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How to Interpret Covid-19 Predictions: Reassessing the IHME's Model

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Abstract

The IHME Covid-19 prediction model has been one of the most influential Covid models in the United States. Early on, it received heavy criticism for understating the extent of the epidemic. I argue that this criticism was based on a misunderstanding of the model. The model was best interpreted not as attempting to forecast the actual course of the epidemic. Rather, it was attempting to make a conditional projection: telling us how the epidemic would unfold, given certain assumptions. This misunderstanding of the IHME's model prevented the public from seeing how dire the model's projections actually were.

At a White House press briefing on 29 March 2020, Dr Deborah Birx cited a new Covid-19 model, which closely matched the government's in-house predictions. The model she was referring to, developed at the Institute for Health Metrics and Evaluation (IHME), quickly became one of the most cited and relied-upon Covid models in the United States. Within weeks, though, the IHME model had come under heavy criticism. A *Politico* headline declared that the "overly optimistic" model had "distorted [the] Trump team's coronavirus response" (Cancryn 2020). And *Vox* even more bluntly announced: "This coronavirus model keeps being wrong. Why are we still listening to it?" (Piper 2020). Although these criticisms of the model were simple and straightforward, assessing them turns out to be a complicated task. But it is a valuable one because it can reveal an important failure in the way the public and policymakers interpreted the IHME model—a failure also seen in the public discussion of other Covid models, including the Imperial College Model (Tufekci 2020).

Let's begin by understanding the main criticisms of the IHME's model as it stood in early April. At that point, the model was predicting that the first wave of the epidemic would slow by late April and end in May, resulting in a total of about 60,000 Covid deaths (IHME

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2020).[1] But by late April it became clear that the United States would exceed this figure and that the epidemic was nowhere near under control. The obvious conclusion to draw was that the IHME model had failed.

A closer look, however, suggests this conclusion was too hasty.[2] As a number of commentators have noted, the IHME model incorporated the surprising assumption that "full social distancing" would be maintained until 30 May. The model's FAQ clarified that "full social distancing" included strict stay-at-home orders, full school closures, closure of all non-essential businesses, and severe travel limitations. The model assumed that any of the country's states that had not yet imposed such restrictions would do so within seven days, maintaining them until 30 May.

Anyone paying attention to the political climate in the United States in April 2020 had to know that this assumption was unrealistic. Much of the country never had a lockdown of the sort the model assumed and few of the places that did showed an appetite to continue strict measures for two months. Why, then, did the IHME build such an unrealistic assumption into its model?

One possibility—the one that most commenting on the model seemed to accept—is that the IHME just made a horrible mistake. They had not realized that the United States was unlikely to mount a response like New Zealand's. That doesn't strike me as likely, though. The IHME is a major research centre that frequently collaborates with governments and non-governmental organizations. I doubt that they would be so politically naive. It seems more likely that the IHME knew this assumption was improbable but built their model around it anyway.

But why would they do that? Why would they build their model around an assumption that they did not expect to prove true? To answer this question, we need to distinguish between two different things that models can do (Adams 2020a, 2020b; Tufekci 2020). One thing a model can do is attempt to predict how the world will actually turn out. This is what a weather forecasting model typically does: it tries to tell us what temperature or how much rain to expect over the next few days. And it is what many economic forecasting models do, trying to predict what will happen to unemployment or oil prices next month. In the epidemiology and demography literature, these are typically called forecasts or simply predictions (Keyfitz 1972).

