

Comparing the IHME COVID-19 health service utilization forecasting team's predicted cumulative COVID-19 deaths to actual deaths

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Abstract

On March 30, 2020, the COVID-19 health service utilization forecasting team at the University of Washington's Institute for Health Metrics and Evaluation (IHME) published national and state-level projections of the number of COVID-19 deaths in the United States anticipated in the next four months (i.e. by July 30, 2020). At the time of writing (May 5, 2020), less than half of the time between that paper's publication and the date to which its predictions apply has passed, but comparing these predictions to the actual number of deaths reported so far is still useful in determining whether the models have significantly underestimated the number of deaths. Data regarding the cumulative number of predicted COVID-19 deaths per state was obtained from the IHME's published paper on medRxiv, as were the corresponding lower and upper bounds accompanying each state-level prediction. These predictions covered all 50 states and the District of Columbia. They were then compared to the reported total number of deaths based on data from the COVID Tracker (as of May 5, 2020). The findings indicate that most of the included regions still have not surpassed the number of COVID-19 deaths predicted that they would experience cumulatively, though seven states (Connecticut, New Jersey, New York, Massachusetts, Maryland, Rhode Island, and Illinois) and the District of Columbia have already done so. Nationally, the total number of deaths reported in the United States as of May 5, 2020 is 62,698, which represents about 77% of the 81,111 deaths predicted in the United States by July 30, 2020. The total national number of deaths has increased at a rate of about 1,726 deaths per day since the IHME report was published. If this trend continues at the same rate until July 30, the number of Americans who would have died from COVID-19 at that point would be 213,689, more than twice the IHME prediction.

Introduction

Numerous mathematical models have been developed to project the ongoing COVID-19 pandemic in the United States (e.g. (Best, 2020)). The aim of this paper is to evaluate the accuracy of the predicted numbers of cumulative deaths made by the COVID-19 health service utilization forecasting team at the University of Washington's Institute for Health Metrics and Evaluation (IHME) in a non-peer-reviewed paper published on March 30, 2020 on the preprint server medRxiv. These predictions included the predicted number of deaths over the following four months for the United States as a whole, as well as for each of the 50 states and the District of Columbia.(and Christopher JL Murray, 2020) My ability to assess these predictions' accuracy is limited by the fact that, whereas the predictions were intended to reflect all deaths over the next four months (which I take to mean by July 30, 2020), only slightly more than one month has passed since their paper was published at the time of writing. Thus, even if the IHME's predictions were all perfectly accurate, you would expect the number of deaths in the United States and each region therein to be, at the time of writing, significantly less than the corresponding predicted number of deaths. However, if the

number of deaths has already, by May 5, matched or even exceeded the number predicted to occur by July 30, this would provide clear evidence that the predicted numbers of death were significantly too low.

Methods

I obtained the number of deaths predicted by the IHME over the four months (i.e. from March 30-July 30, 2020) for each state, as well as the corresponding predicted lower and upper bounds, from the aforementioned medRxiv paper([\(and Christopher JL Murray, 2020\)](#), Table 1). I obtained the actual number of deaths in the United States for each state from the COVID Tracking Project's spreadsheet on May 5, 2020 at 4:18 PM.[*\(Coronavirus numbers by state, n.d.\)*](#) The time at which each state's data was last updated in that spreadsheet varied from state to state and is shown in table 1 below. As this table shows, each state's data was last updated between May 2 and May 4, 2020, inclusive. Nevertheless, for consistency, I will be referring to the number of actual deaths based on these data as being "as of May 5, 2020".

