# COVID-19: What's New for May 4, 2020

***Main updates on IHME COVID-19 predictions since April 29, 2020***

## Updated IHME COVID-19 projections: predicting the next phase of the epidemic

Since our first release of COVID-19 projections on March 26, we have sought to update and advance our modeling strategies alongside the world's rapidly evolving understanding of the pandemic. Processing new types and more routinely collected data, and then revising modeling approaches as the evidence base expands, is foundational to any scientific endeavor. Its importance becomes dramatically higher when a new disease is affecting millions throughout the world.

Our initial COVID-19 modeling strategy drew from the evidence on death reporting earlier in the global pandemic to inform predicted trajectories of deaths and hospital resource needs in the US, Puerto Rico, Canada, and European Economic Area (EEA) countries. Initially, our goal was to predict the peak of the epidemic, both in terms of when the number of deaths would peak, and also when health systems would experience the greatest surge in demand. These projections were informed by early response to the COVID-19 epidemic: the adoption of various social distancing policies to slow and ultimately contain the virus's rapid spread. Some locations enacted such measures swiftly – Australia and New Zealand, among others – and appear to have been successful in curbing their epidemics. Other locations were slower to implement distancing mandates but instituted strict policies like curfews, while some primarily issued behavioral change recommendations to reduce infection risk. It is increasingly clear that COVID-19 epidemic trajectories – and corresponding responses – are highly variable throughout the world.

Globally, data on COVID-19 and key epidemic drivers have markedly improved since the end of March. In addition to an expanded data universe on reported COVID-19 deaths, cases, and hospital resources, we have much more information on COVID-19 hospitalizations and testing. Much more data on human mobility patterns have become available, a critical contributor to heightened exposure and potential transmission of the novel coronavirus. Our team has actively sought to incorporate both new and updated data into our models as soon as they become available, enabling regular updates of COVID-19 predictions for an increasing number of locations.

We, collectively, are now entering a new phase of the COVID-19 pandemic. More locations are easing previously implemented social distancing policies, and human mobility patterns are trending upward – even in places where distancing measures remain in place. Testing has scaled up in many parts of the world, but such progress has been uneven and is not keeping pace with the growing demand for lifting business and gathering restrictions. Carefully tracking what is happening today as locations move to "re-open" will provide vital information for potential COVID-19 trajectories in the coming weeks and months.

**Today we launch a major update to our COVID-19 estimation framework:** a multi-stage hybrid model. This modeling approach involves estimating COVID-19 deaths and infections, as well as viral transmission, in multiple stages. It leverages a hybrid modeling approach through its statistical component (deaths model), a new component quantifying the rates at which individuals move from being susceptible to exposed, then infected, and then recovered (known as SEIR), and the existing microsimulation component that estimates hospitalizations. We have built this modeling platform to allow for regular data updates and to be flexible enough to incorporate new types of covariates as they become available. Last, by relating transmission parameters to predictions of key drivers of COVID-19 epidemic trends – temperature, the percentage of populations living in dense areas, testing per capita, and human mobility – this new modeling approach will allow for a more comprehensive examination of how COVID-19's toll could unfold in the coming months, taking into account these underlying drivers. This is particularly important as many locations ease or end prior distancing policies without having a clear sense of how these actions could potentially affect COVID-19 trajectories given current trends in testing and mobility, among others. With our new modeling framework, we aim to provide a venue through which different COVID-19 epidemic scenarios and responses can be explored by location.

We summarize this new modeling strategy below, as well as the data which have made these modeling innovations possible. The results can be explored online: https://covid19.healthdata.org/projections. We would like to highlight that the SEIR model has been incorporated for the US to date; more countries and locations will be added soon..

**At IHME, our guiding principle is to produce the best possible predictions given what we know today – and to continually improve these estimates to support further gains against COVID-19 tomorrow.** We will be updating our projections in the coming days and weeks to incorporate the world's evolving evidence base on COVID-19.

