A stochastic SEIHR model for COVID-19 data fluctuations

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Abstract

Although deterministic compartmental models are useful for predicting the general trend of a disease's spread, they are unable to describe the random daily fluctuations in the number of new infections and hospitalizations, which is crucial in determining the necessary healthcare capacity for a specified level of risk. In this paper, we propose a stochastic SEIHR (sSEIHR) model to describe such random fluctuations and provide sufficient conditions for stochastic stability of the disease-free equilibrium, based on the basic reproduction number that we estimated. Our extensive numerical results demonstrate strong threshold behavior near the estimated basic reproduction number, suggesting that the necessary conditions for stochastic stability are close to the sufficient conditions derived. Furthermore, we found that increasing the noise level slightly reduces the final proportion of infected individuals. In addition, we analyze COVID-19 data from various regions worldwide and demonstrate that by changing only a few parameter values, our sSEIHR model can accurately describe both the general trend and the random fluctuations in the number of daily new cases in each region, allowing governments and hospitals to make more accurate caseload predictions using fewer compartments and parameters than other comparable stochastic compartmental models.

Full Text

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