COVID-19: What's New for April 10, 2020

Main updates on IHME COVID-19 predictions since April 7, 2020

Our new production schedule

As of today IHME will be publishing its updated COVID-19 projections three times per week. Our ambition to produce daily updates has proven to be unrealistic given the relative size of our team and the effort required to fully process, review, and vet large amounts of data alongside implementing model updates. Our next set of results will be published on Monday, April 13.

More data, better models, improved methods

The data and knowledge landscape on COVID-19 epidemic patterns, health care demand or resource gaps, government response, and the effects of social distancing measures are rapidly evolving worldwide. At IHME, we strive to incorporate new evidence as soon as it becomes available. Our aim is to produce the best possible predictions given what we know today – and to continuously improve these estimates to support further gains against COVID-19 tomorrow.

Today's release of COVID-19 predictions for deaths and hospital use represent a combination of substantial data additions, notably on ICU capacity for many countries in the European Economic Area (EEA), and model refinements.

Predicting COVID-19 deaths: improving projections

Here we describe two key aspects of our models that predict deaths due to COVID-19.

- **Modeling daily deaths.** As also highlighted in our April 7 estimation update, with each day of additional data, our model predictions change. We have also noted that there are substantial fluctuations in the number of COVID-19 deaths reported each day. And in some places, these day-to-day fluctuations appear to have a cyclical nature: for instance, daily deaths reported on Sunday or Monday often show declines from the immediate days prior, followed by a larger increase on Tuesdays. These patterns are more likely to be due to artefacts in how COVID-19 deaths are reported each day than such sizeable fluctuations in daily death counts.

  To mitigate the impact of inconsistent reporting of deaths, our published predictions – what you view in and download from IHME visualization tools – are based on averaging the last three iterations of projections.

  What does this mean? For any given location shown today – April 10 – we report the average of model predictions from reported data up to April 7 (model 1), data up to April 8 (model 2), and data up to April 9 (model 3). This reduces potential volatility that is more related to variable data collection or reporting practices than observed epidemic patterns to date.

- **Modeling the relationship between social distancing policies and COVID-19 deaths.** Our current models average the effects of three social distancing measures – school closures, stay-at-home orders, and non-essential business closures – by using three different weighting schemes. As also highlighted on April 5, this approach aims to capture, community-by-

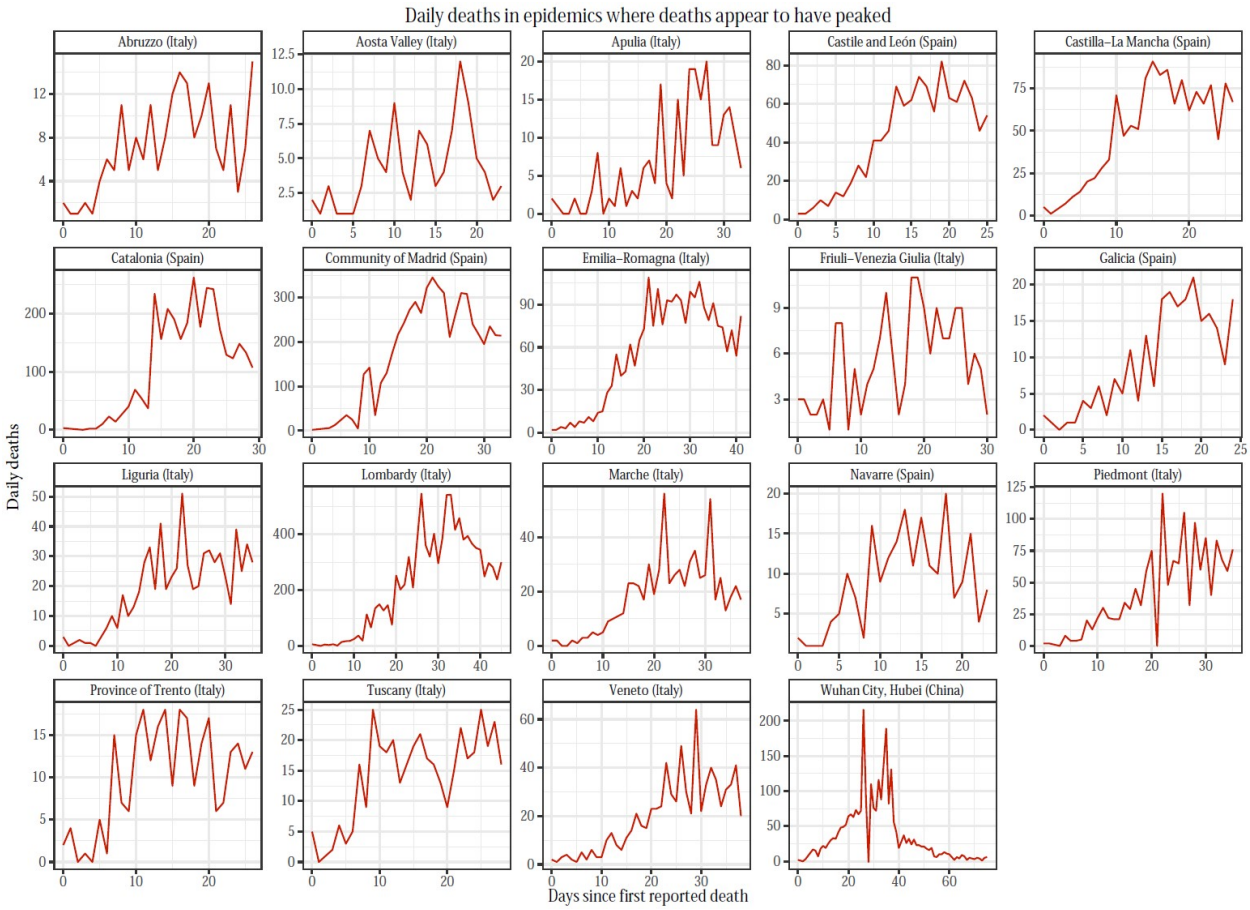
community, differences in how mandates on social distancing behaviors may be related to COVID-19 epidemic patterns.

