Journal of Data Science 18 (3), 473–474
July 2020
DOI: 10.6339/JDS.202007_18(3).0011

Discussion of "Tracking reproductivity of COVID-19 epidemic in China with varying coefficient SIR model"

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Sun et al. proposed a vSIR model with both time-varying transmission rate and removal rate. Based on the traditional SIR (Kermack and McKendrick, 1927) and SEIR (Hethcote, 2000) models, the authors introduced some random mechanisms for the daily changes of infected (I) and removal (R) individuals by assuming the Poisson increments: $\Delta I(t)$ and $\Delta R(t)$. Also, the effective reproduction numbers calculated by the vSIR model were time-varying with corresponding 95% confidence intervals, which could effectively reflect the intervention policies of COVID-19 in different regions. In our discussion, we focus on the following points.

The spreads of COVID-19 The spreads of COVID-19 in different regions of China were accurately estimated. From January 27 to February 17, 2020, the effective reproduction numbers of COVID-19 in 30 provinces and 15 cities in Hubei Province decreased significantly. The effective reproduction numbers had dropped below 1 from February 10 to 17, 2020 in most provinces, indicating that the epidemic situations in most areas in China had been controlled after the implementation of a series of interventions and control measures, which was similar to the conclusion of Tan et al. (2020).

The authors also predicted the ending times of the COVID-19 epidemic through the model by considering the numbers of cumulative infected cases. By setting the recovery rate to 0.1, their model estimated that the number of infected individuals would be significantly reduced during March in China. They obtained the conclusion that the epidemic of COVID-19 outside Hubei province would be approaching to an end in April. These estimations gave rise to a realistic predicted trend of the epidemic, which were close to those of Cui and Hu (2020).

Estimation of R_t^{14} The R_t^{14} was overestimated. The basic reproduction number (R_0) can be considered as the expected number of cases directly infected by one primary case in a population where all individuals are susceptible to infection (Anderson and May, 1992). According to R_0s of COVID-19 reported by Liu et al. (2020), R_0s were between 1.4 and 6.49, with an average of 3.28 and a median of 2.79. For the 14-day time-varying effective reproduction number R_t^{14} defined in the vSIR model, R_t^{14} of 7 cities in Hubei province reached 7.59 on January 27. Since January 23, 2020, the Chinese government has taken stringent measures such as traffic blockade to curb the epidemic. The R_0 of COVID-19 could be similar to the time-varying effective reproduction number in Hubei province in the early period, or even higher than R_t^{14} of Hubei province on January 27 as reported by Tan et al. (2020). Thus, the value of R_t^{14} was relatively high in the early stage of COVID-19 in Hubei province, which may be overestimated.

Factors Affecting the Infection Rate This article did not take into account the infectivity of the infected individuals or the population of migrants between different areas and some parameters are needed to be given in advance. There could be more considerations in the vSIR model.

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For example, the confirmed cases could not be infectious once they have been quarantined, while the infected individuals who should be considered as infectious hosts during the incubation period (Tan et al., 2020; Yang et al., 2020), which is not reflected in the SIR or SEIR model. At the same time, if the method is extended to various countries, the impact of population mobility in different regions could be considered (Yang et al., 2020; Gilbert et al., 2020). Besides, for the predictions from the model in the paper, the parameters in the vSIR model were needed to be specified beforehand. When the model is used to different countries and regions, it may be necessary to adjust the corresponding parameters subjectively to get better prediction results.

Summaries The authors proposed an adjusted SIR model: vSIR model, which can calculate effective reproduction numbers of different regions over time, and make predictions for the future trend. It is effective to evaluate the early epidemic situations in different regions. However, the paper overestimated the value of R_t^{14} in the early stage of the COVID-19 in China and the parameters in the vSIR model were needed to be specified in advance. Furthermore, if the infectivity of infected individuals during the incubation period and the mobility of the population are incorporated into the model, it would make the model more realistic.

Acknowledgment

Wang's work was supported in part by the National Natural Science Foundation of China (Grant No.11771462).

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