A second, very different thing a model can do is attempt to predict how things will turn out, given certain conditions or assumptions. A weather model, for example, might predict of some hurricane that *if* it makes landfall, its intensity will diminish. And an economic model might predict that *if* a particular energy policy is enacted, oil prices will fall. Note that in these cases there is no implication that the condition or assumption is likely to prove true. There is nothing odd, for example, about saying, "The hurricane will probably remain at sea and intensify. However, if it does make landfall, its intensity will diminish." Or, "We don't expect the current government to enact the proposed energy policy but if it did, our model predicts that oil prices would fall." In the epidemiology and demography literature, claims of this sort are typically called projections (Keyfitz 1972). Because the terminology is unclear and varies by discipline (contrast Kirtman et al. 2013, 958), I will refer to them as

[1] The IHME model has changed in important ways since April. Much of what I have to say here does not apply to subsequent versions of the model. I focus exclusively on the early April model because that is the one that was on the receiving end of those criticisms and because that was the version of the model used to make critical policy decisions in the early stages of the epidemic.

[2] One defence of the IHME model might point to the (very large) uncertainty estimates provided around the point estimate of 60,000. I won't pursue that argument because the observations I make below reveal a more fundamental misunderstanding of the model.

conditional projections—in contrast to forecasts, which attempt to make unconditional predictions about the future.

How, then, should we interpret the IHME model? Was it attempting to *forecast* Covid deaths? Or was it making a *conditional projection* of Covid deaths? The matter isn't entirely clear. Public statements from members of the IHME team suggest that they thought of the model as forecasting deaths. When faced with criticism, for example, the IHME's director Christopher Murray said, "We were willing to make a forecast." He cited outputs from the model that did prove accurate and expressed surprise that most states did not institute distancing measures of the sort the model assumed (Cancryn 2020). Some of the documentation associated with the model tells a similar story. The model's FAQ uses the language of "forecasting" and says the model was created to "help hospitals and health care systems prepare for the surge of Covid-19 patients over the coming weeks" (IHME 2020).

Set against this, however, several core features of the model and its documentation suggest that it is best interpreted as making conditional projections. Most importantly, the heading on the model's website read, "Covid-19 projections assuming full social distancing through May 2020." The explicit identification of a condition in the title (full social distancing through May 2020) strongly suggests the model is making a conditional claim. A similar framing can be found in papers the IHME wrote describing the model. In one, for example, the structured abstract identifies their research question this way: "Question. *Assuming social distancing measures are maintained*, what are the forecasted … number of deaths from the Covid-19 pandemic for each state in the United States?" (IHME and Murray 2020; emphasis added). Furthermore, whereas the IHME explains in great detail the source and basis for many elements of the model, they don't make any effort to argue that all states will in fact quickly institute distancing measures.[3] You would expect to find such arguments in a forecasting model, since the truth of that assumption would be critical to an accurate forecast. But you wouldn't necessarily expect them in a conditional projection model, since conditional projections commonly explore scenarios without regard for their likelihood.

For all of these reasons, it seems to me that the early April IHME model is best interpreted as offering conditional projections: projections of what would happen *if* long-term social distancing measures were put in place. And the case for that interpretation gets even stronger in context. Very early in the epidemic it became clear that many state and federal officials were reluctant to institute strict distancing measures. From that point, there remained little reason to interpret a model that assumes such measures—and explicitly draws attention to that assumption—as offering an unconditional forecast. For comparison's sake, imagine an economic model titled, "Economic Projections, Assuming Trump Wins Re-election." Whatever the beliefs, intentions, or public statements of the modellers, it would make little sense to interpret such a model as offering an unconditional prediction once polling made it clear that Trump was unlikely to be re-elected. From that point forward, the right way to use such a model would be as a source of conditional projections, as telling us what would happen *if* Trump were re-elected.

Understanding the IHME model as one that conditionally projected Covid deaths is crucial to properly interpreting it and it puts public discussions surrounding it in a very different light. First, although there may be other grounds for criticizing the model, we can't

[3] The associated paper simply says: "In this study we do include a covariate meant to capture the timing of social distancing measures to take into account that Wuhan instituted 4 out of 4 social distancing measures within 6 days of reaching a threshold death rate of 0.31 per million" (IHME and Murray 2020). But the paper never argues or even claims that the United States *will* institute similar measures and indeed cautions that the model's results will not be valid "if social distancing policies are not vigorously implemented and enforced across all states."