State	Last update (ET)	Check time (ET)
AK	05/04 0:00	05/04 15:27
AL	05/04 0:00	05/04 16:24
AR	05/03 15:40	05/04 16:07
AS	05/03 0:00	05/04 15:35
AZ	05/04 0:00	05/04 15:35
CA	05/04 14:00	05/04 16:38
CO	05/03 18:00	05/04 15:17
CT	05/03 16:00	05/04 16:35
DC	05/03 0:00	05/04 16:14
DE	05/03 18:00	05/04 16:28
FL	05/04 9:12	05/04 15:25
GA	05/04 15:25	05/04 16:37
GU	05/04 7:40	05/04 15:36
HI	05/03 18:00	05/04 15:48
IA	05/03 12:00	05/04 14:51
ID	05/02 19:00	05/04 15:27
IL	05/04 0:00	05/04 16:08
IN	05/03 23:59	05/04 15:20
KS	05/03 10:00	05/04 14:55
KY	05/03 17:00	05/04 15:56
LA	05/04 13:00	05/04 16:28
MA	05/04 12:00	05/04 16:30
MD	05/04 10:00	05/04 15:12
ME	05/03 11:59	05/04 15:09
MI	05/03 11:00	05/04 16:35
MN	05/04 0:00	05/04 14:58
MO	05/04 15:00	05/04 15:39
MP	05/04 0:00	05/04 15:14
MS	05/03 19:00	05/04 15:58
MT	05/04 0:00	05/04 14:39
NC	05/04 10:50	05/04 16:31
ND	05/04 13:00	05/04 14:36
NE	05/03 20:45	05/04 14:35
NH	05/03 9:00	05/04 16:38
NJ	05/04 13:00	05/04 14:45

NM	05/03 17:58	05/04 16:13
NV	05/04 11:00	05/04 16:33
NY	05/04 0:00	05/04 16:32
OH	05/04 14:00	05/04 14:19
OK	05/03 0:00	05/04 14:11
OR	05/04 11:00	05/04 16:35
PA	05/04 0:00	05/04 15:21
PR	05/04 6:00	05/04 15:32
RI	05/04 0:00	05/04 15:24
SC	05/03 15:30	05/04 14:43
SD	05/03 18:00	05/04 15:35
TN	05/04 15:00	05/04 16:01
TX	05/04 13:15	05/04 15:34
UT	05/03 15:00	05/04 15:38
VA	05/03 17:00	05/04 14:55
VI	05/03 20:30	05/04 14:57
VT	05/04 10:20	05/04 16:40
WA	05/03 2:59	05/04 16:19
WI	05/04 0:00	05/04 15:56
WV	05/04 10:00	05/04 16:17
WY	05/04 1:56	05/04 16:02

aTable 1. The update and check times by state for the data on actual COVID-19 deaths I obtained from the COVID-19 Tracking Project's website. If you go to this link <https://covidtracking.com/data/> and click "as a spreadsheet" in the text near the top of the page, it will take you to this same spreadsheet (tab "States Current").

I did not include data from Puerto Rico, the Virgin Islands, Guam, or the Northern Mariana Islands in the

current study. This is because while data for these regions was included in the COVID Tracking Project's spreadsheet, it was not included in the IHME predictions, which as mentioned before included only the 50 U.S. states and the District of Columbia (hereafter simply "the United States".

Results

The total number of reported COVID-19 deaths in the United States as of May 5, 2020 was 62,698. Table 2 below shows the total number of deaths reported by each state and the District of Columbia in the United States.

State	Deaths
AK	9
AL	296
AR	81
AZ	362
CA	2254
CO	842
CT	2495
DC	284
DE	182
FL	1423
GA	1222
HI	17
IA	188
ID	64
IL	2662
IN	1264
KS	136
KY	253
LA	2064
MA	4090
MD	1317
ME	57
MI	4049
MN	428
MO	358
MS	310
MT	16
NC	430
ND	25
NE	78
NH	86
NJ	7910
NM	151
NV	262
NY	19415
OH	1056
OK	238
OR	109
PA	2458

RI	341
SC	275
SD	21
TN	219
TX	884
UT	50
VA	684
VT	52
WA	834
WI	340
WV	50
WY	7

Table 2. The number of COVID-19 deaths reported by each U.S. state and the District of Columbia as of May 5, 2020, according to the COVID Tracking Project's spreadsheet.