After calculating each version of the summary social distancing metric, we use this covariate in two COVID-19 deaths models: one focused on maximizing short-term predictions and one focused on fitting long-term trends. Different hyper-parameters are selected to optimize performance on each model: we aim to maximize performance for the first five days for the short-term prediction model and at 20 days for the long-term model. We then combine these models, weighting their relative contribution in a linear manner: for day 1 of the prediction, the short-term model receives full weight (100%); for day 2, the short-model receives 95% weight while the long-term model receives 5%; and so on until day 10 of daily death predictions. At this point, the short- and long-term models become weighted equally, and then the weighting scheme switches to incrementally weighting the long-term prediction model more heavily until it is the sole model informing predictions at day 20 and beyond. These two models inform our estimates of peak daily death numbers and rates.

More locations with COVID-19 death peaks and their effects on model parameters for social distancing policies

As of April 5, we used data from eight total locations in China (Wuhan City), Italy (Emilia-Romagna, Liguria, Lombardy, Piedmont, and Tuscany), and Spain (Castile-La Mancha and Madrid) for which the number of daily COVID-19 deaths had peaked. These new locations' epidemic peaks and temporal information on social distancing policy implementation then informed the broader model's peak curve fitting in relation to distancing measure enactment.

For today's release – April 10 – in the estimation of the gamma coefficient we use a total of 19 locations that appear to have experienced a peak in daily deaths. They include seven more locations from Italy (Abruzzo, Aosta Valley, Apulia, Friuli-Venezia Giulia, Marche, Province of Trento, and Veneto); and four more from Spain (Castile and León, Catalonia, Galicia, and Navarre). The reported daily deaths for each of these locations are shown in the graphs below (listed alphabetically).



The addition of these 11 locations has had a substantial impact on the estimation of gamma, and as a result, the estimation of epidemic peak dates. Compared to the release on April 7, which was based on eight locations, the gamma parameter used in today's release (based on these 19 locations) implies epidemic peaks that are on average two days later.

Various concerns have been expressed about the reported daily death data from Wuhan City (e.g., potential for under-reporting of deaths amid its outbreak). We have run sensitivity analyses wherein Wuhan's data are omitted and thus do not inform the gamma parameter; no significant effects were found for gamma regarding the inclusion of Wuhan City death data alongside the other 18 locations' data.

