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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, and focusing on the UK, looking at the evidence that undergirded the decision, second, arguing that this provided us with 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 policy-makers. 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 that we generally only regard as justifiable under a very narrow set of circumstances.

Decisions concerning pandemic control can now, over 18 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. Although we remain in an extraordinary position, the degree of uncertainty and seeming immediacy of the situation that marked the beginning of the pandemic, and the climate under which the initial policy decisions were made, posed a distinctive challenge. Is it possible, under these distinctive circumstances, to justify such drastic interventions at all? Here, we mount a defense of the initial imposition of "lockdowns", focusing particularly on the UK (whose decision-making process was particularly well documented), but that should extend to countries with similar features. By lockdowns, we mean combinations of policies aimed

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

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 can 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 sort of evidence available leading 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 damage exceeding any benefit. We will 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 mathematical modelling evidence that played a central role in motivating the imposition of lockdowns was so poor that it could not undergird policy decisions.

2. March 2020 – lead up to lockdown

On January 5, 2020, the World Health Organization (WHO) first reported an increase in cases of pneumonia, of unknown cause, in Wuhan, linked to a wholesale seafood and live animal market (WHO2020a). 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 infections in Wuhan, 80 of which had died (Zhou et al. 2020). The fatality rate of a new virus is always difficult to gauge, due to 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 from 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 UK group that played a crucial role in the eventual implementation of lockdown, held their first, "precautionary" meeting to discuss COVID-19 on January 22, noting some evidence of person-to-person transmission, but also emphasizing the uncertainty surrounding almost all aspects of the virus (Birch 2021; SAGE 2020a). By the end of January, estimates of the basic reproduction number of the virus indicated

[2] We'll get into more detail about the measures actually implemented in the UK below.

sustained human-to-human transmission (Wu et al. 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 US (WHO 2020b). The first two cases in the UK 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 exponentially in the UK, worries about the overburdening of the National Health Service (NHS) began to arise. On February 26, SAGE stated that "without action, the NHS will be unable to meet all demands placed on it", and that "[d]emand 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 bringing the reproduction number under 1. A key shift occurred in the SAGE meeting on March 18, precipitated by two main new pieces of evidence. While continuing to emphasise 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 2020d) – Italy, at the time, was the hardest hit country in Europe, and their healthcare system was close to collapse (Armocida et al. 2020). The second key piece of evidence was a report containing mathematical modelling 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 meeting, suggested that the current mitigation-based measures pursued by the UK 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 the reproduction number to under 1, must be pursued as soon as possible.

Although it's only alluded to in the March 18 meeting (SAGE 2020d), 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 February 25, SAGE noted that available evidence from Wuhan, Hong Kong and Singapore indicated that lockdown measures could reduce the reproduction number to 1, and suggested that such measures could be realistically implemented in the UK (SAGE 2020b). The notion that lockdowns could make a difference in staying within the bounds of ICU capacity also received further support by a study comparing Wuhan (which imposed lockdown late) with Guangzhou (which implemented

[3] The NHS also lacked sufficient personal protective equipment (PPE) – as 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, 3).

lockdown measures early) (Li et al. 2020), suggesting not just that lockdowns could play a pivotal role in keeping healthcare demand within capacity, but also emphasizing that the timing of the intervention is crucial. On March 18 SAGE notes that, although we cannot be sure that strict measures in pursuit of epidemic suppression are necessary, "[i]f the interventions are required, it would be better to act early" (2020d).

On the strength of Report 9, SAGE recommended school closures (2020d), which were implemented across much of the UK on 20 March (BBC 2020). The rest of the suppression-based recommendations in Report 9 were also adopted as policy by the UK government immediately after the release of this report (Boseley 2020; van Basshuysen and White forthcoming). 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 may leave their homes were mandated on March 23, with fines imposed for non-compliance (Gov.UK 2020).

This, then, gives us a sense of the evidence marshalled in support of (or available to support) the initial institution of lockdowns in the UK. 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 pandemic (Correia et al. 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 et al. 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 where 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.