## An updated estimation framework for the next phase of the pandemic

Our new modeling strategy involves three key parts, which we detail more in the following sections. These modeling components build upon inputs and model outputs to establish a modeling platform that supports two interconnected objectives: (1) generate predictions of COVID-19 deaths and infections for all currently included locations; and (2) enable alternative scenarios on the basis of different levels of temperature, the percentage of populations living in dense areas, testing per capita, and social distancing approximated by changes in human mobility.

### Part 1: Estimating COVID-19 deaths and infections

***Estimating COVID-19 deaths***

In addition to the updates on the COVID-19 death model that occurred with our April 17 release and are detailed elsewhere (CurveFit GitHub documentation and the latest version of our manuscript), we have implemented a number of improvements to our death model. These advances have been implemented for all locations for which we have COVID-19 predictions: the US, Puerto Rico, Canada, and all EEA locations.

Our death model improvements are as follows:

- **Smoother daily death trends as model inputs.** As mentioned before, daily reports of COVID-19 deaths are highly variable, mainly due to delays or errors in reporting rather than true day-over-day fluctuations. Using these data as reported (often referred to as "raw" data) without smoothing them first can lead to highly variable predictions. We previously implemented a three-day average of the natural log of cumulative COVID-19 deaths to smooth the input data. While this update helped, it did not fully mitigate the effects of volatile input data. As of today's release, we now apply this algorithm 10 times in a row, which smooths daily death trends for a longer period of time. This approach allows the death model to be better informed by the overall time trend and less sensitive to daily fluctuations.

- **Hospitalizations of COVID-19 patients as an additional leading indicator for estimating COVID-19 deaths in the next eight days.** As of today's release, we now include two leading indicators for locations where hospitalization data are available: the number of COVID-19 cases (added for our April 17 release) and hospitalizations of COVID-19 patients. Each indicator is used to inform the trend in the number of COVID-19 deaths in the coming eight days. In other words, if the number of hospitalizations (and/or cases) has increased over the last few days in a given location, we want our model to predict that deaths are also likely to increase eight days later.
- **Correcting reported cases to account for scaling up testing.** As more locations scale up testing for COVID-19, many places may report increases in cases; however, such increases usually reflect an increased detection of existing cases rather than a true rise in COVID-19 infections. Where data are available, we aim to adjust trends in reported cases based on the relationships between testing per capita and test positivity rates. To date, we have found as testing rates double, cases increase by an average of 22%. We then use this relationship to adjust case trends which then inform our death models, a vital step toward ensuring a more accurate representation of COVID-19 epidemic trends. Other COVID-19 estimation updates do not appear to account for this relationship between reported cases and expanded testing efforts; this could lead to very different conclusions about future epidemic trends.
- **Expanding the range of multi-Gaussian distribution weights for predicting epidemic peaks and shapes.** Since our initial release, we have increased the number of multi-Gaussian distribution weights that inform our death model's predictions for epidemic peaks and downward trends. As of today's release, we are including 29 elements, a substantial increase from our original seven and then 13 (which was introduced for our April 17 update). This expansion now allows for longer epidemic peaks and tails, such that daily COVID-19 deaths are not predicted to fall as steeply as in previous releases.
- **Incorporating changes in mobility in the absence of formally enacted social distancing policies.** In some locations, human mobility patterns have substantially decreased in the last few months – even when governments did not issue mandates to restrict gatherings or close businesses. For modeling purposes, if mobility declined by 40% or more, any social distancing mandates that had yet to be formally implemented were considered in place at present. If mobility reductions had yet to reach 40%, our model assumption is that they would be implemented three weeks from the current date of estimation.

*What do all of these death model updates mean?* Overall, these modeling improvements have resulted in considerably higher projections of cumulative COVID-19 deaths through August, primarily due to longer peaks and slower declines for locations that have passed their peaks. The magnitude of these effects vary by location, and uncertainty intervals still overlap considerably for many places. The mean cumulative projections shown in our online visualization tool and available for download are generally higher for currently included locations.

