Survival-Convolution Models for Predicting COVID-19 Cases and Assessing Effects of Mitigation Strategies

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Research in context

Evidence before this study

The COVID-19 has created major health crisis around the world. As countries respond to the pandemic, it is urgent to predict disease epidemic and compare containment and mitigation efforts between countries to investigate their impacts on infection rates. We searched PubMed for studies published in English up to April 2020, with the terms "COVID-19", "coronavirus", "SARS-CoV-2","2019-nCoV" AND "transmission", "dynamics", "model", "estimate", "forecast", "intervention", "control measures". We found several infectious disease models for epidemic in China, other Asian countries, and Europe, and predictions of mortality rate and hospital demands in United Kingdom and United States. A few studies have investigated the impact of control measures based on simulations. However, existing models for COVID-19 are based on susceptible-exposed-infected-removed (SEIR) models for prior influenza and SARS epidemics, which involve a large number of parameters and may susceptible to perturbation in parameters. No published work has used a parsimonious survival model to directly predict daily new case or use natural experiment design to estimate intervention effect.

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Added value of this study

We present a parsimonious and robust survival convolution model to predict daily new cases and daily hidden latent cases with a few model parameters and assumptions, and estimate intervention effects across countries under longitudinal pre-post quasi-experimental. Our model may provide narrower confidence intervals and more accurate prediction than existing methods based on SEIR models. In China and South Korea, we predict the entire disease epidemic using only data two to three weeks after the outbreak. In Italy, there was no significant effect of national-wide lockdown measured by the difference in the trend of R_t. In the US, series of response measures implemented across states before March 13 has made a significant impact on changing R_t. Early response measures implemented in China and South Korea have reduced the infection rate faster than Italy and the US. Italy's R_t has remained around 1·0 for more than two weeks since March 26, while in the US R_t continues to decrease.

Implications of all the available evidence

Implementing response measures earlier in the disease epidemic reduces the disease transmission measured by R_t at a faster speed. Thus, for regions at early stage of disease epidemic (e.g., South America), mitigation measures should be introduced early. Nation-wide lockdown may not further reduce the speed of R_t reduction compared to regional quarantine measures. In countries where disease transmission has slowed down, lifting of quarantine measures may lead to a persistent infection rate delaying full control of epidemic and thus should be implemented with caution.