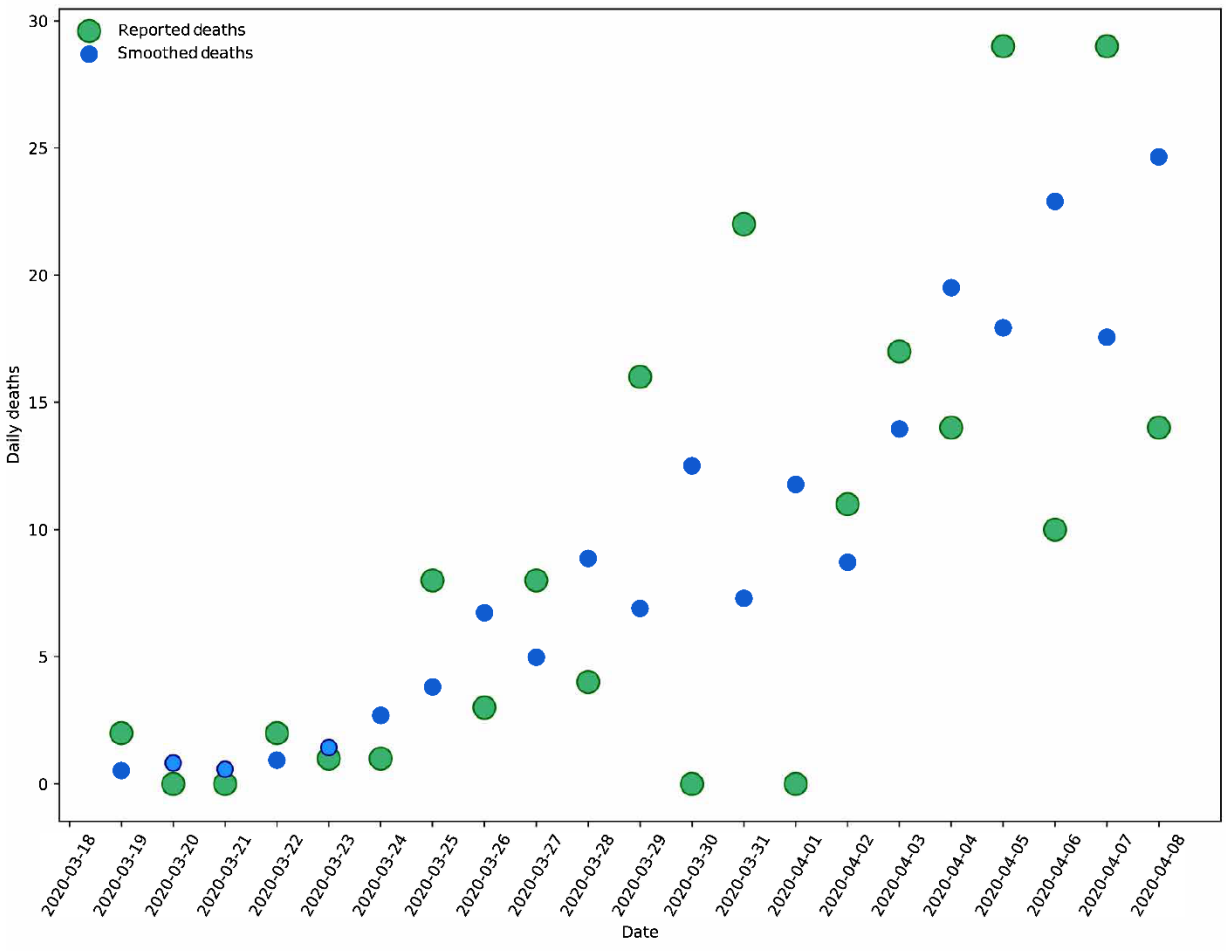
To read more about CurveFit, the modeling approach used to generate IHME's COVID-19 death predictions, please refer to documentation on GitHub.

