Abstract No: PO-41

Qualitative and quantitative analysis of the dengue fever model with reference to the data obtained from Sri Lanka

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Dengue is a rapidly emerging pandemic disease in many parts of the world, especially in tropical and non-tropical areas. The dengue outbreak has a multisectoral impact on the medical, societal, economic, and political sectors. The main economic impact of dengue is due to production costs. Lower-income groups may be more vulnerable to dengue and may also bear a higher financial cost as a result of it. Moreover, once a family's primary wage worker contracts the sickness, the lost productivity that results from the illness puts a financial strain on the family. This affects the household's ability to pay for treatment. Resource-poor countries are particularly hard hit because of inadequate public health infrastructure, lack of resources to combat the vector, and limited health care services to manage cases. Dengue incidence has increased in Sri Lanka over the past 20 years, with deaths and illnesses increasing disproportionately among adults compared to children. Dengue fever is caused by Dengue virus, first recorded in the 1960s in Sri Lanka. Aedes aegypti and Aedes albopictus are both mosquito species native to Sri Lanka. In this study, a SIR model for the human population and SI model for the vector (mosquito) population with a constant treatment function is considered to describe dengue transmission. The equilibrium points and the basis reproduction number (R_0) are computed. It is emphasized that reproduction number affects the asymptotic stability for both endemic and disease-free equilibrium points. The conditions leading to the disease-free and endemic equilibrium are determined. The eigenvalues of the Jacobian matrix corresponding to the reduced system are used to demonstrate the local stability for the equilibrium points, and the Lyapunov function theory is used to assess the global stability. When $R_0 \leq 1$, the disease-free equilibrium point exhibits global asymptotic stability. But as $R_0 > 1$, the endemic equilibrium point becomes globally asymptotically stable. Based on actual data gathered from the Institute of Epidemiology Unit Ministry of Health in Sri Lanka, the parameters for infection and disease-related death rates are estimated. The numerical simulation is used to validate the findings of the analytical results. It is important to determine a suitable capacity for treating a disease. We have observed that the treatment function affects the infected compartment. That is, the increased rate of treatment function reduces the infection. This shows that to eliminate the disease adequate treatment facilities must be provided.

Keywords: Dengue disease, Treatment function, Reproduction number, Global stability, Lyapunov function