of recent influenza pandemics (Verity et al. 2020).

The Scientific Advisory Group for Emergencies (SAGE), the group that played a crucial role in the eventual implementation of lockdown in the United Kingdom, held their first "precautionary" meeting to discuss Covid-19 on 22 January, noting some evidence of person-to-person transmission, but also emphasizing the uncertainty surrounding almost all aspects of the virus (Birch 2021; SAGE 2020d). By the end of January, estimates of the basic reproduction number of the virus indicated sustained human-to-human transmission (Wu, Leung, and Leung 2020), "leav[ing] open the possibility for pandemic circulation of this new virus" (Riou and Althaus 2020, 3). The virus had, by this stage, spread throughout China, to some neighboring countries, and the first case had been diagnosed in the United States (WHO 2020a). The first two cases in the United Kingdom were detected in the last week of January (Moss et al. 2020) and began spreading exponentially (Anderson et al. 2020).

As the virus continued to spread in the United Kingdom, worries about the overburdening of the National Health Service (NHS) began to arise. On 26 February, SAGE stated that "without action, the NHS will be unable to meet all demands placed on it," and that "demand on beds is likely to overtake supply well before the peak is reached" (SAGE 2020c).[3] At this time, however, SAGE continued to advocate a combination of measures that would slow the spread of the disease but stopped short of attempting to bring R below 1. A key shift occurred in the SAGE meeting on 18 March, precipitated by two new pieces of evidence. First, while continuing to emphasize the uncertainty regarding all of their conclusions, SAGE now estimated that "the UK is 2 to 4 weeks behind Italy in terms of the epidemic curve" (SAGE 2020a). Italy, at the time, was the hardest-hit country in Europe, and its healthcare system was close to collapse (Armocida et al. 2020). The second key piece of evidence was a report containing mathematical modeling projections of epidemic development contingent on different policy responses—the much-discussed "Report 9" by the Imperial College Covid-19 Response Team (Ferguson et al. 2020). This report, released two days before the SAGE meeting, suggested that the current mitigation-based measures pursued by the United Kingdom would lead to healthcare capacity being exceeded several times over. In order to avoid this, the report stressed that a "suppression-based" strategy, with the aim of reducing R to less than 1, must be pursued as soon as possible.

Although it is only alluded to in the 18 March meeting (SAGE 2020a), there was further indication that lockdown-type measures could have a significant effect on transmission rates (Kucharski et al. 2020; Lau et al. 2020; SAGE 2020b). On 25 February, SAGE noted that available evidence from Wuhan, Hong Kong, and Singapore indicated that lockdown

[3] The NHS also lacked sufficient personal protective equipment (PPE)—since contingency plans had focused on the possibility of an influenza epidemic, "there was too little PPE and too much of it was of the wrong kinds for this disease" (Atkinson et al. 2020).

measures could reduce *R* to 1 and suggested that such measures could be realistically implemented in the United Kingdom (SAGE 2020b). Further support was provided by a study comparing Wuhan (which imposed lockdown late) with Guangzhou (which implemented lockdown measures early) (Li et al. 2020), which suggested not only that lockdowns could play a pivotal role in keeping healthcare demand within capacity, but also that the timing of the intervention is crucial. On 18 March, SAGE noted that, although they could not be sure that strict measures in pursuit of epidemic suppression are necessary, "if the interventions are required, it would be better to act early" (2020a).

On the strength of "Report 9," SAGE recommended school closures (2020a), which were implemented across much of the United Kingdom on 20 March (BBC 2020). The rest of the suppression-based recommendations in "Report 9" were also adopted as policy by the government of the United Kingdom immediately after the release of this report (Boseley 2020; Van Basshuysen and White 2021b). In order to achieve a drastic reduction in social contact, measures including the closure of businesses, the dispersal of gatherings of more than two people, and strict restrictions on the purposes for which individuals could leave their homes were mandated on 23 March, with fines imposed for non-compliance (Prime Minister's Office UK 2020).

This, then, gives us a sense of the evidence marshaled in support of (or available to support) the initial institution of lockdowns in the United Kingdom. But this, of course, only addresses one side of the equation. It was clear that such drastic interventions could potentially have significant, disruptive impacts that may, in some cases, be difficult to predict. How might these detrimental effects compare to those of unsuppressed proliferation of the virus? There was some evidence to suggest that areas that had embraced stricter control measures had ultimately fared better economically during the 1918 influenza pandemic but this result could not straightforwardly be generalised to the Covid-19 pandemic (Correia, Luck, and Verner 2020).

There were, however, further considerations to suggest that lockdown measures might constitute the lesser of two evils. First, some of the detrimental impacts that might be feared as a result of lockdown measures, such as spikes in unemployment (Gupta, Simon, and Wing 2020) and the closure of businesses (Bartik et al. 2020), had already preceded the implementation of official measures; the associated costs would have accordingly accrued with or without lockdown. Second, although it would be impossible to completely contain the detrimental effects of lockdown measures, governments could have expected, at least, that some of the worst impacts could be mitigated, through the use of measures such as the provision of loans or benefits, moratoria on debt repayments, additional protections for tenants, economic stimulus measures, and so on. Indeed, it might be expected that, as the pandemic had been so economically disruptive even prior to the implementation of lockdowns, many of these measures would be required in any case. Finally, lockdown measures could be lifted if and when evidence emerged about disproportionately detrimental impacts. Although, again, this would not present a means of containing all harm caused, it stood in contrast to a decision not to impose lockdowns, where the available evidence indicated that immediate action could have significant impacts, and even delaying the decision by a couple of weeks could result in damaging and irreversible outcomes. While infections and fatalities were expected to increase exponentially when *R* was greater than 1, there was no reason to think that similar social and economic impacts would result from the short-term imposition of lockdowns.

All this, we must stress, applies only to affluent countries, similar to the United Kingdom, which could expect to successfully implement lockdown mitigation measures, and where it could be reasonably expected that the implementation of lockdowns would not result in a public health catastrophe of its own (see Broadbent 2020). Our argument is also, as we have emphasized, focused on the initial decision to impose these measures, under conditions of uncertainty and unpreparedness. This does not suggest that governments were not obligated to continue to gather evidence, to revise and revoke policies as more evidence emerged, and to seek out and develop less burdensome methods of epidemic control (see White and Van Basshuysen 2021a, 2021b). One might also suggest that governments should be held responsible for insufficient preparedness for a pandemic of this scale, and that such drastic measures would not have been necessary if, for example, adequate contingency plans had been attended to before the event—we regard this claim as compatible with the contention that, given the circumstances they found themselves in, governments could be justified in the initial decision to impose lockdown measures.

Our short retelling here is intended to suggest that, even given the uncertainty surrounding features of the epidemic and the efficacy and harmful effects of lockdowns, the emerging evidence could justify the government's initial decision to take these unprecedented steps; that is, it constituted sufficient grounds for believing that the implementation of a lockdown was the best available option at the time, and it constituted sufficient grounds to restrict people's liberty on a short-term basis. There are two ways in which this claim could be, and has been, challenged. The first is to maintain that the evidentiary bar here is being set too low—particularly when it comes to the restriction of basic liberties, justification requires more certainty; that is, the tentative and emerging evidence upon which the decision to institute lockdowns was made (insofar as it was made upon this evidentiary basis) does not suffice to justify these measures. But even if we accept that one may justifiably make such a decision under a large degree of uncertainty in this particular context, a second line of attack remains open: one might claim that the evidence was so poor that it did not suffice to clear even this lower evidentiary bar. We now proceed to each of these objections in turn.