Reducing the impact of noisy data on COVID-19 predictions: data smoothing steps

During our last two weeks of COVID-19 data intake and prediction modeling, we have noticed patterns in data reporting that are very unlikely to occur due to chance alone. For instance, several locations show sizeable decreases in reported daily deaths on Sundays or Mondays, or both – and then show a large uptick in reported COVID-19 deaths on Tuesdays. Because these types of daily or weekly fluctuations are unlikely to be real changes in daily COVID-19 deaths, we have made the following

refinements to our model that make it less sensitive to daily fluctuations in the number of deaths. These changes were implemented as of April 5, but we are presenting them here again as they have influenced model predictions in a large number of locations:

Before entering the model, input daily death data are smoothed. First, we drop the data from the most recent day if there are no new deaths reported on that day. Then, we smooth the reported data. The smoothing is a three-day (t-1, t, t+1 where t is a given day) moving average in the space we fit the model (i.e., natural log of age-standardized cumulative death rate). For the first day (t=0), we project the average difference in smoothed values from t=1 to t=3 backward from t=1. For the last day (t=n where n is the last day of currently reported daily death data), we do the same thing: we average the difference between t=n-3 to t=n-1 and step that out from t=n-1. The impact – and importance of doing this before daily death data enter the model – is highlighted in the figure for Colorado below. The large green dots represent the highly variable daily death data as reported, while smaller blue dots are the smoothed daily death data points *before* they are used for modeling. These large daily fluctuations in the number of reported deaths is quite common; this example is one of many.

