Editorial

by Gurumurthy Kalyanaram

COVID 19: Forecast of the diffusion

by Gurumurthy Kalyanaram

This manuscript is also available at:
https://gkpolicybriefs.com/briefs/covid-19-forecasting-models

There are many epidemiological, econometric and statistical models that have been designed and developed to forecast the diffusion trajectory of Covid 19, and to forecast the mortality and resource utilization.

We have developed a very parsimonious and elegant model to forecast the mortality. This is an application of The Bass Model. We show that the Bass Model does as well as the other extant and sophisticated models.

This model has been published in the most recent issue of *the International Journal of Pharmaceutical and Healthcare Marketing (IJPHM)* with commentaries from four distinguished scholars and one eminent practitioner.

"We calibrated the model for deaths for the period, March 21st to April 30th for the United States as a whole, and the U.S. States of New York, California and West Virginia. We used the daily data from the COVID-19 Tracking Project, which is a volunteer organization launched from The Atlantic. Every day, data is collected on testing and patient outcomes from all the 50 states, 5 territories, and the District of Columbia. This dataset is widely used by policy makers and scholars. We examined the fit of the model (F-value and its significance, R-Square value) and the statistical significance of the variables (t-values) for each one of the four estimates. We also examined the forecast of deaths for a 3-days period, May 1st to 3rd for each one of the four estimates – US, and States of New York, California and West Virginia. Based on these metrics, we assessed the viability of the Bass Model. The dependent variable is the number of deaths, and the two independent variables are cumulative number of deaths and its squared value. The findings of this paper show that compared to other forecasting methods, the Bass Model performs remarkably well. In fact, it may even be argued that the Bass Model does better with its forecast. The calibration of models for deaths in the US, and States of New York, California and West Virginia. Are all found to be significant. The F values are large and the significance of the F values is low, that is the probability that the model is wrong is very miniscule. The fit as measured by R-Squared is also robust. Further, each of the two independent variables is highly significant in each of the four model calibrations. Our forecasts also approximate the actual numbers reasonably well." (Kalyanaram and Mukherjee, 2020.)

Here, we present a few other representative models with the important and relevant highlights. *These models are described and presented in our IJPHM paper (Kalyanaram and Mukherjee 2020) and in my paper submitted to Society for Advancement of Management Journal (Special Issue) (Kalyanaram 2020). These are direct excerpts from these two manuscripts. We acknowledge these two journals here.*

"SEIR Theory

This is the basic epidemiological theory/framework. Here, the population is described to be in one of four stochastic states: Susceptible, Exposed, Infectious and Recovered (looping back to Susceptible state). Assume S is the fraction of susceptible individuals (those able to contract the disease), E is the fraction of exposed individuals (those who have been infected but are not yet infectious), I is the fraction of infective individuals (those capable of transmitting the disease), and R is the fraction of recovered individuals (those who have become immune). Then we have:

$S + E + I + R = 1$

There are four differential equations each describing one of the four states.

University of Washington's Institute for Health Metrics and Evaluation (IHME) Model

This model has received much acclaim and attention from policy makers, scholars and media. The IHME model is not based on epidemiology. It is a statistical model based on data. This model provides numerical forecasts of total deaths and daily deaths. It also provides an estimate of testing capacity and required hospital resources which is decomposed into three components: all beds, ICU beds, and invasive ventilators. The model is also elegant in that it provides forecast estimates under three scenarios: current status, easing of the conditions, and mandatory universal mask. Accordingly, this model is rich. For more details, please see: http://www.healthdata.org/

Covid Act Now

In partnership with Georgetown University Center for Global Health Science and Security, Stanford University Clinical Excellence Research Center, and Grand Rounds, a multidisciplinary team of technologists, epidemiologists, health experts, and public policy leaders have designed Covid Act Now. The underlying model is based on the fundamental SEIR theory. The forecast estimates are produced in percentage for the following parameters: infection rate; positive test rate; ICU headroom used; and contacts traced. See here for more details: https://covidactnow.org/about

Covid 19 Simulator

Designed by Massachusetts General Hospital and Harvard Medical School in partnership with Georgia Tech University and Boston Medical Center, this model combines infectious disease theory and statistical methodology. The Simulator estimates the required number of hospital beds and ICU beds based on its forecasts of cumulative and daily mortality. Please see here for more details: https://www.covid19sim.org/

