

Critique of the IHME Model for COVID-19 Projections

**Whitepaper Prepared for the Iowa Department of Public Health
by the University of Iowa College of Public Health COVID-19 Response Group**

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Executive Summary

This document is intended to summarize current COVID-19 modeling efforts of the Institute for Health Metrics and Evaluation (IHME) and contextualize their implications for the State of Iowa. In short, the IHME model does appear to give a reasonable estimate of the potential mortality trajectory in Iowa, but appears to underestimate the risk of experiencing a more serious outbreak. The current estimate, as of April 7, 2020, is for a total of 420 deaths with a peak on April 26. Under the assumption that “full social distancing” will be in place through the end of May 2020, the model provides a range of anywhere between 263-711 total deaths through June 1. We believe that outcomes in this range are plausible, but that a substantial risk remains of higher mortality. Additionally, the IHME model is not able to estimate the positive and negative effects of specific social distancing policies for the State of Iowa, including those policies currently in place in Iowa, and therefore has limited utility for informing public policy going forward.

The IHME approach has changed over the course of the epidemic, producing substantial revisions in predictions for the State of Iowa. It has been reliant on the relationship of the “mortality curve” between states and countries, though it has now been extended to utilize additional data sources and methodology. A comprehensive technical report describing the nature of the latest model updates is not available at the time of this writing. The shape of the trajectory from the model has been learned from daily mortality data from US states along with historical data from the Wuhan, Italy, and Spain outbreaks, and the shape of the curve from the model is updated regularly with the availability of new data in each state. To date, the trajectory in Iowa has generally followed a similar pattern to other locations, although Iowa is still in the early stages.

The IHME model does appear to account for the bundled effects of social distancing policy, even though this is not explicitly checked on the Iowa-specific page header. Although the website declares that social distancing is “not implemented” in Iowa, the model projections assume full social distancing through May 2020. Therefore, the estimates in Iowa are largely being influenced

by policy effects in other states. This is because the model is trained on data from these other locations with more stringent social distancing policies, along with the time it took other states to implement social distancing. If the states that the model are trained on have more restrictive policies or experienced greater compliance with public health recommendations, this would result in underestimating the size of the outbreak in Iowa. Mobile phone data suggest that Iowa's adherence to social distancing is lower than the majority of US states, which further enforces this point.

Given the scientific uncertainty concerning important epidemic parameters, the limitations of testing data in the United States generally and Iowa specifically, and the early stage of the outbreak in Iowa, all models, regardless of sophistication, are currently subject to substantial limitations. At this stage, we do not believe that enough data has been observed in Iowa to fit an Iowa-only curve producing reliable estimates of the epidemic peak-date or overall impact. Thus, while the current IHME model appears in line with plausible epidemic outcomes, based on an evaluation of the approach, and on our own investigations, ***we believe that a substantial risk of more severe spread remains.*** This point is particularly important, because the actions of Iowans still have great potential to change the course of the disease in the state. Although the projections of the current model appear plausible based on current numbers, the projections are predictions and we must keep in mind the uncertainty and reliability inherent in the process of prediction. It is far more likely that the model is underestimating the death toll than it is that the model is overestimating the death toll.

Introduction

The goal of this document is to gauge the applicability of the Institute for Health Metrics and Evaluation (IHME) modeling strategy to the State of Iowa. The IHME model does appear to account for social distancing policy, even if it does not directly incorporate each specific policy enacted in Iowa. Moreover, the modelling approach appears to give a reasonable estimate of the mortality trajectory in Iowa, though it may underestimate the risks of greater spread.