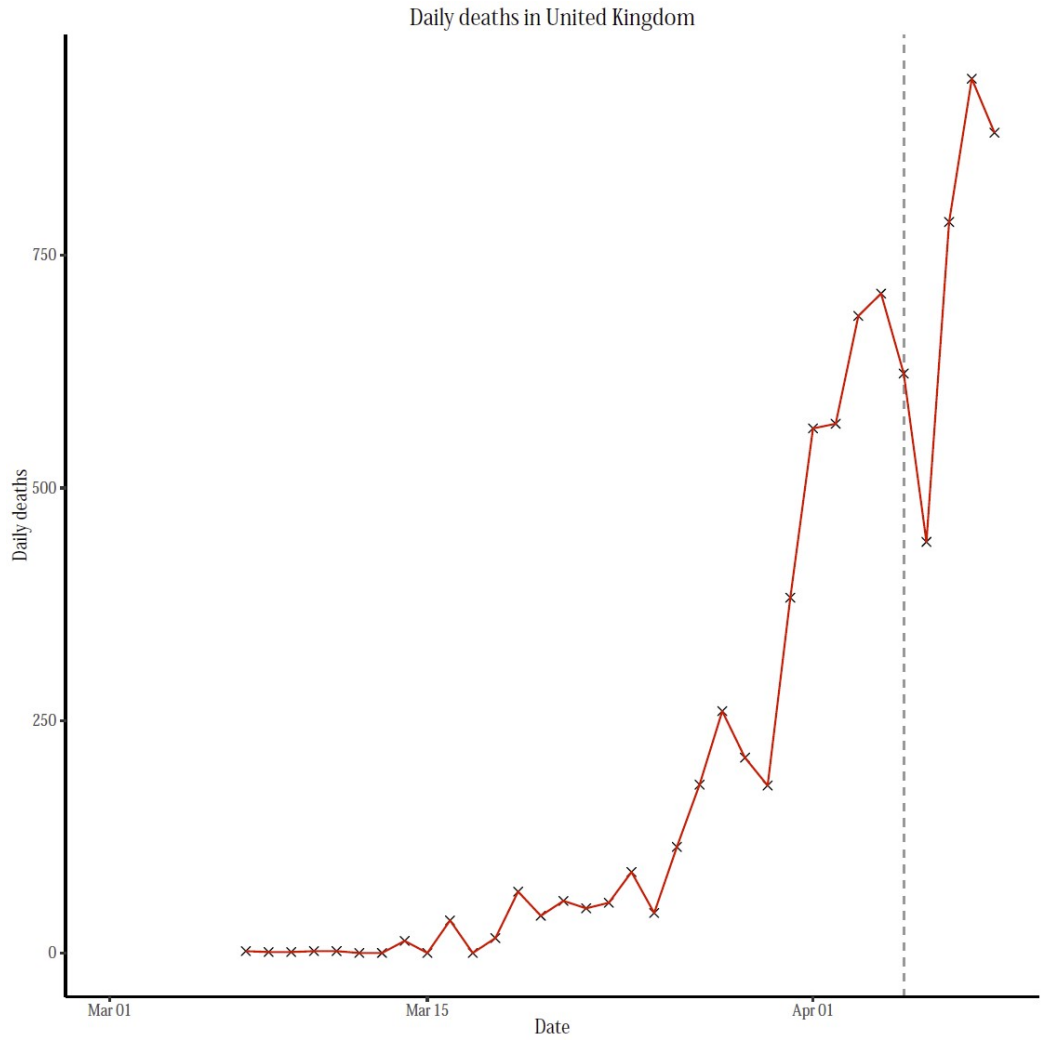


A focus on country-level predictions: what has changed in the UK since the April 7 release

Being able to include more recent data and apply model refinements since our last release has substantively changed COVID-19 death and hospital use predictions in some countries and locations. Here we further examine the United Kingdom (UK) and France, two countries where notable updates have occurred since the April 7 release, as well as the US.

COVID-19 death data and predictions

- Our initial release of EEA country predictions included reported daily deaths through April 5. For the United Kingdom (UK), daily death data during the week prior to April 5 showed sharp and steadily increasing cumulative daily deaths. The plot below illustrates this trend, with a dotted vertical line indicating the data intake cutoff (April 5) for the April 7 release. Our model followed this overall trend observed through April 5, projecting peak daily COVID-19 deaths at 2,932 (estimate range of 829 to 7,922) on April 17 and cumulative deaths of 66,314 (55,022 to 79,995) through the epidemic's first wave.



- Since our last release, we have been able to include four more days of reported daily deaths for the UK (April 6, 7, 8, 9). The combination of a slower increase in daily deaths reported than previously captured and updated values for gamma based on more locations' COVID-19 epidemics peaking (as described above) has resulted in notably lower average projections for the UK: at the same predicted peak date for daily COVID-19 deaths, the prediction is now 1,674 deaths (estimate range of 651 to 4,143) on the peak day and 37,494 cumulative deaths (estimate range of 26,149 to 62,519) through the first wave.
- As summarized in the table below, these updates result in substantial changes to the mean COVID-19 death predictions. Their uncertainty intervals – values reported in parentheses – do overlap, reflecting the inherent uncertainty of generating projections and especially on the basis of rapidly changing data landscapes.

Prediction measure for the UK		**Predictions from our April 10 release (today)**	**Predictions from our April 7 release**	**Change of average values since the April 7 release***
COVID-19 deaths	Peak date for daily deaths	April 17	April 17	0 days
	Daily deaths peak date	1,674 (651 to 4,143)	2,932 (829 to 7,922)	↓ 1,258 deaths
	Cumulative deaths through first wave	37,494 (26,149 to 62,519)	66,314 (55,022 to 79,995)	↓ 28,820 deaths

*Change estimates do not include uncertainty; they are only based on the average value. If prediction values' uncertainty intervals (the numbers reported in parentheses) overlap a lot across different releases, changes in these estimates are not considered substantively different.

Hospital capacity and predictions

- Our April 7 release for EEA countries, including the UK, had projections based on limited information on country-by-country availability of current hospital resources. In general, this type of data – representative and timely information on hospital bed and ICU bed capacity, as well as hospital use – has been less widely available than COVID-19 death data.
- Through the European Observatory on Health Systems and Policies, we received up-to-date data on hospital use and capacity in the UK – including information reflecting the UK's recent efforts to reallocate other types of hospital beds to ICU capacities in response to COVID-19 surges.
- With today's release (April 10), our updated estimates of hospital capacity, in combination with lower COVID-19 death predictions for the UK, have resulted in lower average projections for hospital resource need and gaps at peak demand. It is worth noting that the uncertainty intervals around these estimates remain large. We expect these to narrow as more data from subsequent days can be included in the model; this is planned to occur in the upcoming days.

Prediction measure for the UK		Predictions from our April 10 release (today)	Predictions from our April 7 release	Change of average values since the April 7 release*
Hospital resource use	Peak date for hospital resource use	April 15	April 17	2 days earlier
	Total hospital beds need at peak	64,266 (34,509 to 128,966)	102,784 (65,362 to 157,866)	↓ 38,518
	ICU beds need at peak	14,333 (7,871 to 27,839)	24,544 (16,739 to 37,565)	↓ 10,211
	Invasive ventilator need at peak	12,595 (6,976 to 24,913)	20,862 (14,251 to 32,069)	↓ 8,267

*Change estimates do not include uncertainty; they are only based on the average value. If prediction values' uncertainty intervals (the numbers reported in parentheses) overlap a lot across different releases, changes in these estimates are not considered substantively different.