***Estimating COVID-19 infections***

- As also discussed more in the April 17 estimation update, we use estimates from our COVID-19 death models and estimates of infection fatality ratios (IFRs) to produce estimates of COVID-19 infection incidence and prevalence. To recap: we derive IFRs from a random-effects meta-regression for all locations where we have data on both detected infections and age-specific deaths (further documentation is in the latest version of our manuscript). We apply these IFRs to COVID-19 deaths estimated from our death model to produce age-specific rates of infection. These COVID-19 infection estimates, with COVID-19 death estimates, then feed into the transmission dynamics component of our new estimation platform (as described further in Part 2 below).
- Since our last major methods update, we have conducted cross-validation analyses for IFR by comparing infection estimates and corresponding seroprevalence that would be detected on the basis of survey data reported for the state of New York. Our estimates align very closely with these survey-based estimates of seroprevalence.
- To estimate the duration from COVID-19 infection to death, we sample a range of 17-21 days; this is slightly longer than our previous sampling duration of 16-20 days (as described in the April 17 estimation update).

## Part 2: Fitting and predicting disease transmission dynamics

Today's release brings a major advance in our COVID-19 estimation platform: the addition of a susceptible-exposed-infected-recovered (SEIR) component to our multi-stage model. This allows us to account for potential increases in transmission intensity if – or as the data increasingly suggest, when – social distancing mandates are eased and/or human mobility patterns rise. The latter is particularly important, as it appears that many populations are exhibiting increases in movement and thus possible interactions with each other, even in places where distancing policies remain in place. Last, by including this mechanistic SEIR component into our model, we can more easily incorporate the effects of additional – or new – measures that might reduce viral transmission (e.g., heightened testing and contact tracing, and potentially future treatment regimens or preventive interventions).

***How does our overall SEIR modeling component work?*** First, we combine the observed and predicted daily COVID-19 death counts for the next eight days by location with corresponding estimates of IFR; this produces estimates of how many individuals may be infected in each location through time. We then model the rates at which infectious individuals may come into contact and infect susceptible individuals (denoted as beta, equating the effective reproductive number known as $R_t$) as a function of a number of predictors that affect transmission (see Part 3 below). Once susceptible individuals become infected, they are then considered exposed – the E part of SEIR – where they are first not infectious (incubation) and then become infectious. Our modeling approach acts across the overall population (i.e., no assumed age structure for transmission dynamics), and each location is modeled independently of the others (i.e., we do not account for potential movement between locations).

In terms of more specifics (which will also be detailed further in a forthcoming technical resource):

- For each draw from the death model, we estimate an SEIR modelling component that very closely aligns with the observed number of deaths and those predicted in the following eight days. This is the period we use for our leading indicators, and thus we have good confidence in these inputs. Close alignment with observed deaths is achieved by allowing $R_t$ (the simple transformation of the beta parameter in our model) to vary over time. In other words, we fit 1,000 SEIR models for each location with the beta parameter ($R_t$) varying each day.

- Again, at the draw level, we run 1,000 regressions using each of the 1,000 vectors of beta parameters (i.e., one value of beta for each day) and estimate their relationship with key drivers (i.e., temperature, percentage of populations living in dense areas, testing per capita, and mobility). From each of these regressions, we predict beta for each day. We then use these predicted betas in our SEIR model to get estimates of infections and deaths.
- If the predicted effective reproduction number, or $R_{t,}$ hovers just below 1, our predictions will have a longer tail – or more cumulative COVID-19 deaths that occur as the epidemic curve more gradually declines.

## Part 3: Using independent drivers to inform the trend in the COVID-19 epidemic

To date, our focus has been on capturing the relationships between social distancing policy implementation and COVID-19 trends: first, based on the timing of policy enactment and, since April 17, also using changes in human mobility patterns to estimate the relative importance of different social mandates. Such work has allowed us to better predict peaks in COVID-19 deaths, as we could better approximate potential exposure to the novel coronavirus based on changes in human movement.