3. "We Can't Restrict Liberty on These Grounds!"

We can find a potential argument against the initial imposition of lockdowns in many parts of the world in a paper by Eric Winsberg, Jason Brennan, and Chris Surprenant (2020). In a nutshell, they contend that "freedom [is] the default from which departures must be justified; the greater the imposition, the stronger the justification needed" (2020, 222). Although restrictions upon liberty, including coercive measures, can indeed be justified, this is only the case when very high epistemic standards are met. In the early stages of the pandemic, they argue, when evidence was emerging and uncertain, governments could not meet the high epistemic bar required for the intrusions upon liberty entailed by lockdown policies.

It is difficult to answer, in a precise manner, the question of just how much evidence we need to justify the kinds of severe restrictions on liberty that lockdown policies generally entail. However, by looking at limits of the liberal democratic principle privileging individual liberty over other concerns in most circumstances, and the specific features of a pandemic situation, we can sketch an account of the general circumstances under which restrictions of liberty may be thought to be justifiable. We suggest in this section that

although the above stipulation is indeed compelling in normal circumstances, there are a couple of reasons to think that these requirements do not apply to these particular circumstances. We draw this out by scrutinizing each part of the stipulation in turn: first, that liberty is always the default, and second, that high levels of justification are always required to override it.

We proceed by first looking at when restrictions of liberty are normally justified—when conduct causes harm to others (the "harm principle"). We argue that going about one's daily business in a normally self-regarding way poses an unacceptable risk of harm to others during the Covid-19 pandemic, and thus that the harm principle can justify restrictions on liberty under these circumstances. But there is another issue here, which the previous section has already acquainted us with: particularly at the beginning of the pandemic, the magnitude and likelihood of the harm that would ensue from such conduct was difficult to gauge—the evidence was emerging and uncertain. We contend, however, that where the risk of harm is imminent—that is, where there is reason to believe that immediate action is required to avoid harm—the high evidentiary bar we might normally require to justify policies involving such drastic measures as the restriction of liberty needs to be relaxed somewhat.

Policies falling under the broad moniker of lockdowns might be justifiable even on the basis of uncertain evidence when two conditions are met: unacceptable risk of *harm* (to others) and *urgency*. This is not to say that no evidence at all is required for the institution of such policies—just that these two conditions might require altering the normal moral and epistemic standards to which justified policymaking must be held. Or, more specifically, where normal conduct in a pandemic poses risk of *harm* to others, this might cause us to alter our presumptive privileging of *individual liberty,* and when a situation is *urgent,* it might lead us to relax our *epistemic standards* for justified policy interventions.

So, to begin, under what circumstances can we justifiably circumscribe the liberty of individuals? Almost all liberal theorists suggest that liberty should be limited by the "harm principle," summarized here by Joel Feinberg:

> State interference with a citizen's behavior tends to be morally justified when it is reasonably necessary … to prevent harm or the unreasonable risk of harm to parties other than the person interfered with. More concisely, the need to prevent harm … to parties other than the actor is always an appropriate reason for legal coercion. (1984, 11)

Feinberg goes so far as to say that "no responsible liberal theorist denies the validity of the harm principle" (1984, 14). We can see similar stipulations in liberal public health ethics frameworks, such as that of James Childress et al., who contend that the voluntary conduct of citizens may be justifiably restricted by coercive means "to reduce or prevent the imposition of serious risk onto others" (2002, 175).

It should be noted that, in each of the stipulations above, one does not have to *intend* to cause harm for the restriction of liberty to be justified—the risk of unwittingly passing a dangerous virus on to others could qualify as putting others at risk of harm (see also Brennan 2018; Flanigan 2014; Frowe 2020). But not all exposure of others to risk is straightforwardly unacceptable. We allow some exposure of others to risk all the time—we do not forbid people from driving, for instance, even though they put others on the road at risk by doing so (Hansson 2003). This is reflected in the definitions of both Feinberg and

Childress et al.—for Feinberg, it is the "*unreasonable* risk of harm" that justifies restrictions upon liberty, while for Childress et al., it is "the imposition of *serious* risk." How, then, might we determine whether the risk posed by going about one's business in a pandemic constitutes the type of unreasonable or serious risk that can justify restrictions upon liberty?

One suggestion for distinguishing between acceptable and unacceptable risk comes from risk theorist Sven Ove Hansson. He proposes that "exposure of a person to a risk is acceptable if and only if this exposure is part of an equitable social system of risk-taking that works to her advantage" (2003, 305). The idea here is that in exchange for being exposed to risk by, for example, others being able to drive a car, I am also allowed to drive a car and expose others to the attendant risks. This is justifiable because, we might presume, it is to everyone's benefit.

So is potentially exposing yourself, and then others, to the risk of contracting a potentially serious virus a case of unacceptable risk? Jason Brennan presents us with a fictional case that might lead us to believe that it does; the case of the "reckless astronauts":

> Elon Musk has just invented instantaneous interplanetary teleportation, and the technology is widely available. Suppose a group of privately-funded astronauts plans to visit a newly discovered planet, a planet that, for all they know, contains a wide range of deadly bacteria and viruses. When they arrive, they drink the water, without sanitizing it. They also give the possibly contaminated water to their children. When they arrive back home a day later, they refuse quarantine. Some of them visit Disneyland, while others immediately place their (for all they know, infected) children in daycare centers or schools. They could have taken steps to sanitize the water samples and to prevent themselves from contracting any alien diseases, but they decided not to do so, because they get their health advice from Jenny McCarthy. (2018, 41)

The astronauts' conduct, according to Brennan, involves active exposure of others to risk of harm, and this risk cannot be regarded as acceptable because others do not benefit from the astronauts' refusal to take precautions. Because of this, Brennan concludes—perhaps surprisingly given his position in his article with Winsberg and Surprenant (2020)—that the forcible quarantine of the reckless astronauts is justifiable.

There are, however, two ways in which we might want to question this analogy when we carry it over to general restrictions in response to Covid-19. First, Brennan's case might be thought to provide an argument for the justifiability of *quarantine* measures—targeted at specific individuals whom we judge as particularly likely to pose some risk (as a result, for example, of their direct exposure to potential disease vectors) but this argument might not extend to general restrictions. If what we are considering is placing restrictions on *everyone* in order to reduce risk, we might think that not imposing such restrictions could in fact be mutually beneficial.[4] In exchange for being free to go about my daily business in a pandemic,

[4] Brennan's case might actually run into similar problems in the context of the purpose for which it is used—to provide an argument for general mandatory vaccination measures. One might similarly say here that the freedom to refuse vaccinations (or other medical treatment) and expose others to risk is justifiable because the same freedom/advantage is extended to everyone. Of course, mandatory vaccination advocates might question the idea that vaccination refusal works to the advantage of anyone who is not a vaccine skeptic, and thus cannot be regarded as a "reciprocally beneficial right" (Hansson 2003, 304). This is less plausible in the case of restrictions concerning Covid-19, where the ability to go about one's business free of restrictions is more clearly a significant right or benefit.

potentially exposing you to the virus, you are free to go about your normal activities, potentially exposing me to the virus. This, then, might be more like driving a car than quarantine—everyone exposes one another to risk but within an equitable system that works (*ex ante*) to the advantage of all.[5]

When it comes to Covid-19, or any other epidemic with potentially serious and widespread consequences, this line of thinking could fall apart for two reasons. The first is because of the fact that certain parts of the population—the elderly, people with various comorbidities, and so on—are not likely to feel free to share in the benefit of going about their business unaffected (see Flanigan 2014). Certain groups of people, based on the available evidence, can judge themselves to be at a much higher risk of serious complications or death, and many might feel forced to isolate themselves in order to avoid taking on this risk. Activities that may be unavoidable, such as grocery shopping, become more risky for these groups of people in this environment, while they are unable to share in the corresponding benefits of moving about freely. And even if they take all possible measures to avoid contact with others, their risk of exposure is nonetheless increased by allowing the spread of a virus through the community. Due to the disparate effects of the virus on different groups, which had clearly emerged even in the early stages of the pandemic, we might question whether this amounts to an *equitable* exchange of risks that works to everyone's advantage.