Key findings from today's release (April 10, 2020)

A focus on Europe COVID-19 death predictions

- Although cumulative death projections have changed for several countries since our April 7 release, the UK, Italy, Spain, and France remain among the EEA countries with the highest predicted cumulative deaths from COVID-19 during this first wave (as shown below). Note that the Netherlands' currently high projections have wide uncertainty and thus could change considerably as more data become available.

Country	Predictions for cumulative COVID-19 deaths through the first wave from our April 10 release (today)	Predictions from our April 7 release	Change of average values since the April 7 release*
United Kingdom	37,494 (26,149 to 62,519)	66,314 (55,022 to 79,995)	↓ 28,820 deaths
Italy	20,333 (19,691 to 31,377)	20,300 (19,115 to 21,960)	↑ 33 deaths
Spain	18,363 (17,095 to 20,842)	19,209 (17,110 to 22,351)	↓ 846 deaths
Netherlands	18,067 (6,541 to 41,614)	5,808 (2,546 to 15,811)	↑ 12,259 deaths
France	15,741 (13,668 to 20,714)	15,058 (9,737 to 27,428)	↑ 683 deaths

*Change estimates do not include uncertainty; they are only based on the average value. If prediction values' uncertainty intervals (the numbers reported in parentheses) overlap a lot across different releases, changes in these estimates are not considered substantively different.

- Of countries with the highest reported or projected peak of daily COVID-19 deaths, three – Italy, Spain, and France – appear to have potentially experienced their peaks. Other European countries with relatively high daily COVID-19 deaths that may have already peaked include Belgium (peak on April 7, 403 deaths) and Germany (April 8, 254 deaths). Switzerland, which is not part of the EEA, currently has a predicted peak of 124 COVID-19 deaths (estimate range of 9 to 454) on about May 4. As increasingly more data become available – and/or as countries adjust social distancing policies – these predictions may change.

Country	**Predicted potential peak date of daily COVID-19 deaths**	**Predicted daily COVID-19 deaths at peak: average projection (estimate range)**
United Kingdom	April 17	1,674 (651 to 4,143)
Italy	March 27	969*
Spain	April 1	950*
France	April 6	920*
Netherlands	May 4	468 (132 to 1,063)
Belgium	April 7	403*
Sweden	May 4	379 (163 to 756)
Germany	April 8	254*
Switzerland	May 4	124 (9 to 454)

* Reported daily death data; no uncertainty estimates accompany these values.

A focus on the US

- **Predicted peak for daily COVID-19 deaths.** At the national level, current data suggest that the predicted peak for daily COVID-19 deaths could be approximately April 10, reaching 1,983 deaths (estimate range of 500 to 5,583). These projections suggest that the US may be nearing its peak for COVID-19 deaths; subsequently, we may soon see the number of daily deaths decreasing at the national level.

  Across the US, it appears that several states – especially those with large COVID-19 epidemics earlier on – may be nearing or have already reached their peaks. For instance, the latest data indicate that New York is reaching or has experienced its peak – at 799 COVID-19 deaths reported on April 9 – as well as New Jersey and Illinois (272 and 154 reported deaths on April 8, respectively). Three states with the highest potential daily COVID-19 death peaks in the coming weeks are listed below:

State	**Predicted peak date of daily COVID-19 deaths**	**Predicted daily COVID-19 deaths at peak: average projection (estimate range)**
Massachusetts	April 27	201 (29 to 677)
Connecticut	April 25	146 (32 to 409)
Florida	April 27	112 (29 to 283)

- **Predictions for cumulative deaths.** For the US, projected cumulative COVID-19 deaths could reach 61,545 (estimate range of 26,487 to 155,315) across states during the epidemic's first

wave. Today's release aligns closely with national-level predictions published on April 7, where the cumulative death toll was projected to be 60,415 (estimate range of 31,221 to 126,703).