With today's release, we are directly modeling disease transmission as a function of mobility, as well as temperature, testing rates, and the proportion of populations that live in dense areas. We have also made improvements in our mobility estimates and produce forecasts of mobility. In addition, we have incorporated information on other key potential drivers of COVID-19 transmission and trajectories.

*Why is this important?* By expanding what we capture and model as potential drivers of COVID-19 epidemic trajectories, we can generate more data-informed projections *and* model the potential scenarios for COVID-19 predictions should levels or trends for a given driver change.

Our currently included drivers are as follows; if – or as – more data become available to incorporate (e.g., availability of personal protective equipment, mask use by the general public), we aim do so in a timely manner. Note that such estimates are for the US to date; more countries and locations will be added soon.

**Driver 1: Daily temperature**

- Source: Daily data on temperature (in Kelvin) from the Physical Sciences Laboratory NCEP/NCAR Reanalysis dataset served as our data source on temperature. Maintained by the National Oceanic and Atmospheric Administration (NOAA), these data are updated daily with a one-day delay in reporting.
- Processing and predictions: We take the gridded temperature data and calculate population-weighted averages for each location per day. To predict the beta parameter, we use a two-week rolling average of observed temperature readings. For dates that have yet to occur in 2020, we use the median temperature readings from the last four years to serve as proxy readings.

- Implications for COVID-19: To date, the relationship between temperature and estimated changes in transmission appears to modest for our currently included locations. However, this could be more related to the limited months and time of year – March to April – than how temperature could affect COVID-19 trends as the Northern Hemisphere moves toward summer. It is very possible temperature will become a stronger predictor into May and June.

**Driver 2: Percentage of populations living in highly dense areas**

- Source: We use gridded population count estimates for 2020 at the 1 x 1 kilometer (km) level from WorldPop.
- Processing and predictions: For this work, we capture the impact of population density as a driver by including in the model the percentage of the population who live in an area with more than 1,000 individuals per square km. For each of our currently included locations, we calculate this by converting the gridded count estimates into density per square km based on the provided area weighting raster layer. Data do not account for potential migration or seasonal changes of populations, so estimates for this driver do not vary with time.
- Implications for COVID-19: Some locations with a high proportion of their population living in dense areas have experienced large COVID-19 epidemics (e.g., New York state). However, potentially due to its time-invariant nature, this indicator is not as strong of a predictor of changes in COVID-19 epidemic trends as our other currently included drivers.

**Driver 3: COVID-19 testing per capita**

- Sources: Our primary sources for US testing data are compiled by the COVID Tracking Project.
- Processing: If locations lack reported testing numbers for the past, we redistribute and extrapolate total testing data back to the date of the first confirmed case report. Before producing predictions of testing per capita, we smooth the input data by using repeated iterations of the three-day-average; this is the same smoothing algorithm used for smoothing daily death data prior to modeling.
- Predictions: Testing per capita projections are based on linearly extrapolating the mean day-over-day difference in daily tests per capita for each location.
- Implications for COVID-19: Changes in testing per capita predictions are related with changes in predicted beta (effective reproductive number, or $R_t$), such that increases in testing correspond with declines in the transmission parameter. With all else being equal, rising rates of COVID-19 testing contribute to downward trends in epidemic trajectories.

**Driver 4: Changes in human mobility and its relationship to social distancing policies**

- Sources: We currently use up to four data sources on human mobility and then construct a composite mobility indicator (described next). Two sources – Google's COVID-19 Community Mobility Reports and Facebook's Data for Good initiative – have mobility information for all currently included locations, while two other sources (Descartes Labs and SafeGraph) focus on the US only. Subsequently, all four sources inform the mobility composite indicator for US locations, while Google and Facebook are sources informing composite mobility outside of the US.

