Simple Formulae, Deep Learning and Elaborate Modeling for the Covid-19 Pandemic

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Predictive modelling of infectious diseases is very important in planning public health policies, particularly during outbreaks. This work reviews the forecasting and mechanistic models published earlier. It is emphasized that researchers' forecasting models exhibit, for large t, algebraic behavior, as opposed to the exponential behavior of the classical logistic-type models used usually in epidemics. Remarkably, a newly introduced mechanistic model also exhibits, for large t, algebraic behavior in contrast to the usual Susceptible-Exposed-Infectious-Removed (SEIR) models, which exhibit exponential behavior. The unexpected success of researchers' simple forecasting models provides a strong support for the validity of this novel mechanistic model. It is also shown that the mathematical tools used for the analysis of the first wave may also be useful for the analysis of subsequent waves of the COVID-19 pandemic.

Keywords: COVID-19 ; forecasting model ; SARS-CoV-2 ; variant of concern ; VOC

The first period of the COVID-19 pandemic in Europe, often referred to as 'the first wave', provides an ideal situation for the retrospective study of the various mathematical formulations used for modelling the dynamics of this viral epidemic. Indeed, during this phase, many European countries employed similar measures for combating the spread of the epidemic, and moreover, the pandemic was dominated by a single viral strain. Such a study is not only useful for academic purposes, but also, importantly, could identify an accurate mathematical formalism that could be used in a variety of epidemiological phenomena.

In the framework introduced by Holmdahl and Buckee [1], epidemiological models are broadly divided into two categories: *forecasting* and *mechanistic*. The former models fit a specific formula to the data, and then attempt to predict the dynamics of the quantity under consideration. The main limitation of these models is that they usually remain valid for a short period of time, and specifically only if the epidemiological situation remains unchanged. For example, they can be used during a lockdown period, but will not make accurate predictions after the lockdown is lifted. In contrast to forecasting models, mechanistic models can make predictions even when the relevant circumstances change. The main limitation of the forecasting models is the difficulty of determining the parameters specifying them.

In what follows, the researchers first discuss specific forecasting and mechanistic models introduced by the collaborative efforts published in [2][3][4][5][6][7][8]. In particular, the researchers provide an explanation for the remarkable success of researchers' simple forecasting models for predicting the dynamics of the first wave. The researchers then emphasize that the tools introduced for the analysis of the first wave can also be useful for analyzing subsequent waves of the COVID-19 pandemic. This is illustrated with a brief discussion of the second wave.

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