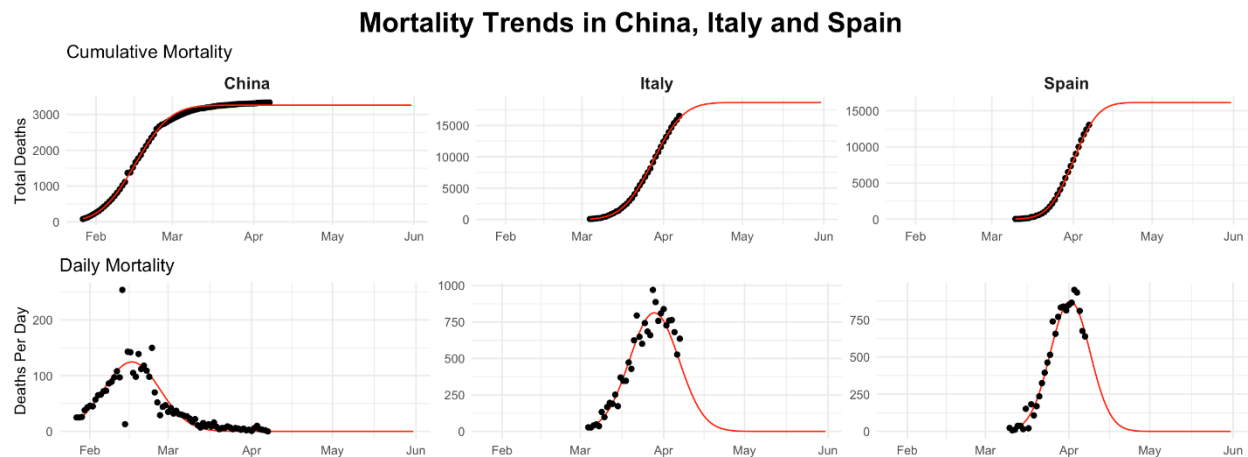
Details of the COVID-19 Model that form our opinion follow.

IHME Model

Brief Overview – The *IHME COVID-19* model is a forecasting model developed by researchers at the University of Washington School of Medicine. It was designed to forecast the trajectory of the COVID-19 outbreak across the entire US, as well as for states individually. The IHME model's ***primary*** focus is to estimate the number of deaths in each state across time. Along with the total number of deaths, the modeling approach gives an estimate of what date the outbreak is expected to reach its peak, which is specific to each state. Once the number of deaths in each state is forecast, results are then used to project the expected hospital bed utilization, along with ICU beds and ventilators needed each day. With the information on expected hospital beds, the model provides an estimate of the expected date that healthcare resources may become overwhelmed. Aggregated projections can also be viewed for the entire US.

Approach – The IHME approach is reliant on the total number of fatal cases over time, tracking a specific shape of the mortality curve. This *curve-fitting approach* is defined in order to give a consistent curve/pattern to the cumulative mortality data for each state being modeled. The curve

that is fit to the data provides an “epidemic curve” that approximately represents growth in cumulative mortality of the COVID-19 outbreak. We plot this curve to data from other countries (China, Italy, Spain) where COVID-19 outbreaks occurred prior to the United States outbreak.



The shape of the trajectory from the model relies upon daily mortality data from US states along with historical data from the Wuhan outbreak, and the shape of the curve from the model is updated regularly with the availability of new data in each state.

Statistical Modeling Specifics - The statistical specifics of the IHME model have changed over time, and at the time of this writing a technical presentation of the model is not available. Nevertheless, in general the IHME model has utilized a mixed modelling approach, where some model parameters are allowed to vary by state, while others are estimated to be similar across all states. In other words, the model assumes that the shape of the epidemic curve in one state should share similar features across states, but each state may also have its own unique aspects. Thus, as the epidemic plays out nation-wide, those states where the outbreak begins earlier (e.g., NY and WA) help to inform the trajectory in other states that are expected to peak later (e.g., IA).

The IHME model **accounts for social distancing**, doing so originally by measuring the amount of time between when a state’s mortality rate passes 0.31 cases per million and when social distancing policy is first implemented. This mechanism for accounting for social distancing may have been modified, but we can confirm that the model does indeed assume that all US states are fully pursuing this end. In addition, we know that different social distancing policies were considered: school closures, non-essential business closures, stay-at-home recommendations, and travel restrictions.

Advantages of the IHME Model

1. Uses a relatively simple, population average, modelling approach – this relies on a limited number of parameters and may tend to be more robust than alternative models that often rely on a more complex set of assumptions. The approach allows the different states to have similar shapes to their projected curves.
2. Utilizes information from other countries/states, that may be further ahead on the epidemic curve, when estimating the trajectory for individual states that may be further behind. This

allows the model to make reasonable projections in a state like Iowa, where very limited data are currently available. If Iowa implements strong social distancing measures throughout the remaining course of the epidemic, it is reasonable to assume that our shape will be similar to the other states and countries that experienced earlier outbreaks.

3. Utilizes mortality data for estimating the shape of the epidemic curve, which may be more accurate/stable than using identified case counts. We know that case counts are severe undercounts with lags in testing and that during the epidemic rates of testing have begun to increase. However, we assume that mortality data is more accurate.
4. Frequently updated with new data from each state (every 4 days). The IHME group summarizes changes that occur with these updates and model performance is compared across updates.
5. Does not rely on disease specific parameters – many of the disease specific parameters (e.g., R_0 , case-fatality rate, case-hospitalization rate, etc.) remain largely uncertain with COVID-19.