criticize it simply because the death toll has turned out to be far higher than what the model projected. The model told us how many Covid deaths the United States would see if the country implemented strict social distancing measures. Since it didn't do that, the actual death toll can't prove the model wrong. Even though the actual Covid death toll in the United States had passed 100,000 before the end of May 2020, it still may be true that the Covid death toll would have been 60,000, if the whole country had enacted strict social distancing measures.[4]

Second, the model can't be used to determine whether to relax social distancing measures or to institute less strict social distancing measures. The IHME model made a projection concerning one scenario: long-term, strict social distancing measures. It made no projections about what would happen in other scenarios. Thus, when the White House cited the model to recommend a short extension of distancing measures that fell far short of those assumed in the model (White House 2020), that was a misuse of the model.

At this point, one might wonder about the utility of models like the IHME's that make only conditional projections—indeed, conditional projections about unlikely scenarios. Wouldn't it have been wiser for the IHME to use its considerable resources and expertise to attempt to predict the *actual* course of the epidemic? Not necessarily. Forecasts and conditional projections both provide critical information for decision-makers. But they are typically useful for different types of decisions.

For some purposes, decision-makers ideally want forecasts. If I am a hospital administrator responsible for acquiring ventilators, I ultimately want to know how many patients are actually going to need ventilators—not how many would need them in some merely possible scenario.[5] If I am a restaurant owner making staffing decisions, I want a prediction of when it will actually be safe to reopen—not a projection of when it would be safe to reopen if distancing measures were enforced.

But if I am a policymaker deciding whether to enact distancing measures (or any other policy intended to slow the spread of Covid) I don't want a forecast. Here's why: a forecasting model will need to, at least implicitly, make some assumption about what decisions I will make concerning distancing measures. A model forecasting future Covid deaths in California, for example, must take a guess at whether the governor of California will implement and enforce distancing measures, because his decisions will impact the forecast. If he is going to enforce distancing measures, the model should forecast a lower number of deaths. If he isn't, the model should forecast a higher number of deaths. Because forecasting models must build in assumptions about what distancing measures policymakers will implement, they are not very useful for policymakers trying to make those decisions.

What those policymakers can benefit from are conditional projections: for example, projections about what will happen if they implement distancing measures, combined with projections about what will happen if they don't. Such conditional models don't aim to tell decision-makers what will happen; their job is to spell out what would happen under different scenarios, so that decision-makers can choose what path to embark upon.

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[4] The experience of other countries that did take aggressive action suggests that that whether or not this projection was correct, it wasn't unreasonable. Germany, for example, which has a population about a quarter of that of the United States, saw 9,000 deaths by the end of its first wave. So, it seems entirely possible that universal adoption of strict social distancing measures could have kept the death toll in the United States to 60,000 through the first wave.

[5] As noted above, the IHME model was originally developed to help nearby hospitals predict resource needs. A forecast would indeed be best for that purpose. The IHME is based in Seattle, however—a region that did institute strict social distancing measures early on. So, for the hospitals in that region, the IHME's conditional projections may have been equivalent to a forecast.

Of course, decision-makers don't simply have two options, to implement strict distancing measures or not. They have a wealth of intermediate options. Ideally, decision-makers would have conditional projections for all of the options at their disposal. Because of the way it was constructed, the early IHME model was not capable of providing this range of conditional projections.[6] (More recent iterations of the model have provided projections covering a range of scenarios: one involving near-universal mask use, one in which distancing mandates are steadily eased, and an intermediate scenario where mandates may be eased but are reimposed whenever Covid deaths reach a threshold level.) But the early IHME model was still valuable, in that it provided decision-makers with one important piece of information—an estimate of what would result if they instituted strict, long-term distancing measures.