Northeastern University Model

This is an individual-based stochastic model which uses actual data to perform simulations to estimate the diffusion of COVID-19 under various assumptions of mitigation and social distancing. Using Bayesian updates, the model accounts for new data (Chinazzil *et al.,* 2020). The model produces forecast estimates of the total number of hospital beds and ICU beds that will be required. For details, see: https://covid19.gleamproject.org/

Columbia University Model

The model produces projections for daily mortality and infections. The model also projects the cumulative demand of hospital beds, ICU and ventilators as well. These projections are made based on four scenarios of social distancing ranging from no-distancing to substantial-distancing (Pei and Shaman, 2020). Based on how levels of social distancing will change in the future, this model assumes a 20% reduction in contact rates for each successive week that stay-at-home orders remain in place and a 5% increase in contact rates per week once a state has re-opened. For details about the model and estimation, please see: https://github.com/shaman-lab/COVID-19Projection

Johns Hopkins University Model

The model offers a flexible framework to calibrate the diffusion trajectory and the impacts under various assumptions of policy and/or behavioral interventions. The model requires multiple components as inputs into the model. For more details, please see here:
https://github.com/HopkinsIDD/COVIDScenarioPipeline

Los Alamos Model

This model consists of a statistical model of COVID-19 infections. The number of infections is then mapped to the actual data. The model forecasts are probabilistic. For more details, please see: https://covid-19.bsvgateway.org/

MIT Model

This is an operations-research model where optimization is done under various assumptions. The model is fairly complex and intensely computations-based. However, the projections assume that current interventions will remain in place indefinitely. For details, please see: https://www.covidanalytics.io/

Northeastern University Model

This is an individual-based stochastic model which uses actual data to perform simulations to estimate the diffusion of COVID-19 under various assumptions of mitigation and social distancing. Using Bayesian updates, the model accounts for new data. For details, see: https://covid19.gleamproject.org/

The UT Austin Model

This model estimates the extent of social distancing using geolocation data from mobile phones, and it assumes that the extent of social distancing does not change for the model's forecasting period. As with other models, this model makes predictions only for one wave of the infection. The model forecasts the daily mortality.

UCLA Model

This is an augmented SEIR model that also takes into consideration the untested/unreported cases of the infection. Here the assumptions are this. COVID-19 has an incubation period of 2 to 14 days. However, individuals who have been exposed to the virus are also likely to infect the susceptible group. For additional details, please see: https://covid19.uclaml.org/model.html

Youyang GU Model

This prediction model adds the power of data and artificial intelligence to the SEIR model which forms the basis for the simulation. The simulation inputs are then learned using machine learning techniques “to minimize the error between the projected outputs and the actual results.” The model is robustly validated including correcting for “overfitting.” For more details, please see: https://covid19-projections.com/about/#about-the-model"

__Dr. Gurumurthy Kalyanaram (GK)__, a resident-scholar alumnus of the Wilson Center and a doctoral alumnus of MIT, is a global academic, a management and policy consultant, and an Education Counselor to MIT. He has contributed and continues to contribute as Adviser, Counselor, Dean, Director, and Professor in academe. Dr. Kalyanaram serves on the advisory boards of several scholarly journals, think-tanks and businesses.

Dr. Kalyanaram is a well-cited scholar and an institution builder. He has had affiliations with many prestigious universities such as MIT, The University of Texas, Frankfurt School of Finance and Management, International University of Japan, Jiang Xi School of Economics and Finance, KIMEP (Kazakhstan), London School of Economics, MIT Asia School of Business, Saint Petersburg University (Russia), and Vienna University of Economics and Business globally, and Amrita University, NMIMS University and Tata Institute of Social Sciences in India.

For his services, MIT has recognized Dr. Kalyanaram with Harold Lobdell Award, and Honor Roll of Service.
http://www.gkeducationalservices.com/
https://gkpolicybriefs.com/

Dr. Kalyanaram serves as the Editor-in-Chief of NMIMS Management Review, NMIMS Economics and Public Policy, and NMIMS Engineering and Technology Review.