One could ask here if this argument might not also apply to the seasonal flu. It is difficult to draw a hard line in terms of degree of risk here, and to balance risks and benefits to determine what in fact should be seen as working to the advantage of all. We might think, for example, that even for the susceptible, the comparatively small risk of contracting and developing complications from a seasonal flu might still lead them to see going about their business free of restrictions as ultimately being to their benefit. But even if we doubt this, there is another distinguishing factor presented by the Covid-19 pandemic—the propensity of poorly prepared healthcare systems to become overwhelmed in the absence of adequate mitigation measures. If there is reason to believe that this will happen, this introduces a new set of risks into the equation—the increased risk that individuals will be unable to access necessary medical care. If, again, as suggested by the available evidence, we take this to pose a significant risk, we can expect that certain subsections of the population—those who expect with high enough probability that they will require access to medical care—will not make a judgment that exposure to this risk is likely to work to their overall benefit.

Second, it should be noted that Brennan's example involves a highly uncertain risk. We have no idea whether the astronauts do indeed expose themselves to serious communicable diseases on the newly discovered planet, and thus have no means of gauging the risk they actually pose. But we might want to be a bit more stringent than this—more along the lines of what Winsberg, Brennan, and Surprenant (2020) propose—and insist that only when we

[5] The question of whether the increased viral spread in the absence of a lockdown would constitute a mutually beneficial distribution of risk is ambiguous as it can be given an *ex-ante* or an *ex-post* reading. To illustrate, while it might be the case that driving cars is a mutually beneficial practice *ex ante,* this may not be the case *ex post;* that is, after I was severely injured in a traffic accident. While our discussion here is focused on an *ex-ante* reading of mutual benefit, as seems reasonable in this context (see John and Curran 2021), one might wonder whether an increased viral spread in the absence of a lockdown would be mutually beneficial *ex post*. It is, however, even less likely that increased viral spread could achieve mutual benefit *ex post* than it is *ex ante:* for not only will the death toll be higher among the elderly and other high-risk groups, these groups will also disproportionately suffer from overwhelmed healthcare systems, thus leading to substantial inequities *ex post*.

have good grounds to believe that there is in fact a serious risk can this justify state interference with liberty.

As we have seen in the previous section, we did have some reason to believe that Covid-19 had the potential to kill more people than the seasonal flu, spread more virulently, and overwhelm healthcare systems. But the evidence at the time was emerging and uncertain. Although by the time that the decision to implement lockdown measures was made in the United Kingdom it was clear that Covid-19 was spreading exponentially, we could only estimate just how infectious and deadly it was, and whether lockdown measures were really required in order to avoid the worst consequences of viral spread. To return to the quote with which we opened this section: "the greater the imposition [on people's liberties], the stronger the justification needed" (Winsberg, Brennan, and Surprenant 2020, 222). Our argument thus far in this section has relied on the severity of the consequences of letting Covid-19 spread without serious mitigation measures—that because of the magnitude and nature of these risks, we cannot think of a lack of restrictions as mutually advantageous risk exposure. But can we justify such severe impositions on the liberties of entire populations on the basis of the limited evidence that we had concerning these potential consequences? Did policymakers have an epistemic duty to gather more evidence, and to establish these conclusions to a higher degree of certainty, before making such radical decisions?

In order to support their claim that a higher evidentiary bar must indeed be met, Winsberg, Brennan, and Surprenant (2020) introduce the case of a suspected serial killer, detained and held by the state for the protection of the public. It is clearly unjustifiable, as they contend, to hold this suspect for months on end, without gathering the appropriate evidence, and submitting it to the appropriate procedure of a trial, even if we strongly suspect that harm will ensue if we release him, and even if we have some evidence supporting this belief. Even if the suspect *is* indeed guilty, this does not suffice to justify continuing to hold him; "to justify infringing the suspect's rights, the state needs to be more than factually correct: it needs to have strong epistemic grounds for its claims … governments are required to possess a certain level of justification before they may restrict citizens' liberties" (2020, 216). In some ways, this presents a compelling analogy with the case of lockdown; just as in the case of the suspected serial killer, this is a situation in which one's fundamental rights are at stake. To elaborate on this legal analogy, although we might require only a "preponderance of evidence" when it comes to matters of tort law, the more serious rights infringements dealt with by criminal law require a correspondingly higher burden of proof. It is exactly when these sorts of rights are at stake, in other words, that we *cannot* relax our standards.[6] Is there any reason, then, that this should not also apply to the imposition of lockdowns?

An initial way in which we might question this line of argument is to draw attention to the variability of evidentiary standards required to justify rights violations even within criminal law. While the high evidentiary standard of "beyond reasonable doubt" is required for criminal conviction (and while prolonged detention is unjustifiable without criminal conviction), the far less demanding evidentiary standard of "probable cause" is applied to the arrest and subsequent short-term detention of suspects while evidence is gathered to

[6] Thanks to an anonymous reviewer for pressing this concern. It should be noted that although Winsberg and colleagues' example provides an evocative way of presenting this challenge, it is not clear that they would dispute our contentions about the initial, short-term imposition of lockdowns—see, for example, Winsberg, Brennan, and Surprenant (2020, 237).

bring charges against them. This is not to challenge the unacceptability of the prolonged detention of the suspected serial killer in the above example, or to take issue with the authors' point about long-term lockdowns, but rather to suggest that the initial imposition of lockdowns might be regarded as more akin to the short-term detention of a suspect while evidence is gathered to bring charges. This requires *some* evidence and the extension of this period of detention can only be justified where further evidence can be provided and accepted through the appropriate channels, but the initial, circumscribed restriction of liberty may be justified on more limited grounds.

A second way in which we might want to challenge this analogy is to point to the contextual differences between lockdown and the imprisonment of a suspect, as well as the context dependence of appropriate evidentiary standards. The latter point is emphasized by Marion Vorms and Ulrike Hahn in their exploration of the notion of "reasonable doubt" in various (including but not limited to judicial) contexts (2021). For Vorms and Hahn, it is not possible to establish a context-independent evidentiary standard in any situation and a key factor in deciding whether one has sufficient evidence to act (among others) is "the risks and potential benefits of delaying the decision" (2021, S3630).

Though the decision to detain a potentially dangerous suspect does bear a close resemblance to the decision to institute lockdowns in several key aspects—both involve the restriction of fundamental liberties, and one might support both decisions by appealing to the harm that failing to act poses to the public—there are also several important contextual differences here, which bear heavily on the risks and benefits of delaying the decision. One concerns the potential efficacy of alternate mitigation measures. Delaying the decision to imprison the suspected killer results in potential harm but this threat might be mitigated by measures stopping short of imprisonment, such as, for example, surveillance.[7] In contrast, as we have seen above, the available evidence suggested that no alternate measures would prevent the threat of the healthcare system being overwhelmed if the decision to institute lockdowns were to be delayed while further evidence was gathered.[8] A second, related contextual difference concerns the immediacy of the threat. Failing to institute lockdowns almost immediately was expected to lead to a situation in which exponential viral spread would make effective mitigation of the worst consequences after that point impossible, and overwhelmed healthcare systems inevitable. A third difference concerns the nature of the threat. Delaying the decision to imprison a suspect until more evidence can be gathered might lead to the killer striking again. This is a serious harm, but the harm that might be expected to result from an overwhelmed healthcare system is of a much more widespread nature and threatens to undermine an institution central to the functioning of society.