Based on the latest data and current model, the following states could have the highest cumulative COVID-19 death toll through the epidemic's first wave:

- New York, at 13,463 deaths (estimate range of 9,382 to 24,236)
- Massachusetts, at 6,739 deaths (estimate range of 1,269 to 22,854)
- Connecticut, at 4,614 deaths (estimate range of 1,143 to 13,559)
- Florida, at 3,999 deaths (estimate range of 1,218 to 10,293)
- Georgia, at 3,564 deaths (estimate range of 1,300 to 9,020)

- **Hospital resource use predictions**. Across the US, the predicted peak date for hospital resource use could be around April 11, with COVID-19 patients potentially requiring 86,379 total hospital beds (estimate range of 24,290 to 232,948) – with 17,707 ICU beds (estimate range of 7,375 to 42,511) – and 15,414 invasive ventilators (estimate range of 5,780 to 38,595). Based on the current data and model, New York and New Jersey may be experiencing their peak hospital use or have recently experienced this peak (April 8). Conversely, the following states with high COVID-19 death projections could see hospital resource need peak between April 24 and April 26:

State	Predicted potential peak date of hospital resource use	Predicted hospital bed need at peak	Predicted ICU bed need at peak	Predicted invasive ventilator need at peak
Massachusetts	April 26	8,104 (1,109 to 27,640)	1,873 (274 to 6,213)	1,637 (232 to 5,530)
Connecticut	April 24	7,430 (1,572 to 21,167)	1,499 (340 to 4,132)	1,276 (281 to 3,563)
Florida	April 26	6,431 (1,695 to 16,238)	1,241 (339 to 3,077)	1,041 (280 to 2,610)
Georgia	April 26	5,496 (1,877 to 13,825)	1,048 (373 to 2,573)	877 (308 to 2,164)

Data updates since our last release on April 7, 2020

Data and locations

- For all currently included locations, we have added reported data points on COVID-19 deaths and available information on social distancing policies through April 9 at 5:00 pm PST.
- Currently included locations are the United States (national level) and 50 states plus the District of Columbia, as well as EEA countries and Switzerland. Three EEA countries – Germany, Italy, and Spain – also have subnational estimates at the first administrative level.

What's in the development pipeline for IHME COVID-19 predictions

Before we introduce new model components or improvements to our current analytical platform for predictions, IHME's COVID-19 development team members test these additions or changes.
Below are some highlights from IHME's current development pipeline:

- **Social distancing policy and population-level mobility.** Companies and organizations have increasingly published mobility data at the local level – how much people are traveling on foot or by car, broad patterns on where they are traveling to – based on geo-located information captured by cell (mobile) phones. Our team aims to introduce a new set of models soon wherein the adherence to social distancing measures can be directly approximated by location-specific mobility data.

  This kind of update has the potential to more accurately reflect how different populations, especially in different parts of a country or continent, are responding to different types of distancing measures – and thus more accurately capture how coronavirus exposure or risk could vary across settings.

- **Infectious disease compartmental models capturing susceptible-to-recovered populations.** Our team is currently developing what is known as SEIR models – disease models that simulate if and how groups of people move from being **S**usceptible to **E**xposed to **I**nfected to **R**ecovered – to correspond with our current statistical approach. These SEIR models then can be used to explore intervention scenarios following the first epidemic wave. Such scenarios could include relaxing or reintroducing different distancing policies and introducing different treatment or prevention options, among others. Given the world's current vaccine and pharmaceutical pipelines for addressing COVID-19, any scenarios exploring vaccine or antiviral introduction would require some assumptions about their efficacy and availability until more data were available.

- **Additional locations.** We are actively working on collating the data and model adaptations needed for generating projections for increasingly more locations and countries throughout the world.

A note of thanks

None of these estimation efforts is possible without the tireless data collection and collation efforts of individuals throughout the world. Your work in hospitals, health care organizations, local health departments, and state and national public health agencies, among others, is invaluable.

We thank you for your dedication to fighting the coronavirus pandemic and we appreciate your willingness to share data and collaborate with the IHME COVID-19 team.

For all COVID-19 resources at IHME, visit http://www.healthdata.org/covid.
Questions? Requests? Feedback? Please contact covid19@healthdata.org.