Models of coronavirus underestimate the epidemic's peak and overestimate its duration

7 April 2020

Credit: CC0 Public Domain

Many of the models being used to forecast the COVID-19 epidemic give poor predictions of both the epidemic's peak and its duration—according to an academic at the University of East Anglia (UEA).

Comparison of a new approach with a published model of COVID-19 in Wuhan before isolation and social distancing measures were imposed shows that the standard model underestimates the peak infection rate by a factor of three—meaning it could be three times higher—and substantially overestimates how long the epidemic will continue after the peak.

Mathematical models are widely used to understand and predict the dynamics of epidemics, and to assess the likely effectiveness of different disease management measures such as quarantining of infected individuals.

Some track the progress of the disease through individuals, but most publications that model the COVID-19 epidemic use what is known as a 'compartment' or "SEIR' model. This tracks numbers of individuals that are Susceptible to the disease, have been Exposed but not yet showing symptoms (sometimes called the incubation period), are Infected (showing symptoms) or Recovering.

However, these models group all individuals in a compartment together, ignoring the actual time since they were infected. They then predict the future course of the epidemic from information on rates of transmission and the average time that an individual takes before they show symptoms and then to recover.

In his paper Prof Alastair Grant, of UEA's School of Environmental Sciences, argues that while SEIR and other compartment models can predict how far the disease transmission rate needs to be reduced to stop an epidemic growing, they do a poor job of predicting the path of an epidemic that is growing. He says this problem was identified in the research literature at least 15 years ago, but the available solutions to it are far more difficult to use than the SEIR model.

Attempting to address this Prof Grant, who has previously introduced key methodological tools into matrix population modelling, presents a new approach that tracks the time since individuals were infected, while retaining the simplicity of a model that can be described in a few lines of code.

Due to the rapid-response nature of this research, it has not yet been peer-reviewed.

"Standard compartment models of disease, such as SEIR, are being widely used to model the dynamics of the COVID?19 epidemic," said Prof Grant.

"However, they do not accurately capture the distribution of times that an individual spends in each compartment, so do not accurately capture the transient dynamics of epidemics.

"This paper shows how matrix models can provide a straightforward route to accurately model stage durations, and therefore correctly reproduce epidemic dynamics. Our explicit time model shows that the peak of infection may be either earlier or later than the peak in the simple SEIR model.

"I believe that the approach outlined here provides a valuable solution to the problem of incorporating a time dimension within each compartment. This model could readily be adapted and we hope that it will be of some use to the COVID?19 modelling community."

Prof Grant cautions that the implications of these findings for state policies to manage of COVID?19 epidemics are not clear.

"If SEIR models use parameter values estimated independently from data they will underestimate the proportion of the population which will be infected at the epidemic's peak," said Prof Grant. "But, if inverse modelling uses SEIR models to estimate parameters from disease time series, they may give estimates that are too pessimistic.

"National policies are guided by a range of disease models, including ones which deal more effectively with the known time course of infection within individuals, but details of this modelling work are not always made public.

"However, the domination of the published scientific literature by compartment models may be in danger of creating a discontinuity between the views held in the research community and the modelling that is informing national decision making about the management of COVID?19."

"Governments must make available details of the models that provide the basis for policy decisions, so that the scientific community can critically assess these and help to improve the quality of predictions being made.

"Dynamics of COVID-19 epidemics: SEIR models underestimate peak infection rates and overestimate epidemic duration" is published on the preprint server MedRvix, on April 6, 2020.

More information: Alastair Grant. Dynamics of COVID?19 epidemics: SEIR models underestimate peak infection rates and overestimate epidemic duration, (2020). DOI: 10.1101/2020.04.02.20050674

Provided by University of East Anglia