Indeed, when we are talking about a decision with these sorts of societal ramifications, where immediate action appears required to allow for effective mitigation, and where our opportunity for action is constrained, we are coming closer to the types of concerns

[7] We also need, on the other side, to take into account the societal harm and threat to institutions of justice if epistemic standards are relaxed, either in this case in particular, or in general. We will not pursue this claim in requisite detail here but the nature of this harm may be different to the harm of relaxing evidentiary standards in order to deal with a potential public health threat.

[8] Vorms and Hahn also make an interesting point, highly relevant to our concerns here, about the complex nature of this judgment—in gathering evidence that allows us to determine whether we have met the necessary threshold for action, we are sometimes also gathering evidence that is relevant to determining where the threshold should be set; the threshold for action, in some cases, cannot be made independent of the evidence gathering process (see 2021, S6360).

discussed in the field of "emergency ethics." While the level of threat here might not rise to the type of existential threat to society that theorists such as Michael Walzer (1988), in the context of war, argue can justify wide-ranging exceptions to normal moral standards, the widespread and societal nature of potential threat brings the situation closer to the types of societal threats that, according to theorists such as Walzer, might require extraordinary measures that go beyond what we appeal to in cases of potential individual harm (see also Birch 2021). The "imminence" of the threat also features heavily in discussions of "supreme emergency" (see, for example, Walzer 1988, 1). Part of the reason for this is that in situations in which risk is imminent, refraining from action until further data is gathered can effectively preclude the possibility of acting to mitigate the potential harm. As Tom Sorell notes, "the importance of minimising significant harm is usually reflected in the appropriateness of longer and more careful practical deliberation than usual—precisely what unexpected emergency rules out. In unexpected emergencies one is usually forced to decide quickly when the stakes are high" (2003, 24). The kind of decision-making norms that we might normally require in a liberal democratic society—further evidence gathering, inclusive deliberation, and so on—can be precluded in these circumstances. To admit of no exceptions to a high and fixed evidentiary bar is to forestall the possibility of taking action in an emergency.[9]

The types of risk-benefit considerations advocated by Vorms and Hahn in setting evidentiary standards, or the communitarian concerns motivating Walzer in his espousal of the departure from everyday norms in extreme circumstances, are not going to be regarded as universally compelling reasons to adjust our standards of evidence in certain situations. For example, one might believe that departures from these evidentiary standards simply cannot be justified by competing concerns under any circumstances—broadly what Marcus Dahlquist and Henrik Kugelberg refer to as "the libertarian conclusion" (2021, 4). But if we believe that there are some circumstances under which the costs of the libertarian conclusion are just too high (see Dahlquist and Kugelberg 2021), these sorts of considerations might point us in the direction of where, and for what reasons, rare departures from this high epistemic bar might be justified.[10]

This, of course, does not suggest that policymakers have no further duties to continue to gather evidence, both about the danger they are responding to, and the impact of implemented policy measures. This was emphasized by epidemiologist John Ioannidis, who

[9] Clearly any departure from these norms is something that must be taken very seriously—we should, of course, be concerned about the abuse of emergency powers, particularly by governments that keep such measures in place long term. But that does not necessarily mean that we can, or should, do away with extraordinary provisions for extraordinary circumstances entirely—see Sorell (2003) and Brennan (2018) for a similar argument about government failure.

[10] As an anonymous reviewer pointed out, there are similarities between this line of argument and a precautionary approach to policymaking. The two conditions we are highlighting here—a threat of catastrophic harm and a lack of knowledge of the probabilities associated with various outcomes—are frequently identified as triggers for a precautionary approach aimed at preventing reasonable worst-case scenarios (cf., for example, Gardiner 2006). Indeed, Jonathan Birch (2021), on roughly these grounds, advocates a broadly precautionary approach to pandemic policymaking. There is, however, a third condition identified by Gardiner that is arguably not met in the case of the current pandemic—that the potential costs of taking precautionary measures are minimal compared to the catastrophic threat prevented (see also Rawls 1999). The precautionary measures themselves threaten to incur significant costs. Although this might complicate a precautionary approach somewhat, and we thus do not appeal directly to a precautionary principle in spelling out this argument, the failure to meet this condition does not necessarily entail that precautionary reasoning cannot be employed here (see Gardiner 2006).

became a leading figure in the United States in calls for caution concerning lockdowns, and the need for more and better data (more on this below). Despite this, however, Ioannidis maintains: "I think lockdown was justified as an initial response, given what little we knew about this new virus" (2020). This, we contend, further underscores that something is going wrong with the application of normal epistemic standards to urgent situations—it is precisely *because* we knew so little that Ioannidis took the initial decision to be justified. In addition, as noted above, this does not abrogate policymakers' responsibilities to mitigate the burdens imposed on citizens in their attempts to avoid imminent risk, and to seek out less burdensome alternatives. For example, an aggressive digital contact-tracing regime may have been preferable to continuing lockdowns (White and Van Basshuysen 2021a, 2021b) but at the very beginnings of an emergency situation like a pandemic, where there is no time to put such infrastructure in place, our options for action are limited.

To summarize, then, the Covid-19 pandemic represents an unusual instance where our normal self-regarding conduct poses unacceptable risk of harm to others—thus restrictions on liberty are justifiable. Although estimations of the magnitude and nature of harm were, in the early months of the pandemic, based only on emerging and uncertain evidence, the necessity of provisions for acting quickly where potential harm is imminent should lead us to relax the epistemic standards to which we normally hold policymakers when there is time for further evidence gathering and extensive deliberation.

4. "The Evidence Was Too Poor to Have Any Epistemic Weight!"

But this is all premised on the idea that there was *some* evidence that could provide a basis for thinking we were faced with this sort of imminent threat and that lockdown was a necessary means of avoiding it. One type of evidence, as we have seen, that played a prominent role in the justification of lockdown policies (although it should be stressed that that this was just one type of evidence considered by scientists and policymakers) was evidence based on epidemiological models. Some researchers, however, have criticized the use of these models in policy decisions so heavily that one might worry whether the putative evidence such models were able to provide was too poor to guide policy decisions at all, even in extreme circumstances.

Ideally, the performance of models used to inform policy choices will have been adequately tested before the models' predictions are passed on to policymakers, the data used for the models will have been shown to be reliable, and models will only be used for purposes for which their adequacy has been confirmed. But last March, when governments in many countries were faced with the difficult question of whether to impose social-distancing measures to slow the spread of SARS-CoV-2, models were just being developed, many of the parameters in the models were not empirically well constrained, and there were not yet sufficient performance tests available to confirm the adequacy of these models for providing information upon which public policy decisions could be based.