This, we must stress, applies only to affluent countries, similar to the UK, that 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). This 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 2021, forthcoming). 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 that 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, that the emerging evidence, particularly concerning the drastic difference that early action could effectuate, could justify the government's initial decision to take these unprecedented steps. But to properly defend this claim, we now turn to two objections to acting on this evidence. The first is an ethical concern with the circumstances under which these restrictions can be justified – that these tentative and uncertain grounds cannot constitute sufficient reason to restrict people's basic liberties. The second is an epistemic concern with the mathematical modelling evidence that formed important evidentiary support for these decisions – this evidence, some hold, was so poor, that it shouldn't be given any epistemic weight at all. Let's proceed, then, to each objection 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 et al. (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). In other words, 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, 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 will 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 will 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 will proceed by first looking at where restrictions of liberty are normally justified – when conduct causes harm to others (the "harm principle"). We will argue that going about one's daily business in a normally self-regarding way poses 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 will 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.

That is, 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 policy-making 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 onto 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—this would make the principle much too broad. We allow some exposure of others to risk all the time—we don't 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 "[e]xposure 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 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, he believes 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 – that is, measures targeted at specific individuals whom we judge as particularly likely to pose some risk (due to, for example, 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 the lack of these restrictions could in fact be mutually beneficial. [4] In exchange for being free to go about my daily business in a pandemic, 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 each other to risk, but within an equitable system that works to the advantage of all.

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 due to 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

[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 can't 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.

Flanigan 2014). Certain groups of people are at a much higher risk of serious complications or death,[5] and many might feel forced to isolate themselves in order to avoid taking on this risk. Activities that may be unavoidable, like grocery shopping, become more risky for these groups of people in this environment, with no corresponding benefit. 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, 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, 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. When we take these additional risks into account, it becomes even less plausible that this exposure to risk ultimately should be regarded as working to each person's *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 Mars, and thus no means of gauging the risk they do in fact pose. But we might want to be a bit more stringent than this, and say that people should indeed avoid exposing others to risk of serious harm, and that this can justify state interference with liberty, but only when we have good grounds to believe that there is in fact a serious risk. Perhaps, we might further think, we lacked sufficient evidence, at the start of the pandemic, to gauge the level of risk that the virus did in fact pose, and thus the evidence to justify 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 health care systems. But the evidence at this time was emerging, and uncertain. Although, by the

[5] A potential problem here - the fact that we were not sure about the magnitude of the risk posed - will be discussed presently.

time that the decision to implement lockdown measures was made in the UK 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" (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 due to the magnitude and nature of these risks, we cannot think of the 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 policy-makers have an epistemic duty to gather more evidence, and to establish these conclusions to a higher degree of certainty, before making such radical decisions?

While positing this as an epistemic duty might make sense in normal circumstances, it is difficult to maintain that we should uphold such a duty under these particular circumstances. The admittedly limited evidence available to us in early March suggested not just risk of potentially serious consequences, but that this risk was *imminent*—and the imminence of danger might require acting upon different norms to those that apply in regular circumstances (see Walzer 1988). Here, this might require the revision of our usual epistemic norms (cf. Birch 2021). The reason for this is obvious—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. There was some evidence in March 2020, as documented in the previous section, to suggest that immediate action was required in order to avoid hospital systems being overwhelmed, and even small decision-making delays would make it impossible to avoid this outcome. There must be some legitimate provision, when we have reason to believe that harm is imminent, to act on the evidence available to us, or we have no means of acting quickly when it is the only way of avoiding catastrophic consequences.[6]

[6] Clearly any departure from these norms is something that must be taken seriously – we should of course be concerned about the abuse of emergency powers, particularly by governments that keep such measures in place long

This, of course, does not suggest that policy makers have no further duties to continue to gather evidence, both about the danger they are responding to, and the impact of implemented policy measures.[7] This was emphasized by epidemiologist John Ioannidis, who became a leading figure in the US in calls for caution concerning lockdowns, and the need for more and better data (more on this below). Despite this, however, Ioannidis maintained that "I think lockdown was justified as an initial response, given what little we knew about this new virus" (2020). This displays, we contend, 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 policy-makers' 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 2021, forthcoming), 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 policy-makers 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 which 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 policy-makers) was evidence based on epidemiological models. Some researchers, however, have criticized the use of these models in policy decisions so

term. But that does not mean we can do away with extraordinary provisions for extraordinary circumstances entirely (see Sorell 2003, also Brennan 2018 for a similar argument about government failure).