Each source has a slightly different way of capturing mobility and recent changes. For Google, change in mobility is captured for six categories based on movement to places (e.g., workplaces, residential) and is benchmarked against median values of corresponding days of the week from January 3 to February 6, 2020. For Facebook, change in mobility is based on trips from different start and end locations relative to the median for the 45-day period preceding the first day Facebook had data for that location. For SafeGraph, change in mobility is based on the percentage change in devices not "completely home" relative to a baseline of February 8 to 14, 2020. And for Descartes Labs, change in mobility is based on median of the maximum distance traveled for samples in a given location relative to a baseline of February 17 to March 3, 2020.

- Processing: Before constructing a composite mobility indicator, we implement a few processing steps to standardize these different data sources. For Facebook, we take the mean percentage change from the Google mobility source and apply this to each location's baseline period in the Facebook dataset. This step is necessary to account for time series where social distancing measures have already been implemented (and thus could result in a skewed percentage change in mobility). We calculate a seven-day moving average for each data source to account for fluctuations in mobility over different days of the week, and calculate the ratio of between each of the mobility sources per location over time. For US locations, we model this ratio before and after March 3 as the Descartes Lab source more abruptly decreases at this time. Per location, we use these ratios to impute missing data points for each source and thus generate a complete time series of changes in mobility for each source. We then take the average across data sources and calculate the variance over time using a Gaussian process regression. This synthesis produces a single, composite time series of change in mobility for each location; based on the latest available data, this covers a time period of January 1 to April 28, 2020.
- Predictions: We run a meta-regression Bayesian regularized trimmed model (MR-BRT) with random effects by location on the composite mobility indicator to estimate the effects of social distancing policies on changes in mobility. In addition to the six distancing measures we track (i.e., mass gathering restrictions, any business closure, school closures, stay-at-home orders, broader non-essential business closures, and severe travel restrictions), we also included a covariate one week prior to the first mandate implementation. This "anticipatory effect" was meant to capture how mobility changed in many places prior to any formal mandate implementation. For locations where particular measures had been eased or ended, we "switched off" – treated them as 0 – those policies at the time point of policy easing or ending. On the basis of the MR-BRT model, we generated predictions of mobility by location from January 1 to August 4, 2020. For locations where distancing policies have been eased or clear plans have been instituted for their easement, we used those dates for the predictions. In the absence of identified easing plans, we assumed policies would remain in place through August. We calculated the residuals between our predicted composite mobility time series and input composite time series, and then applied ARIMA (autoregressive integrated moving average) models to fit residuals by location. These ARIMA fits then were used to predict residuals from January 1 to August 4, which were then added to the mobility predictions to produce a final time series: "past" changes in mobility from January 1 to April 28 and projected mobility from April 29 to August 4, 2020.

This modeling approach sets the foundation for building scenarios for future COVID-19 trajectories both based on these covariates, but also potentially on additional ones as more information becomes available on human behaviors and changes in behavior in the coming weeks.

## Key findings from today's release (May 4, 2020)

### A focus on the US

- **Based on our updated model and latest available data, a projected 134,475 cumulative COVID-19 deaths (estimate range of 95,092 to 242,890) could occur in the US through August.** These projections are considerably higher than previous estimates, representing the combined effects of death model updates and formally incorporating the effect of changes in mobility and social distancing policies into transmission dynamics.

- New York, New Jersey, Pennsylvania, Massachusetts, and Michigan are projected to have the highest cumulative COVID-19 death toll through August (summarized in the table below). While these states have generally been among those with the highest predicted tolls from COVID-19, each of their cumulative death projections have increased by at least 2,000. This is due in part to updates to death data and modeling approaches, with the latter now estimating longer epidemic peaks and slower downward trajectories following those peaks in many locations.

