Analysing Covid-19 Epidemic Trajectories: are Countries Flattening the Curve?

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Abstract

Introduction: According to the World Health Organization (WHO), Corona virus disease 2019 (COVID19) reached the pandemic phase on March 11, 2020. As of April 29, 2020, it had spread to more than 200 countries worldwide, leading to 2,954,222 registered infections and 202,597 deaths. Particularly alarming characteristics of COVID-19 are its very high spreading rate with Reproduction Number higher than influenza [1], and severe illness trajectory observed in some patients requiring lengthy hospitalization and high-intensity care [2]. Hence, governments around the world considered, and to some extent, implemented a range in measures aimed at limiting people movements and interactions to attempt slowing down transmission of the COVID19 and to dampen the severity of the epidemic trajectory.

Methods: We used open-domain data on COVID-19 reported cases and deaths per country per day. A subset of 47 countries was analysed. Data were fitted with an analytical model following Gompertz equation. Uncertainty pertaining to the model forecasts was also quantified. To relate differences in epidemic trajectories of different countries to the mitigation approach taken by governments of those countries, we made use of the COVID-19 Government Response Stringency Index developed and published by Oxford University and Blavatnik School.

Results: Acceptable quality fits were obtained for all the countries with R2 mostly in excess of 0.98. Uncertainty on the final Cases and/or Deaths count is typically a factor of two early in the epidemic but this quickly reduces as the epidemic progresses. Uncertainty on Epidemic Duration also reduces but less fast. Statistics on key parameters like Epidemic Duration, Epidemic Peak and Final Mortality Rate were obtained and then cross-correlated with the rigor of government measures as recorded in the Stringency Score. Most significantly, we find a clear trend of decreasing Peak Epidemic height (and to a less extent, shorter Epidemic Duration) with increased Government Stringency at the epidemic onset. We also find that Final Mortality Rate decreases with increased Stringency of Government Testing and Contact-Tracing.

Conclusions: We observe that the modelled epidemic curves of various countries generally look remarkably similar and mimic the observed trajectory shape of the epidemic in China. That is, the increase in the number of Cases from time of epidemic onset to Epidemic Peak is steeper than the subsequent decline. The Gompertz model allows for a good quality of fit to the data and can capture this asymmetry adequately. Our approach to estimating uncertainty which we validated via a blind test to China data suggests that the model prognoses included the estimated uncertainty bands become robust shortly after the time of Epidemic Peak.

The observed relationship between recorded Government Stringency at the time of epidemic onset and the height of the Epidemic Peak (and to a less extent, Epidemic Duration), is significant and impactful. It suggests that government measures taken very early in the epidemic have the potential to significantly suppress the Epidemic Peak (reduce the maximum number of cases per day by a factor of 10 or more) and also shorten the Epidemic Duration. On the other hand, measures taken later on in the epidemic (around Epidemic Peak time or later) appear to not impact the epidemic trajectory significantly any more. This hypothesis appears one plausible explanation for the differences in epidemic trajectories between Switzerland and Romania, the example we highlighted earlier..

Keywords

COVID-19; Epidemic Trajectory; Epidemic Forecasts; Gompertz model; Government Stringency