[7] One analogy provided by Winsberg et al. in their defense of high epistemic standards is of holding a suspect for an extended period of time without sufficient evidence for a conviction. We might see the initial imposition of lockdown, to extend this analogy, as akin to holding someone for 24 hours before bringing charges against them – arguably justifiable in the short term as necessary evidence is gathered – but only justifiable longer term where adequate evidence can be provided and accepted through the appropriate channels.

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 policy-makers, the data that are input into the models will have been shown to be reliable, and models will only be used for purposes for which their adequacy has been well-confirmed. But last March, when governments in many countries were faced with the difficult question 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 so-called 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 too inadequate for modeling results to be passed on to policy-makers, 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). Winsberg et al. 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" (2020, 229). Was the evidence provided by models then 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 will survey the different kinds of evidence that models are able to provide and argue that, contrary to what the critics charged, 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 while exhibiting some of the putative flaws to which the 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, so-called "SIR" or "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 *s*usceptible", "*i*nfectious", "*r*emoved/*r*ecovered", and, in the case of SEIR models, also the "*e*xposed" 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 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 UK—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 levied 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 are *data-driven* models; less theoretical models that essentially engage in curve-fitting, i.e. plotting a curve to fit what are generally very large data-sets to predict the course of the pandemic. The IHME model (IHME COVID-19 health service utilization forecasting team 2020) that was used as a basis for some national policy decisions in the U.S. (Begley 2020) is such a data-driven model. One challenge in the application of such models is to determine the conditions under which the output of a model that is 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 a guide for public policy? The models' critics tend to compare model outcomes with the actual epidemic outcomes and conclude from a poor fit that models fail (see e.g Cochrane 2020; Friedman et al. 2021; Winsberg et al. forthcoming). 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 a by now well-rehearsed point that every model idealizes its target system in certain respects and abstracts from some of the target system's properties (see e.g. 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 of 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 a particular choice 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.

Now, 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, naively 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 (see Gupta et al. 2020). Because SIR models do not incorporate these factors, the Stanford economist 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 et al. (forthcoming), who have criticized the CovidSim model in Report 9 (Ferguson et al 2020) for claiming that the pandemic could result approximately two million deaths in the U.S., 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" (forthcoming, 4) as Winsberg et al. claim. Rather, the model projected approximately 2 million total deaths in the US "In the (unlikely) absence of any control measures or spontaneous changes in individual behaviour" (Ferguson et al. 2020, 6). That is, this number was 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 2021). 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 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 evaluate these in the context of the models' intended use.

What degree of accuracy could we have reasonably demanded of epidemiological models, especially toward the beginning of the pandemic in 2020? The models' critics are surely right that many of the parameter choices in the models were not well-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 were not mere 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 originally to model a flu outbreak in Southeast Asia).

Moreover, by March 2020, preliminary evidence on how SarsCov-2 spreads was available, allowing for somewhat empirically constrained educated guesses of many of the modeling parameters. To be sure, modeling results that had to rely heavily on educated guesses and expert judgment are clearly less credible than results based on more tightly empirically constrained inputs. Given the dearth of empirical data on SarsCov-2, especially during the first months of 2020, it would have been a mistake to treat model outputs as offering numerically precise predictions of infection and fatality rates, 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 policy makers were warranted 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 like "only suppression, and not mitigation, can prevent hospital resources from being overwhelmed", as Jonathan Birch has suggested (in conversation).

We see here one possible role for projections in policy advice, since Birch's 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, then 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, then it is less problematic if the actual value of this parameter is not well constrained empirically. For example, (Edeling et al. 2020) show that the CovidSim model is particularly sensitive to variations in just three parameters[8] and that variations in these parameters' values are very likely to result in projections of the same order of magnitude. This

[8] 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.

suggests that CovidSim is a useful tool for making order-of-magnitude projections even if more fine-grained predictions were not to be reliable.

Yet another purpose for projections is to yield information about causal structures or mechanisms. Consider compartment models. In the first instance compartment models 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 decision relevant, 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.

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 UK, 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 the viral reproduction number to under 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, due to the fact that some potential detrimental economic effects were 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 modelling 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. Namely, 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 policy-makers found themselves in uncharted territory, forced to make drastic decisions with far-reaching implications under uncertainty and extreme time pressure, the availability of some legitimate, albeit tentative, evidence meant that they did not make these decisions completely blind.

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