Biomathematics Seminar Series

Department of Mathematics and Statistics

Modelling and Analysis of Low Persistent ZIKV Dynamics with Sexual Transmission

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Zika fever, caused by the Zika virus (ZIKV), becomes a global threat for birth deficiency. In addition to the primary transmission mediated by Aedes mosquitoes, ZIKV can be transmitted sexually. A recent study shows evidence on endemic ZIKV in Thailand and concludes that low but sustained level ZIKV transmission in the lower level immunity population leads to disease outbreaks. The limited understanding of ZIKV with its low but sufficient transmission to maintain itself makes the establishments of prevention techniques more challenging. To analyse the low persistence ZIKV with large periodic outbreak cycles, we use a simple SIR model. An important novelty part of this paper is modeling of human-human encounter rate as a pure birth process by considering the infected human's searching distance as a Poisson point process. The mathematical analysis shows the model exhibits disease-free equilibrium (E_0) and positive endemic equilibrium (E^*). Moreover, we derive a formula for basic reproduction number R_0. The proposed model shows at least one positive endemic equilibrium when $R_0 > 1$ and we prove E_0 is locally asymptotically stable if $R_0 < 1$. The global stability analysis shows the disease-free equilibrium is globally asymptotically stable when $R_0 < 1$ under certain model parameter conditions. However, when the sexual transmission route is absent, E_0 is globally asymptotically stable when $R_0 < 1$ and $R_0 = 1$ is a sharp threshold. We further find a closed-form formula for the occurrence of the backward bifurcation where the disease free equilibrium coexists with endemic equilibrium. The existence of backward bifurcation leads to Hopf bifurcation, which serves as an oscillation source. Furthermore, bifurcation analysis and numerical simulations show that the proposed simple model is sufficient to describe the large periodic epidemic cycles and low persistent ZIKV.

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