Moreover, as empirical evidence was emerging, it seemed to some that the evidence that did exist showed that models were too inaccurate to be useful or even, as one critic claims in the case of susceptible-infectious-recovered (SIR) models, "completely and totally wrong" (Cochrane 2020). Similarly, a group of epidemiologists argued that the performance of models, at least early on in the pandemic, was inadequate for modeling results to be passed on to policymakers and that more performance tests ought to be performed "before their results are provided to policy makers and public health officials" (Chin et al. 2020,

733). Winsberg, Brennan, and Surprenant similarly maintain that Covid-19 models are "flawed" (2020, 216), and ask why "so many expert epidemiologists fail so badly, or rely on speculative parameters within their models" (229). Was the evidence provided by models in the early stages of the pandemic perhaps too poor to be taken into account at all? In this section we discuss the uses to which epidemiological models (and scientific models more generally) can be put in guiding policy decisions. We survey the different kinds of evidence that models are able to provide and contend that, contrary to what critics argued, the preliminary and uncertain evidence provided by epidemiological models early in the pandemic was able to play a legitimate role in informing policy decisions, even if the models did exhibit some of the putative flaws to which their critics drew attention.

We can distinguish three types of epidemiological models that played a role in policy debates during the pandemic (see also Fuller 2021). The simplest models, SIR or susceptible-exposed-infectious-removed (SEIR) or *compartment* models, provide population-level, highly idealized representations of how diseases spread. These models assign members of a population to three or four compartments, the susceptible, infectious, removed/recovered, and, in the case of SEIR models, also the exposed subgroup of a population. They then represent, with the help of a small set of deterministic equations, how the sizes of the different compartments change with time. Compartment models treat populations as a whole, abstracting from interactions among individuals and individual transmission events. An example of a SEIR model is the Standards for Quality Improvement Reporting Excellence (SQUIRE) model used by researchers at the Imperial College London to model the global evolution of the pandemic in different regions of the world (Walker et al. 2020).

The second type of model used to model the spread of SARS-CoV-2 are *individual-level* or agent-based models, in which individuals are assigned to different types of location where contacts occur—within households, at school, in the workplace or in the wider community—and then movements of individuals between these locations and transmission events through contacts among individuals are modeled. Agent-based models may be deterministic or add a stochastic or random element. In the latter case, different runs of the same model will lead to different projections of how infections spread. The CovidSim model discussed in "Report 9" (Ferguson et al. 2020)—the results of which, as we have seen, played an important role in the initial decision to implement lockdowns in the United Kingdom—is a stochastic, individual-level model. As input into this type of model, modelers construct a "synthetic population" with characteristics that closely resemble what survey data reveal about the actual population modeled. In contrast with compartment models, individual-based models are extremely complex, and contain a very large number of parameters. Thus, one challenge modelers face in constructing individual-based models is to gain access to data that are rich enough to allow the model parameters to be sufficiently constrained empirically. And, indeed, one of the criticisms leveled against the use of models in policy decisions early on in the pandemic was that models had to rely on insufficient data and, hence, could not avoid making speculative parameter choices.

A third, somewhat newer type of model is the *data-driven* model, a less theoretical model that essentially engages in curve-fitting—plotting a curve to fit what are generally very large data sets to predict the course of the pandemic. The Institute for Health Metrics and Evaluation (IHME) model (IHME COVID-19 Health Service Utilization Forecasting Team 2020) that was used as a basis for some national policy decisions in the United States

(Begley 2020) is an example of a data-driven model. One challenge in the application of such models is to determine the conditions under which the output of a model constructed as the best fit for the evolution of the pandemic in one geographic location at one time can be applied in a different context.

How adequate were these various models as guides for public policy? The models' critics tend to compare model outcomes with the actual epidemic outcomes and conclude from a poor fit that the models failed (see, for example, Cochrane 2020; Friedman et al. 2021; Winsberg, Brennan, and Surprenant 2021). This suggests that the only purpose of models is to predict outcomes as precisely as possible. But this is too narrow in two senses: first, in the demand for maximal precision as the hallmark of success and, second, in the restriction of models as tools for prediction.

Beginning with the first sense, it is by now a well-rehearsed point that every model idealizes its target system in certain respects and abstracts from some of the target system's properties (see, for example, Cartwright 1983). There is no "perfect model" that represents all features of its target system and does so completely accurately. A model may be adequate for predicting one range of quantities, even while it is not adequate for predicting the values of other quantities. And what counts as sufficient precision is dependent on the context in which a model is used: a model may be useful for making coarse-grained, order-of-magnitude, or merely qualitative predictions, even where it is not adequate for predicting more precise numerical values.

Moreover, and this is the second sense, models can be used for purposes other than making predictions. It is customary to distinguish *predictions or forecasts* that are statements concerning the values of quantities in the actual world from *projections* that use non-actual counterfactual inputs (either initial conditions or non-actual parameter values) to output the value of some quantity under counterfactual circumstances. Projections, that is, are conditional predictions (Fuller 2021; Schroeder 2021). Projections aim to examine how the values of certain quantities depend on particular choices of model structure, of initial conditions, and of parameter values. A well-known example of projections are climate projections, which explore how global mean surface temperatures evolve under different radiative-forcing scenarios and emission pathways.

Some of the criticisms of pandemic models are the result of treating highly idealized projections as predictions, or of not paying sufficient attention to the counterfactual assumptions on which a projection is conditioned. Many models abstract from spontaneous or endogenous changes to social interactions, and do not distinguish between policy decisions and their full implementation. This abstraction, naïvely speaking, gets something "wrong" about the world: policy decisions do not directly cause infection rates to drop but rather do so only by having an effect on individuals' behaviors (such as the number and kind of contacts people have). Moreover, there is evidence that people do and did adjust their behavior, not only in response to policy interventions, but also in response to information about the spread of the virus (Gupta, Simon, and Wing 2020; see Van Basshuysen et al. 2021 for discussion). Because SIR models do not incorporate these factors, the Stanford economist John Cochrane claims they are "completely and totally wrong" (Cochrane 2020). Yet this criticism has force only if the highly idealized and abstract models were indeed meant to provide fully accurate representations of and predictions for the evolution of social interactions.

As a second example, consider Winsberg, Brennan, and Surprenant (2021), who criticize the CovidSim model in "Report 9" (Ferguson et al. 2020) for claiming that the pandemic could result approximately two million deaths in the United States, maintaining that this claim is wildly exaggerated and overly pessimistic. Yet it is not the case that CovidSim "predicted 2.2 million deaths in the US by August 2020 without strict mitigation measures" (Winsberg, Brennan, and Surprenant 2021, 433). Rather, the model projected approximately two million total deaths in the United States "in the (unlikely) absence of any control measures or spontaneous changes in individual behaviour" (Ferguson et al. 2020, 6). This number was, therefore, a projection for a do-nothing, worst-case scenario under the counterfactual assumption that *nobody adjusts their behavior at all* in response to the spread of the virus (see also Van Basshuysen and White 2021a). This projection functions as a counterfactual limiting case of the death toll under a completely uncontained spread of the virus—an unrealistic limiting case, as all parties agree, but one that may nevertheless play a role in anchoring our perceptions of the severity of the threat posed by the virus.

While the distinction between predictions and projections is important, it is not as sharp as is sometimes suggested, since all models are, in some sense, projections. Since all models involve idealizations and abstractions, and no model provides a complete and completely accurate representation of the actual system modeled, all models make what invariably will involve non-actual, counterfactual assumptions about the structure and dynamics of a system, and then project how quantities characterizing the system will evolve under these assumptions. A projection can be used as a prediction, if we take the idealizations and abstractions to be such that, in a given context and for a particular purpose, the model's projections allow us to make predictive inferences about the values of certain quantities in the actual world. It is thus a mistake to criticize a model projection simply by pointing out that the model's structure and parameters do not fully or accurately represent the actual world. But we may criticize a projection for its failure to match an actual outcome to a certain degree of accuracy, if the modeling inputs and the model's structure are intended to adequately represent certain features of an actual system to this degree of accuracy. It is therefore crucial in evaluating a model to pay careful attention to the (counterfactual) modeling assumptions and to evaluate these in the context of the model's intended use.

