Mathematical Model for Dengue Transmission Dynamics

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Mathematical Model for Dengue Transmission Dynamics

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ABSTRACT

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, economical, and political sectors. Dengue incidence has increased in Sri Lanka over the past 20 years, with deaths and illnesses. Almost all the districts in Sri Lanka have reported cases and posed a threat to the health of the people. Dengue fever is caused by dengue virus, first recorded in the 1960s in Sri Lanka. In this study, we propose a mathematical model to describe the transmission of dengue with a standard incidence rate for both human and vector populations. The impact of treatment capacity in the case of an epidemic scenario has been studied by using a constant treatment function. The equilibrium points and the basic reproduction number are computed. The conditions leading to the disease-free and endemic equilibrium are determined. We observed that the reproduction number affects the asymptotic stability for both disease-free and endemic equilibrium points. The Lyapunov function theory is used to discuss the global stability. Based on actual data of infective population gathered from the Institute of Epidemiology Unit Ministry of Health in Sri Lanka, the parameters for infection and disease-related death rates are estimated. Numerical simulations of various compartments are used to investigate the impact of the key parameters affecting the disease's transmission.

KEYWORDS: Global Stability, Lyapunov Function, Reproduction Number, Standard Incidence Rate, Treatment Function

1 INTRODUCTION

A broad spectrum of diseases is brought on by dengue ranging from subclinical infection to severe flu. Effective mosquito management is the cornerstone of dengue prevention in the absence of an antiviral medication or vaccine (Wickramaarachchi et al., 2018). There are no specific antiviral drugs to treat dengue infection. The creation of the vaccine is crucial for eradicating the disease (Bhatt et al., 2013) parallel to vector management to control the spread of dengue. To explain this kind of phenomenon, epidemiologists have used mathematical modeling as a tool. Mathematical modeling gives precision and strategy for problem solutions and provides a systematic understanding of the system modeled. So in this study, a new mathematical model related to SIR and SI Mathematical Models with standard incidence rate and a constant treatment function is proposed to describe the dynamics of transmission of dengue.

2 METHODOLOGY

2.1 Model Formulation

In forming our model, it is assumed that all newborn humans, as well as mosquito populations are infection free and susceptible. Furthermore, it has been considered that all the susceptible and infected humans and vectors are homogeneously mixing with each another. It has been supposed that the treatment infectives become recovered when they are treated in treatment sites.