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WITH-IN-HOST MATHEMATICAL MODELING FOR COVID-19

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Two mathematical models are proposed to represent the within-host dynamics of the SARS-CoV-2 virus. The first proposed model contains the interaction between interferon responses, host cells, and viral dynamics of the SARS-CoV-2 virus. The second model considers the innate and adaptive immune responses against the viral infection, a more detailed version of the first model. We developed two-compartment models using ordinary differential equations to represent the rate of change of host cells, viral load and immune responses. Data fitting and numerical simulation show that viral replication below the detectable level, 18 – 22 days after onset of symptoms. We considered different starting times of infection to maintain high accuracy. The parameters were estimated using a fit-model function in the python package to best fit the actual viral load data of two infected patients. The results show that the second model, including innate and adaptive immune responses, best fit the available data. Two sets of parameters for each model were estimated using the available viral load data of the two patients. Hence, four sets of parameters and four basic reproduction numbers were calculated as 4.383, 4.635, 8.892 and 8.841 using these two proposed models. The resulted reproduction numbers show that the SARS-CoV-2 virus had higher cellular level infectivity inside the host. Both the model with interferon responses and the model with immune responses predict that the virus may clear after 28 – 33 days from the onset of symptoms.

Keywords: COVID-19, Immune response, Interferon, Mathematical modeling, Within-host dynamics