What degree of accuracy could we have reasonably demanded of epidemiological models, especially near the beginning of the pandemic in 2020? The models' critics are surely right that many of the parameter choices in the models were not constrained by empirical evidence and that the values of these parameters were (and in many cases still are) deeply uncertain. In the absence of strong empirical constraints for parameter choices many modeling choices had to be based on *expert judgment*. Yet these judgments did not have the character of random guesses, since epidemiologists had prior experience modeling epidemics, compartment models had been widely used, and the Imperial College's agent-based model CovidSim was not a new model (originally having been developed to model a flu outbreak in Southeast Asia).

Moreover, by March 2020, preliminary evidence on how SARS-CoV-2 spreads was available, allowing for somewhat empirically constrained choices of many of the modeling parameters. Thus, a model by the London School of Hygiene & Tropical Medicine (LSHTM) developed independently at around the same time as CovidSim (and discussed by SAGE on

16 March 2020) reached qualitatively similar conclusions (Davies et al. 2020).[11] To be sure, modeling results that had to rely heavily on expert judgment are clearly less credible than results based on more tightly empirically constrained inputs. Given the dearth of empirical data on SARS-CoV-2, especially during the first months of 2020, it would have been a mistake to treat model outputs as offering numerically precise predictions of infections and fatalities, or of the strengths of the causal effects of non-pharmaceutical interventions on these rates. But this does not mean that modeling predictions had no epistemic relevance. Rather, instead of taking models as sources of precise quantitative predictions, modelers and policymakers were justified in taking model outputs to provide coarse-grained, order-of-magnitude, or qualitative information about the spread of SARS-CoV-2, and to underwrite qualitative conclusions such as the claim that only suppression, and not mitigation, can prevent hospital resources from being overwhelmed (see Birch 2021).

We see here one possible role for projections in policy advice, since this conclusion cannot merely be based on a single prediction but requires a comparison of different projections with different input parameters. More generally, policy deliberations require exploring projections of the consequences of different (counterfactual) policy choices. Comparing different projections that result from varying the value of some parameter may also be part of a sensitivity or robustness analysis. If we are uncertain about the value of a particular input parameter in a model, it is important to know how sensitive the model output is to variations in the value of this parameter. If the output of a model does not vary significantly with changes in the value of a parameter, it is less problematic if the actual value of this parameter is not well constrained empirically. For example, Wouter Edeling et al. (2020) show that the CovidSim model is particularly sensitive to variations in just three parameters,[12] and that variations in these parameters' values are very likely to result in projections of the same order of magnitude. This suggests that CovidSim is a useful tool for making order-of-magnitude projections even if more fine-grained predictions were not reliable.

Yet another purpose for projections is to yield information about causal structures or mechanisms. Consider compartment models, which are merely dynamical models consisting of a number of equations governing how the sizes of the different compartments change with time. Read as standard mathematical equations, they inform us how values of quantities co-vary but not which change in the values of a quantity causes what other change. But, if they can be given a causal interpretation, counterfactual manipulations of compartment models can be used to help judge the causal effectiveness of different interventions for preventing infections (see also Fuller 2021) and can thereby be relevant to decision-making, even when the precise strengths of these effects are not known.

As long, then, as we attend carefully to the purposes to which models can be put, and the type of information that we can draw from their projections when inputs are not empirically well constrained, Covid-19 models could indeed provide legitimate public policy guidance during the early months of the pandemic.

[11] Thanks to an anonymous reviewer for bringing this paper to our attention.
[12] The parameters representing the length of the latent period in which a patient has no symptoms and is not infectious; a parameter representing the delay to start case isolation; and a parameter capturing the effectiveness of social distancing.

5. Conclusion

We have attempted to provide a defense of governments' initial decisions to impose lockdowns (in affluent countries with certain features) in three stages. First, focusing particularly on the United Kingdom, we presented the evidence available (and drawn upon) in reaching this decision, suggesting that the government had some grounds to believe that instituting lockdown measures was an immediately required means of reducing R to less than 1, and thereby avoiding the collapse of the healthcare system. We suggested that although little was known about the potential adverse effects of such measures, there was also reason to believe that this initial decision would not result in harms outweighing unmitigated viral spread since some potential detrimental economic effects were already being experienced prior to official lockdown measures, many detrimental effects could be mitigated, to a degree, by further policy measures, and the decision could be revised or revoked as evidence of harm emerged.

We then turned to two objections to making such a drastic policy decision on this admittedly uncertain evidential basis. First, we addressed the concern that it is not justifiable to restrict people's liberty on such tentative grounds, arguing that the risk of harm provided justification for restricting liberty, and that the urgency of the situation allowed for a relaxation of the normally high epistemic standards required to establish the exact magnitude of this risk. Then, we addressed the contention that the modeling evidence that formed a key underpinning of policy decisions was too poor to function as a guide for policy. Although critics may be correct in maintaining that the models were constructed on the basis of limited and uncertain evidence, and that this can undermine their ability to give fine-grained predictions, we argued that poorly constrained epidemiological models can still function as a basis for policy advice, once we have a more nuanced idea of the purposes for which they can be used: they can underwrite qualitative or order-of-magnitude inferences about the course of the pandemic and they can contribute to an understanding of the causal mechanisms governing the evolution of the spread of the virus. Although policymakers found themselves in uncharted territory, forced to make drastic decisions with far-reaching implications in uncertain conditions and under extreme time pressure, the availability of some legitimate, albeit tentative, evidence could justify the short-term imposition of lockdowns.

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References

Anderson, Roy M., T. Déirdre Hollingsworth, Rebecca F. Baggaley, Rosie Maddren, and Carolin Vegvari. 2020. "COVID-19 Spread in the UK: The End of the Beginning?" *The Lancet* 396, no. 10251: 587–590. https://doi.org/10.1016/s0140-6736(20)31689-5.

Armocida, Benedetta, Beatrice Formenti, Silvia Ussai, Francesca Palestra, and Eduardo Missoni. 2020. "The Italian Health System and the COVID-19 Challenge." *Lancet Public Health* 5, no. 5, e253. https://doi.org/10.1016/S2468-2667(20)30074-8.

Atkinson, Paul, Nina Gobat, Suzannah Lant, Hayley E. Mabelson, Caitlin Pilbeam, T. Solomon, Sarah Tonkin-Crine, and Sally Sheard. 2020. "Understanding the Policy Dynamics of COVID-19 in the UK: Early Findings from Interviews with Policy Makers and Health Care Professionals." *Social Science & Medicine* 266, 113423. https://doi.org/10.1016/j.socscimed.2020.113423.

Bartik, Alexander, Marianne Bertrand, Zoe Cullen, Edward L. Glaeser, Michael Luca, and Christopher Stanton. 2020. "The Impact of COVID-19 on Small Business Outcomes and Expectations." *Proceedings of the National Academy of Sciences* 117, no. 30: 17656–17666. https://doi.org/10.1073/pnas.2006991117.

BBC. 2020. "Coronavirus: UK Schools, Colleges and Nurseries to Close from Friday." 18 March. https://www.bbc.com/news/uk-51952314 (accessed 29 August 2021).

Begley, Sharon. 2020. "Influential Covid-19 Model Uses Flawed Methods and Shouldn't Guide U.S. Policies, Critics Say." *Stat News,* 17 April. https://www.statnews.com/2020/04/17/influential-covid-19-model-uses-flawed-methods-shouldnt-guide-policies-critics-say/ (accessed 31 August 2021).