By contrast, the total number of deaths predicted by the IHME to happen in the United States by July 30, 2020 was 81,111. This means that, nationally, $62,698/81,111 =$ about 77.3% of the cumulative number of COVID-19 deaths in the United States predicted to happen by July 30, 2020 had already happened by May 5, 2020.

Of the 50 states and the District of Columbia ($n = 51$), 8 of them (7 states—Maryland, Massachusetts,

Connecticut, Illinois, New Jersey, New York, and Rhode Island—and the District of Columbia) had already surpassed the best-estimate prediction of the cumulative number of deaths. Clearly, given that they had surpassed these predictions by May 5 even though the predicted numbers were not supposed to be reached until July 30, the prediction was significantly too low in these regions. In other words, $8/51 =$ about 15.7% of the included regions had surpassed the cumulative predicted number of deaths almost three months earlier than expected. Of these 8 regions, 2 of them (25% of the states that had already surpassed the predicted number of deaths, and $2/51 = 3.9\%$ of the total) had surpassed even the IHME's upper bound. In total, of the 51 included regions in the current study, 24 of them ($24/51 = 47.1\%$) had surpassed the IHME's lower bound. These 24 included the aforementioned 8 regions that had surpassed the IHME's best-estimate prediction, as well as 16 that had not. The remaining 27 regions (all states) had not yet surpassed even the IHME's lower bound. Figure 1, below, illustrates this pattern of results in a map.

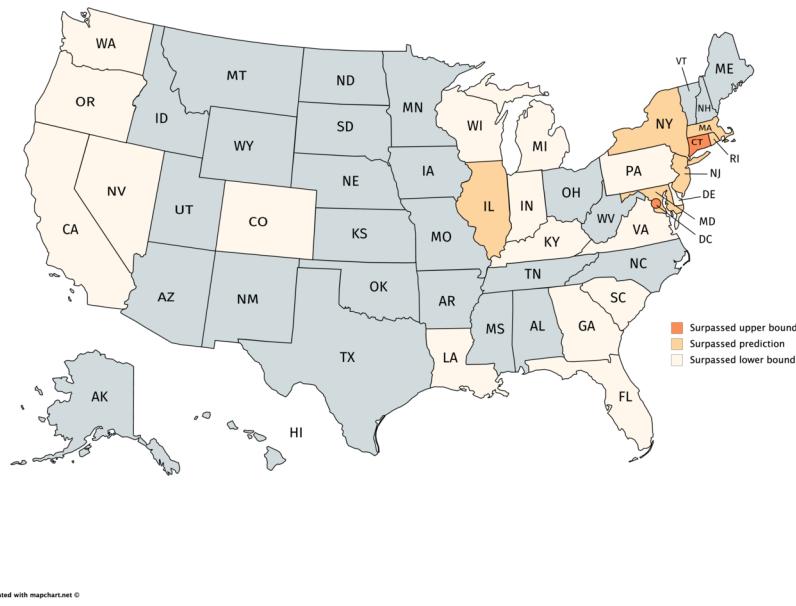


Figure 1: The 50 U.S. states and District of Columbia colored to reflect whether they had surpassed any of the IHME report's three predicted numbers of cumulative COVID-19 deaths. States that had surpassed only the lower bound are shown the lightest shade of red (almost white, e.g. Florida), those that had surpassed both the lower bound and the best estimate are shown a somewhat darker shade (e.g. Illinois), and the two regions that had surpassed all three of the IHME's values (lower bound, best-estimate prediction, and upper bound) are shown in the darkest shade of red (those two being Connecticut and the District of Columbia).

