Article

Advanced Science, Engineering and Medicine
Vol. 6, 1–7, 2014
www.aspbs.com/asem

The Optimal Release Strategy of Wolbachia Infected Mosquitoes to Control Dengue Disease

A. K. Supriatna[1,*], N. Anggriani[1], L. Nurulputri[1], R. Wulantini[1], and D. Aldila[2]

[1] *Department of Mathematics, Padjadjaran University, Sumedang 45363, Indonesia*
[2] *Industrial and Financial Research Group, Institut Teknologi Bandung, Bandung 40132, Indonesia*

The paper discusses a mathematical model of dengue transmission. We assume that to control the spreading of the disease in human population we give vaccination to newborn human population and introduce wolbachia-infected mosquitoes into the wild mosquitoes population. The presence of wolbachia is assumed to be able to reduce the life expectancy of the mosquitoes and the biting rate due to the damage of their proboscis. The optimal control for the interventions are obtained via the Pontryagin Maximum Principle. Some numerical examples are explored, and the result indicates that the effect of the optimal control into the reduction of infected human population is critically influenced by both epidemiological parameters, such as the level of the contagiousness of the wolbachia infection, as well as economics factors, such as the cost of the implementation of the intervention program. It also reveals that if wolbachia disease is difficult to transmit among the mosquitoes, introducing too many wolbachia-infected mosquitoes into the wild could be counter productive.

Keywords: Mathematical Model, *Aedes aegypti*, Wolbachia Infection, Vaccination, Multi-Agent Intervention.

1. INTRODUCTION

Recently many scientists have made a scientific speculation that an introduction of bacteria from the genus wolbachia into the responsible vector mosquitoes may reduce the transmission of dengue disease.[1,2] They argue that wolbachia infection in mosquitoes reduces the biting rate of the mosquitoes, such as dengue fever mosquitoe *Aedes aegypti*, by destroying the mosquitoes proboscis so that it is difficult for them to penetrate human skin. The infection also reduces the life span of the mosquitoes.[3] Although the introduction of wolbachia is prospective in eliminating dengue, however so far there is still limited references dealing with the effect of the introduction of wolbachia on the spread of dengue in human population. This paper is aimed as an attempt to fill this gap via mathematical modeling. In this paper we discuss an optimal control problem based on previously published model[4] to combine wolbachia introduction and vaccination to newborn human population, reflecting a multi-agent control in the population.

2. MATHEMATICAL MODEL

We consider the following system of differential equations as a dengue transmission mathematical model[4]

$$\frac{dH_S}{dt} = (1-u_1)Q_S - \delta_S H_S M_{DS} - \delta_W H_S M_{DW} - \mu_H H_S \quad (1)$$

$$\frac{dH_D}{dt} = (\delta_S M_{DS} + \delta_W M_{DW})H_S - \gamma_H H_D - \mu_H H_D \quad (2)$$

$$\frac{dH_R}{dt} = \gamma H_D - \mu_H H_D + u_1 Q_s \quad (3)$$

$$\frac{dM_S}{dt} = R_S - \alpha M_S M_W - \beta_S M_S H_D - \nu_S M_S \quad (4)$$

$$\frac{dM_W}{dt} = u_2 R_s + \alpha M_S M_W - \beta_W M_W H_D - \nu_W M_W \quad (5)$$

$$\frac{dM_{DS}}{dt} = \beta_S M_S H_D - \nu_{DS} M_{DS} \quad (6)$$

$$\frac{dM_{DW}}{dt} = \beta_W M_W H_D - \nu_{DW} M_{DW} \quad (7)$$

The model describes the transmission of dengue disease in human and mosquitoes as presented in an earlier work,[4]

*Author to whom correspondence should be addressed.