Birch, Jonathan. 2021. "Science and Policy in Extremis: The UK's Initial Response to COVID-19." *European Journal for the Philosophy of Science* 11, no. 90: 1–27. https://doi.org/10.1007/s13194-021-00407-z.

Boseley, Sarah. 2020. "New Data, New Policy: Why UK's Coronavirus Strategy Changed." *The Guardian,* 16 March. https://www.theguardian.com/world/2020/mar/16/new-data-new-policy-why-uks-coronavirus-strategy-has-changed (accessed 1 March 2021).

Brennan, Jason. 2018. "A Libertarian Case for Mandatory Vaccination." *Journal of Medical Ethics* 44, no. 1: 37–43. https://doi.org/10.1136/medethics-2016-103486.

Broadbent, Alex. 2020. "Lockdown Is Wrong for Africa." *Mail & Guardian,* 8 April. https://mg.co.za/article/2020-04-08-is-lockdown-wrong-for-africa/ (accessed 30 August 2021).

Cartwright, Nancy. 1983. *How the Laws of Physics Lie*. Oxford: Oxford University Press.

Childress, James F., Ruth R. Faden, Ruth D. Gaare, Lawrence O. Gostin, Jeffrey Kahn, Richard J. Bonnie, Nancy E. Kass, Anna C. Mastroianni, Jonathan D. Moreno, and Phillip Nieburg. 2002. "Public Health Ethics: Mapping the Terrain." *Journal of Law, Medicine, and Ethics* 30, no. 2: 170–178. https://doi.org/10.1111/j.1748-720x.2002.tb00384.x.

Chin, Vincent, Noelle I. Samia, Roman Marchant, Ori Rosen, John P.A. Ioannidis, Martin A. Tanner, and Sally Cripps. 2020. "A Case Study in Model Failure? COVID-19 Daily Deaths and ICU Bed Utilisation Predictions in New York State." *European Journal of Epidemiology* 35, no. 8: 733–742. https://doi.org/10.1007/s10654-020-00669-6.

Cochrane, John. 2020. "An SIR Model with Behavior." *The Grumpy Economist,* 4 May. https://johnhcochrane.blogspot.com/2020/05/an-sir-model-with-behavior.html (accessed 31 August 2021).

Correia, Sergio, Stephan Luck, and Emil Verner. 2020. "Pandemics Depress the Economy, Public Health Interventions Do Not: Evidence from the 1918 Flu." *SSRN,* 5 June. https://doi.org/10.2139/ssrn.3561560.

Dahlquist, Marcus and Henrik Kugelberg. 2021. "Public Justification and Expert Disagreement over Non-Pharmaceutical Interventions for the COVID-19 Pandemic." *Journal of Medical Ethics*. Published online first: 12 October. http://dx.doi.org/10.1136/medethics-2021-107671.

Davies, Nick, Adam Kucharski, Ross Eggo, and John Edmunds. 2020. "The Impact of Aggressively Managing Peak Incidence." Report from the London School of Hygiene & Tropical Medicine (LSHTM), 11 March. https://www.gov.uk/government/publications/the-impact-of-aggressively-managing-peak-incidence-11-march-2020 (accessed 5 January 2022).

Edeling, Wouter, Hamid Arabnejad, Robert C. Sinclair, Diana Suleimenova, Krishnakumar Gopalakrishnan, Bartosz Bosak, Derek Groen, et al. 2020. "Model Uncertainty and Decision Making: Predicting the Impact of COVID-19 Using the CovidSim Epidemiological Code." Preprint. *Research Square*. https://doi.org/10.21203/rs.3.rs-82122/v3.

Farrar, Jeremy and Anjana Ahuja. 2021. *Spike: The Virus vs the People – the Inside Story*. London: Profile Books.

Feinberg, Joel. 1984. *Harm to Others: The Moral Limits of Criminal Law*. Oxford: Oxford University Press.

Ferguson, Neil M., Daniel Laydon, Gemma Nedjati-Gilani, Natsuko Imai, Kylie Ainslie, Marc Baguelin, Sangeeta Bhatia, et al. 2020. "Report 9: Impact of Non-Pharmaceutical Interventions (NPIs) to Reduce COVID-19 Mortality and Healthcare Demand." Report from Imperial College COVID Response Team, 16 March. https://doi.org/10.25561/77482.

Flanigan, Jennifer. 2014. "A Defense of Compulsory Vaccination." *HEC Forum* 26, no. 1: 5–25. https://doi.org/10.1007/s10730-013-9221-5.

Friedman, Joseph, Patrick Liu, Christopher E. Troeger, Austin Carter, Robert C. Reiner Jr., Ryan M. Barber, James Collins, et al. 2021. "Predictive Performance of International COVID-19 Mortality Forecasting Models." *Nature Communications* 12, no. 1, 2609. https://doi.org/10.1038/s41467-021-22457-w.

Frowe, H. 2020. "Is Staying Home Really about Saving Lives?" *CAPX,* 14 May. https://capx.co/is-staying-at-home-really-about-saving-lives/ (accessed 25 August 2021).

Fuller, Jonathan. 2021. "What Are the COVID-19 Models Modeling (Philosophically Speaking)?" *History and Philosophy of the Life Sciences* 43, no. 47: 1–5. https://doi.org/10.1007/s40656-021-00407-5.

Gardiner, Stephen. 2006. "A Core Precautionary Principle." *Journal of Political Philosophy* 14, no. 1: 33–60. http://dx.doi.org/10.1111/j.1467-9760.2006.00237.x.

Gupta, Sumedha, Kosali I. Simon, and Coady Wing. 2020. "Mandated and Voluntary Social Distancing during the COVID-19 Epidemic: A Review." National Bureau of Economic Research Working Paper No. 28139. https://doi.org/10.3386/w28139.

Hansson, Sven Ove. 2003. "Ethical Criteria of Risk Acceptance." *Erkenntnis* 59, no. 3: 291–309. https://doi.org/10.1023/A:1026005915919.

IHME COVID-19 Health Service Utilization Forecasting Team (Christopher J.L. Murray). 2020. "Forecasting the Impact of the First Wave of the COVID-19 Pandemic on Hospital Demand and Deaths for the USA and European Economic Area Countries." Preprint. *medRxiv,* 26 April. https://doi.org/10.1101/2020.04.21.20074732.

Ioannidis, John P.A. 2020. "The Totality of the Evidence." *Boston Review,* 26 May. https://bostonreview.net/science-nature/john-p-ioannidis-totality-evidence (accessed 25 August 2021).

John, Stephen D. and Emma Curran. 2021. "Costa, Cancer and Coronavirus: Contractualism As a Guide to the Ethics of Lockdown." *Journal of Medical Ethics*. Published online first: 19 March. https://doi.org/10.1136/medethics-2020-107103.

Kucharski, Adam J., Timothy W. Russell, Charlie Diamond, Yang Liu, CMMID nCoV Working Group, John Edmunds, Sebastian Funk, and Rosalind M. Eggo. 2020. "Early Dynamics of Transmission and Control of COVID-19: A Mathematical Modelling Study." Preprint. *medRxiv,* 18 February. https://doi.org/10.1101/2020.01.31.20019901.

Lau, Hien, Veria Khosrawipour, Piotr Kocbach, Agata Mikolajczyk, Justyna Schubert, Jacek Bania, and Tanja Khosrawipour. 2020. "The Positive Impact of Lockdown in Wuhan on Containing the COVID-19 Outbreak in China." *Journal of Travel Medicine* 27, no. 3: 1–7. https://doi.org/10.1093/jtm/taaa037.