Finally, consulting the COVID Tracking Project's historical data for the United States reveals that on the date the IHME's paper was published (March 30, 2020), the total number of COVID-19 deaths reported in the United States was 3,060, including 1 death from Guam and 6 from Puerto Rico. When we only include deaths from the 50 US states and DC, the number for March 30 thus drops to 3,053; as noted earlier, by May 5, 2020, that number had grown to 62,698. This increase of $62,698 - 3,053 = 59,645$ deaths occurred over 36 days, reflecting about $59,645 / 36 = 1,657$ new deaths per day on average during that time period. In the 86 days between May 5 and July 30, 2020 (the date to which these predictions apply), assuming a constant rate of growth in deaths, the number of total deaths accumulated will be $86 * 1,657 = 142,485$, for a total of $62,698 + 142,485 = 205,813$ deaths in the United States. By contrast, in order to have exactly the predicted number of deaths in the United States on July 30, we would need to accumulate exactly $81,111 - 62,698 = 18,413$

additional deaths in the 86-day period between May 5 and July 30. This would require reducing new deaths per day nationally to an average of about 214—only about 12.9% of the average number for the 36 days between March 30 and May 5. This seems very unlikely given a recent White House report projecting that the number of new deaths per day would continue to increase into June, and would reach about 3,000 by June 1. ([“Models Project Sharp Rise in Deaths as States Reopen”, 2020](#)) Furthermore, extrapolating into the future for each state based on the average number of deaths per day in each state indicates that the 51 regions included here are almost exactly evenly split between those expected to exceed the IHME prediction (n=26) and those expected to fall below it (n=25). The difference between the IHME’s best estimates for the number of deaths in each state by July 30 to the number predicted based on the linear trend just described is illustrated in the table below.

State	Predicted cumulative deaths	Predicted based on trend since 3/30 (7/30)
New York	10,243	62,886
New Jersey	4,109	26,333
Massachusetts	2,231	13,564
Michigan	4,061	13,282
Illinois	2,454	8,847
Connecticut	773	8,369
Pennsylvania	3,094	8,213
California	6,109	7,321
Louisiana	2,081	6,553
Florida	3,342	4,672
Maryland	857	4,427
Indiana	2,440	4,200
Georgia	3,165	3,933
Ohio	2,733	3,486
Colorado	940	2,732
Virginia	1,543	2,258
Washington	1,429	2,234
Minnesota	1,280	1,427
Rhode Island	245	1,146
Wisconsin	853	1,119
Mississippi	675	1,012
District of Columbia	132	941
South Carolina	768	889
Nevada	801	852
Kentucky	585	836
Delaware	228	602
Texas	5,847	2,915
North Carolina	2,411	1,443
Missouri	2,977	1,182
Arizona	1,687	1,179
Alabama	1,155	989
Oklahoma	898	766
Tennessee	1,551	711
Iowa	742	623
New Mexico	513	507
Kansas	669	442
Oregon	584	331
New Hampshire	318	284
Nebraska	437	260

Arkansas	707	258
Idaho	388	203
Maine	334	186
West Virginia	460	167
Utah	619	160
Vermont	386	148
North Dakota	163	80
South Dakota	201	69
Hawaii	352	58
Montana	251	45
Wyoming	136	24
Alaska	154	23

2600.0%
2500.0%

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2500.0%

Discussion

This study compared the predicted number of deaths in each US state as of May 5, 2020 to the number predicted on March 30, 2020 for four months later (July 30, 2020). The findings show that, as expected, in most states the actual number of deaths on May 5 was lower than the predicted number for July 30 (almost three months later). Nationally, there were about 77% as many deaths in the United States on May 5 as the IHME predicted there would be on July 30.

However, the accuracy of the predictions was highly variable across states, and of the 51 regions (50 states and the District of Columbia) included here, 8 of them had already surpassed the predicted number of deaths nearly three months in advance. Furthermore, extrapolating the number of new deaths per day in the 36 days between the IHME's publication of their article to the writing of the present paper until July 30 leads to the prediction of 213,689 deaths in the United States by that date, more than double the IHME's prediction of 81,111 deaths. Hence, these results corroborate other arguments that the IHME's predictions for the United States are overly optimistic. [\(Piper, 2020\)](#) [\(Cancryn, 2020\)](#)

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