| **Location** | **Predictions for cumulative COVID-19 deaths through August from our May 4 release (today)** | **Predictions from our April 29 release** | **Change of average values since the April 29 release*** |
|---|---|---|---|
| **US (national)** | **134,475 (95,092 to 242,890)** | **72,433 (59,343 to 114,228)** | **↑ 62,042 deaths** |
| New York | 32,132 (29,248 to 37,136) | 24,314 (22,649 to 28,356) | ↑ 7,817 deaths |
| New Jersey | 16,044 (11,718 to 25,654) | 7,246 (6,587 to 9,094) | ↑ 8,798 deaths |
| Pennsylvania | 8,607 (4,700 to 22,371) | 2,400 (2,098 to 3,312) | ↑ 6,207 deaths |
| Massachusetts | 7,697 (5,739 to 12,809) | 5,634 (3,391 to 13,109) | ↑ 2,063 deaths |
| Michigan | 7,080 (5,363 to 11,241) | 3,920 (3,621 to 4,834) | ↑ 3,160 deaths |
| Results as of 05/04/2020<br>© 2020 IHME<br>See terms and conditions of use, https://bit.ly/3aK1FSO | | | |

*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.

- In addition to the states listed above, our updated modeling strategy shows noticeable changes for some other states' cumulative COVID-19 death trajectories (as summarized below). Exact reasons vary by state, but at least for some states, a few commonalities emerge. Based on the latest available data and updated models, most of these states are currently experiencing or have yet to experience their epidemic peaks – all of which appear to be lasting longer and declining more slowly after their peaks. Further, for a subset of states, the easing of social distancing policies has begun and mobility patterns are on the rise (or even started increasing before easing actions occurred).

| Location | Predictions for cumulative COVID-19 deaths through August from our May 4 release (today) | Predictions from our April 29 release | Change of average values since the April 29 release* |
|---|---|---|---|
| Indiana | 6,248 (2,221 to 21,622) | 1,041 (920 to 1,430) | ↑ 5,207 deaths |
| Illinois | 6,353 (3,951 to 13,050) | 2,337 (2,157 to 2,851) | ↑ 4,016 deaths |
| Georgia | 4,913 (2,013 to 12,125) | 2,009 (1,121 to 4,850) | ↑ 2,904 deaths |
| California | 4,666 (3,107 to 9,164) | 2,104 (1,895 to 2,676) | ↑ 2,563 deaths |
| Texas | 3,632 (1,470 to 10,721) | 1,288 (774 to 2,953) | ↑ 2,344 deaths |
| Florida | 3,971 (1,991 to 11,269) | 1,898 (1,246 to 3,963) | ↑ 2,073 deaths |
| Alabama | 2,308 (479 to 11,264) | 294 (248 to 454) | ↑ 2,015 deaths |
| Results as of 05/04/2020<br> | | | |

*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.

- **Our updated modeling approach indicates that the US appears to be in a prolonged epidemic peak, averaging near or over 2,000 predicted COVID-19 deaths a day for the last few weeks.** Several states with large epidemics are following a similar trajectory (e.g., New Jersey, Pennsylvania, Massachusetts); New York is the main exception, with its predicted peak in early-mid April and gradual downward trend in predicted deaths. In contrast, several states have predicted peaks from early May into June. These include states with larger epidemics (e.g., California, Georgia, Massachusetts, Ohio, Pennsylvania, Texas), as well as others (e.g., Arkansas, Delaware, Nebraska, New Hampshire, New Mexico).

- **Starting today, our visualization tool depicts state-level changes in mobility, as well as estimated trends in COVID-19 infections and testing.** We show changes in the composite mobility indicator over time, as well as predictions, overlaid against the timing of social distancing policy implementation – and for some locations, easing. Relative to baseline levels of mobility, most states experienced substantive declines in mobility by late March or early April. Further, several states recorded decreases of at least 50% or even 60%; such states included Alaska, Colorado, Florida, Massachusetts, Michigan, New Jersey, New York, and Washington. At the same time, many states are seeing mobility rise now – and these increases appear to have begun even before policies were eased. These patterns have been observed in Alabama, Florida, Georgia, Idaho, Louisiana, Minnesota, Montana, and Texas, among others.