Li, Ruoran, Caitlin Rivers, Qi Tan, Megan B. Murray, Eric Toner, and Marc Lipsitch. 2020. "The Demand for Inpatient and ICU Beds for COVID-19 in the US: Lessons from Chinese Cities." Preprint. *medRxiv*, 16 March. https://doi.org/10.1101/2020.03.09.20033241.

Moss, Peter, Gavin Barlow, Nicholas Easom, Patrick Lillie, and Anda Samson. 2020. "Lessons for Managing High-Consequence Infections from First COVID-19 Cases in the UK." *The Lancet* 395, no. 10227: e46. https://doi.org/10.1016/S0140-6736(20)30463-3.

Prime Minister's Office, UK. 2020. "Prime Minister's Statement on Coronavirus (COVID-19): 23 March 2020." https://www.gov.uk/government/speeches/pm-address-to-the-nation-on-coronavirus-23-march-2020 (accessed 25 August 2021).

Rawls, John. 1999. *A Theory of Justice*. Revised edition. Cambridge, MA: Harvard University Press.

Riou, Julien and Christian L. Althaus. 2020. "Pattern of Early Human-to-Human Transmission of Wuhan 2019 Novel Coronavirus (2019-nCoV), December 2019 to January 2020." *Euro Surveillance* 25, no. 4: 1–5. https://doi.org/10.2807/1560-7917.ES.2020.25.4.2000058.

SAGE (Scientific Advisory Group for Emergencies). 2020a. "Addendum to Seventeenth SAGE Meeting on Covid-19, 18 March 2020." https://www.gov.uk/government/publications/sage-minutes-coronavirus-covid-19-response-18-march-2020 (accessed 30 August 2021).

———. 2020b. "Addendum to the Tenth SAGE Meeting on Covid-19, 25 February 2020." https://www.gov.uk/government/publications/sage-minutes-coronavirus-covid-19-response-25-february-2020 (accessed 25 August 2021).

———. 2020c. "Potential Effect of Non-pharmaceutical Interventions (NPIs) on a Covid-19 Epidemic in the UK 26th February 2020." https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/887550/03-potential-effect-of-non-pharmaceutical-interventions-npis-on-a-Covid-19-epidemic-in-the-UK.pdf (accessed 25 August 2021).

———. 2020d. "Precautionary SAGE 1 Minutes: Coronavirus (COVID-19) Response, 22 January 2020." https://www.gov.uk/government/publications/precautionary-sage-minutes-coronavirus-covid-19-response-22-january-2020 (accessed 26 August 2021).

Schroeder, S. Andrew. 2021. "How to Interpret Covid-19 Predictions: Reassessing the IHME's Model." *Philosophy of Medicine* 2, no. 1. https://doi.org/10.5195/philmed.2021.43.

Sorell, Tom. 2003. "Morality and Emergency." *Proceedings of the Aristotelian Society*, 103, no. 1: 21–37. http://dx.doi.org/10.1111/j.0066-7372.2003.00062.x.

Van Basshuysen, Philippe and Lucie White. 2021a. "The Epistemic Duties of Philosophers: An Addendum." *Kennedy Institute of Ethics Journal* 31, no. 4: 447–451. https://doi.org/10.1353/ken.2021.0023.

———. 2021b. "Were Lockdowns Justified? A Return to the Facts and Evidence." *Kennedy Institute of Ethics Journal* 31, no. 4: 405–428. https://doi.org/10.1353/ken.2021.0028.

Van Basshuysen, Philippe, Lucie White, Donal Khosrowi, and Mathias Frisch. 2021. "Three Ways in Which Pandemic Models May Perform a Pandemic." *Erasmus Journal for Philosophy and Economics* 14, no. 1: 110–127. http://dx.doi.org/10.23941/ejpe.v14i1.582.

Verity, Robert, Lucy C. Okell, Ilaria Dorigatti, Peter Winskill, Charles Whittaker, Natsuko Imai, Gina Cuomo-Dannenburg, et al. 2020. "Estimates of the Severity of the COVID-19 Disease." Preprint. *medRxiv,* 13 March. https://doi.org/10.1101/2020.03.09.20033357.

Vorms, Marion and Ulrike Hahn. 2021. "In the Space of Reasonable Doubt." *Synthese* 198, suppl. 15: S3609–S3633. https://doi.org/10.1007/s11229-019-02488-z.

Walker, Patrick, Charles Whittaker, Oliver Watson, Marc Baguelin, Kylie E.C. Ainslie, Sangheeta Bhatia, Samir Bhatt, et al. 2020. "Report 12: The Global Impact of COVID-19 and Strategies for Mitigation and Suppression." Report from Imperial College COVID Response Team, 26 March. https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-12-global-impact-covid-19/ (accessed 25 August 2021).

Walzer, Michael. 1988. *Emergency Ethics*. Colorado: U.S. Airforce Academy.

White, Lucie and Philippe van Basshuysen. 2021a. "Privacy versus Public Health? A Reassessment of Centralised and Decentralised Digital Contact Tracing." *Science and Engineering Ethics* 27, no. 23: 1–13. https://doi.org/10.1007/s11948-021-00301-0.

———. 2021b. "Without a Trace: Why Did Corona Apps Fail?" *Journal of Medical Ethics* 47, no. 12: 1–4. https://doi.org/10.1136/medethics-2020-107061.

WHO (World Health Organization). 2020a. "Novel Coronavirus (2019-nCoV) Situation Report—3." 23 January. https://www.who.int/docs/default-source/Coronaviruse/situation-reports/20200123-sitrep-3-2019-ncov.pdf (accessed 25 August 2021).

———. 2020b. "Pneumonia of Unknown Cause—China." 5 January. https://www.who.int/csr/don/05-january-2020-pneumonia-of-unkown-cause-china/en/ (accessed 25 August 2021).

Winsberg, Eric, Jason Brennan, and Chris Surprenant. 2020. "How Government Leaders Violated Their Epistemic Duties during the SARS-CoV-2 Crisis." *Kennedy Institute of Ethics Journal* 30, no. 3–4: 215–242. https://doi.org/10.1353/ken.2020.0013.

———. 2021. "This Paper Attacks a Strawman but the Strawman Wins: A Reply to Van Basshuysen and White." *Kennedy Institute of Ethics Journal* 31, no. 4: 429–446. https://doi.org/10.1353/ken.2021.0029.

Wu, Joseph T., Kathy Leung, and Gabriel M. Leung. 2020. "Nowcasting and Forecasting the Potential Domestic and International Spread of the 2019-nCoV Outbreak Originating in Wuhan, China: A Modelling Study." *The Lancet* 395, no. 10225: 689–697. https://doi.org/10.1016/S0140-6736(20)30260-9.

Zhou, Peng, Xing-Lou Yang, Xian-Guang Wang, Ben Hu, Lei Zhang, Wei Zhang, Hao-Rui Si, et al. 2020. "A Pneumonia Outbreak Associated with a New Coronavirus of Probable Bat Origin." *Nature* 579, no. 7798: 270–273. https://doi.org/10.1038/s41586-020-2012-7.

Zhu, Na, Dingyu Zhang, Wenling Wang, Xingwang Li, Bo Yang, Jingdong Song, Xiang Zhao, et al. 2020. "A Novel Coronavirus from Patients with Pneumonia in China, 2019." *New England Journal of Medicine* 382, no. 8: 727–733. https://doi.org/10.1056/NEJMoa2001017.