Limitations of the IHME Model

1. Likely produces interval estimates which are too narrow, failing to capture the full uncertainty about the course of the outbreak in individual states.
2. Assumes that the shape of the epidemic curve is reasonably symmetric. This detail makes the tail of the distribution likely too low, and the confidence interval at the end of the epidemic far too narrow.
3. Does not model individual sub-populations (e.g., age-groups, counties, healthcare settings).
4. Does not model transmission, or individual actors or settings. This means that exact results of social distancing and stay at home policies cannot be determined. Importantly, ***the IHME model cannot estimate the effect of implementing additional or more stringent social distancing measures or of relaxing the social distancing measures already in place.***
5. May underestimate the trajectory of an outbreak, if trained on data from locations with more effective social distancing policies. This is likely the case, as mobile phone data seem to suggest that adherence to social distancing in Iowa is low, while social distancing policy actions were far more restrictive in other locales, e.g., Wuhan. Similarly, if states further ahead have implemented more restrictive policies or experienced greater compliance with public health recommendations, this distinction may be missed.
6. Limited in scope - because IHME is not examining the transmission process, it ***cannot be used to model a secondary outbreak*** (e.g., in the fall, or if social distancing is relaxed).
7. Potentially less accurate in mapping healthcare utilization and ICU beds. These projections rely on mappings to the estimated mortality rate. These do not appear as accurate for all states and may need to be scaled back for Iowa.
8. Is impacted by modifications to the methodology over time. Thus, the corresponding changes in predictions for Iowa reflect the large but potentially underreported model uncertainty.

Applicability to Iowa

The modelling approach appears to give a reasonable estimate of the mortality trajectory in Iowa, but policymakers should be mindful that the model likely underestimates the potential for significantly more severe outcomes. We base this opinion on the following points.

1. The model *does* appear to be considering social distancing efforts in Iowa, projections, even if this is not explicitly checked on the Iowa-specific page header. Any deviation between the social distancing policies and general practice in Iowa, and as defined in the model, could lead to underestimated mortality outcomes.
2. While the model may not directly consider Iowa-specific policies, the estimates in Iowa are largely being influenced by policy effects in other states. With little mortality data available in Iowa, the model must rely heavily on how the outbreak has played out in other states/countries that are further along the epidemic curve. Most of these states have as aggressive, or more aggressive, policies on social distancing in place. In other words, the estimated shape of the epidemic curve in Iowa is being “learned” by evaluating the epidemic curve in other states, along with the time it took other states to implement distancing. Because of this, the Iowa projection is being indirectly influenced by policies in other states. To evaluate the applicability of the predictions, we can ask the simple question: *“is the information obtained from other states causing the model to over- or underestimate the peak in Iowa?”*

Another consideration in the applicability of the IHME model to Iowa is the dynamic nature of its forecast estimates. Because Iowa is further behind many other states in the timing of the epidemic, and because Iowa has a population that differs in many characteristics from states that experienced the outbreak earlier, the model forecast is likely to change as new data becomes available in both Iowa and other states or countries. In the figure below, we have plotted different projections from the IHME that were forecast on three different dates after new data was available: March 29, April 1 and April 6. The total cumulative mortality in these estimates were 138, 1,488 and 420, respectively. Notice also that the confidence bounds of all three cumulative death estimates did not overlap. Thus, it is likely that there will exist future updates to the forecast that may differ from current projections, and such estimates may lie outside of the confidence bounds of the current model.

General Limitations of Modeling in Iowa

Given the scientific uncertainty concerning important epidemic parameters, the limitations of testing data in the United States generally and Iowa specifically, and the early stage of the outbreak in Iowa, all models, regardless of sophistication, are currently subject to substantial limitations. We do not believe, at this stage, that enough data has been observed in Iowa to fit an Iowa-only curve producing reliable estimates of the epidemic peak-date or overall impact. We believe, therefore, that it is necessary to rely on information from other states. As such, we believe that the approach used by IHME is reasonable, albeit still subject to substantial uncertainty. Our evaluation of the model, and our own investigations, indicate that while the approach taken by IHME is reasonable, it likely underestimates the risk of more severe epidemic outcomes.

Historical IHME Forecasts