  **Recent progress in scaling up testing starkly contrasts with early gaps in estimated infections and confirmed cases.** This was particularly evident among states where COVID-19's toll struck earlier (e.g., Louisiana, New York) and tests were not as widely available. In recent weeks, many states appear to be testing more and/or have enough tests to keep pace with current infection predictions. However, some states have only just started to close gaps in estimated infections and testing (e.g., Connecticut, the District of Columbia, Georgia, Massachusetts, Minnesota, South Carolina); if their epidemic trajectories shift upward and/or testing rates falter, they could face challenges in effectively detecting and responding to the epidemic's next phase. Last, other states still have predicted infections that could be exceeding current levels of testing (e.g., Indiana, New Jersey, Pennsylvania); in the absence of concerted progress in testing, these locations may be at higher risk for undetected transmission among populations in the coming months.

## Initial updates in cumulative death estimates for EEA countries

- While today's release is primarily focused on US results, we have generated updated predictions for all currently included locations. We will cover results outside of the US in more depth later this week; below we summarize some of the more substantive changes in our death projections for EEA countries with an estimated 2,000 or more cumulative COVID-19 deaths through August.

- Based on the latest data and modeling updates, cumulative COVID-19 deaths could reach 40,555 (estimate range of 29,657 to 74,539) in the United Kingdom (UK) through August. This is higher than our last release of estimates; this is due to our improved modeling strategy, which allows for longer epidemic peaks and corresponding tails. Other countries also saw their cumulative COVID-19 death projections at least somewhat rise; however, their uncertainty intervals typically overlapped. Of note, Sweden and the Netherlands were among the few EEA countries that saw lower projected cumulative COVID-19 deaths compared with our last release. This pattern is related to both additional data on number of deaths since the past release and better accounting for these countries' changes in human mobility, even in the absence of more social distancing policies, in predicting epidemic peaks.

| **Location** | **Predictions for cumulative COVID-19 deaths through August from our May 4 release (today)** | **Predictions from our April 29 release** | **Change of average values since the April 29 release*** |
|---|---|---|---|
| United Kingdom | 40,555 (29,657 to 74,539) | 27,100 (22,291 to 44,203) | ↑ 13,455 deaths |
| Italy | 31,458 (29,605 to 34,969) | 27,777 (27,393 to 29,149) | ↑ 3,681 deaths |
| France | 28,859 (25,280 to 38,798) | 25,096 (23,795 to 29,099) | ↑ 3,763 deaths |
| Spain | 27,727 (25,720 to 32,130) | 25,231 (24,088 to 28,948) | ↑ 2,496 deaths |
| Sweden | 10,196 (3,474 to 37,830) | 17,337 (2,904 to 76,403) | ↓ 7,141 deaths |
| Belgium | 9,464 (8,056 to 13,936) | 7,699 (7,361 to 8,878) | ↑ 1,765 deaths |
| Germany | 8,543 (7,006 to 12,151) | 6,922 (6,055 to 9,592) | ↑ 1,621 deaths |
| Netherlands | 6,572 (5,143 to 11,613) | 9,101 (4,896 to 23,736) | ↓ 2,529 deaths |
| Switzerland | 2,148 (1,824 to 3,124) | 2,156 (1,718 to 3,994) | ↓ 8 deaths |
| Results as of 05/04/2020<br>© 2020 IHME<br>See terms and conditions of use, https://bit.ly/3aK1FSO | | | |

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## Data updates since our last release on April 29, 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 for three days (April 29, April 30, and May 1 at 5:00 pm PDT).
- Currently included locations are the United States (national level) and 50 states plus the District of Columbia, Puerto Rico, Canada (nationally and by province), and 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.

Based on currently available data and model testing progress, these are some of our immediate- and medium-term priorities:

- **Initial COVID-19 projections for additional countries**. Data collation and processing for a wider set of locations and countries worldwide are in progress. We are currently working on adapting our prediction model to countries which have experienced more than 50 total COVID-19 deaths to date. With the increasing recognition of under-counting of COVID-19 deaths in many locations outside of EEA and North America, we are now exploring methods that can approximate excess mortality and incorporate such estimates into our COVID-19 models.

## 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.](http://www.healthdata.org/covid)
**Questions? Requests? Feedback?** Please contact us here.