This information, in fact, can be valuable for a variety of purposes beyond the immediate decision about whether to implement distancing measures. For example, if the IHME's conditional projection was accurate, it can tell us how many Covid deaths resulted from the failure to enact strict distancing measures. The IHME's model asserted that with distancing measures, the United States would have seen approximately 60,000 Covid deaths by the end of May 2020. In fact, there were 107,000 Covid deaths by the end of May. Thus, if the model was accurate, the cost of failing to enact distancing measures was about 47,000 Covid deaths through the end of May.[7] (Failing to enact distancing measures almost certainly led to a much greater cost past the end of May but since the model didn't project any possible second wave, it is harder to use the model to precisely assess that cost.)

Stepping back from the specifics of the IHME model, this episode reinforces the challenges involved with interpreting scientific models—a topic that has received a great deal of recent attention.[8] The difference between forecasts and conditional projections can be especially tricky because they look the same. A model that outputs deaths tied to points in time might be making a forecast (how many deaths to *actually* expect on those dates), or it might be making a conditional projection (how many deaths we *would* see on those dates, given a particular assumption). Typically, the only way to tell the difference is to look carefully at the documentation associated with the model. This is, unfortunately, something that even researchers often fail to do.[9]

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[6] The early IHME model took a "curve-fitting" approach. Essentially, it looked at the trajectory of Covid in affected populations before it struck the United States (especially China and Italy) and then attempted to determine where along that "curve" the United States outbreak was. Since, globally, the populations that experienced early Covid hotspots responded by enacting strict distancing measures, the IHME model was essentially projecting the United States outbreak by comparing it to the trajectory of outbreaks in places that enacted strict distancing measures. Thus, the IHME model was best suited to project a scenario in which the United States enacted strict distancing measures.

[7] This is the number of additional deaths *attributed to Covid* that, if the model is accurate, resulted from a failure to enact distancing measures. That may not, however, be the same as the number of additional deaths that resulted from a failure to enact distancing measures. This is because distancing measures may cause and prevent deaths that, given the way epidemiological statistics are compiled, wouldn't be counted as Covid deaths. Enforcing distancing measures, for example, would likely decrease the number of traffic fatalities, but increase the number of domestic violence deaths. As a result, the number of additional deaths resulting from a failure to enact distancing measures may be a bit lower or (more likely) somewhat higher than 47,000. See Schroeder (2020) for a discussion of the often-arbitrary way epidemiological statistics assign deaths to causes and the many philosophical questions this raises.

[8] In addition to Adams (2020b), see Saltelli et al. (2020) for a discussion targeting scientists and the general public. Among philosophers, I think Parker (2020) offers a very helpful framework for thinking about models, which shows why and how evaluating them can be complicated and dependent on context.

[9] The website https://covid19-projections.com, for example, compares the IHME model to the LANL model, which explicitly says it "produces forecasts, not projections." Given the IHME's public statements suggesting they interpreted their model as forecasting, it is fair to ask who bears the responsibility for confusions like these. My own view is that there is plenty to go around. The IHME certainly could have done a better job of describing how their model worked and how it should and shouldn't be used. At the same time, the conditional nature of

The difference between forecasts and conditional projections is a critical one—not only for policymakers but also for the public. Public discussion of the IHME model treated it as a forecast, as if it was telling Americans how many Covid deaths to expect. But as I have argued here, the IHME model should have been interpreted as making a conditional projection of Covid deaths *if* long-term, strict distancing measures were universally enacted. Those distancing measures were our best means of slowing the spread of Covid and so what the IHME model was really doing was projecting outcomes in a best-case scenario. It was telling us how many deaths to expect if the entire country took the most effective, aggressive measures at its disposal and maintained them for two months. If the model was accurate, then in not opting for such measures, the United States was accepting that the Covid death toll would likely be substantially greater than 60,000. That is a much darker and more urgent message than the public received and (mis)understood.

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the projections was not buried somewhere deep in the model's documentation where no one could reasonably be expected to find it. It was announced in bold, in the model's title. So, I think that policymakers, science journalists and other consumers of the model also bear some responsibility here. Ultimately, these questions—about the ethical obligations of scientists, science journalists and policymakers—are complicated ones that would require a separate essay to explore.

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