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Assessing the impact of vaccination on the spreading of COVID-19 through mathematical modeling

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Presently, COVID-19 (CoronaVirus-2019) virus attacks the whole world due to its high transmission rate. As a result of the efforts of several countries, many vaccines have been invented at present. Several compartmental mathematical models for COVID-19 can be found in the literature. In this paper, a new mathematical model that consists of eight compartments; susceptible (S), exposed (E), vaccinated (V), infected (I), self-quarantine (Q_1), quarantine in centers (Q_2), hospital isolated (H), and recovered (R) is proposed. Based on the model, the effectiveness of the vaccination factor for the spread of the disease is performed. Based on the matrix operator method, the disease-free reproduction number, R_{df}, of the model is derived. We estimate the effectiveness of the model parameters on the spread of the disease by analyzing the sensitivity of R_{df}. Based on the results, we observed that the vaccination rate is the most effective parameter, and the next effective parameter is the disease transmission rate. We determine the least vaccination rate (critical vaccination rate) which is required to prevent the spreading of the disease and interpret the variation of the population sizes against the vaccination rate.

Keywords: Disease-free reproduction number, Vaccination, Sensitivity analysis, Critical point

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