Global Dynamics of a Fractional-order HFMD Model Incorporating Optimal Treatment and Stochastic Stability

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ABSTRACT

Hand, foot and mouth disease (HFMD) is highly contagious and occurs primarily among children under the age of five. Analysis of transmission dynamics of infectious diseases is essential to prevent the adverse effects caused by the diseases. The current study presents a fractional-order SEIR-type epidemic model to investigate the dynamics of HFMD transmission. The biological feasibility of the proposed model system is demonstrated from an epidemiological perspective. The basic reproduction number, R_0, is obtained through the next-generation matrix approach. Around the feasible equilibrium points, the asymptotic dynamics of the proposed model system are examined, both at local and global levels. It is found that, the model undergoes transcritical bifurcation at $R_0 = 1$. As a result, R_0 plays the role of threshold in determining the future course of the disease. The optimal treatment control of fractional epidemic models is less explored. Here, an optimal control problem is formulated considering a time-dependent treatment measure $u(t)$ both in exposed and infected classes. The findings are also visualized and verified by simulating the model using some feasible parameter values, from which it can be concluded that fractional-order gives better results. A gradual decrease in the total cases as well as in the peak is observed in the presence of treatment control. Further, we extend the study in a stochastic environment with the help of white noise and investigate the stochastic stability of the endemic equilibrium point. Finally, parameters defining the threshold quantity R_0 are scaled with the normalized forward sensitivity index.

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