Stochastic Dengue Mathematical Model in the Presence of *Wolbachia*: Exploring the Disease Extinction

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Abstract: A new strategy against dengue is proposed by the use of the *Wolbachia* bacterium. In this paper, we analyse the effects of *Wolbachia* on dengue transmission dynamics using deterministic and stochastic epidemic models. The reduction in the reproduction number is measured and the probability of disease extinction is determined. We found that *Wolbachia* can reduce the reproduction number by up to 64%. We also found that the probability of extinction is around 90%, although the reproduction number is slightly above one. However, if the reproduction number is too high, which indicates a higher transmission level, the probability of disease extinction is smaller. Consequently, an outbreak is likely to take off. The results suggest that *Wolbachia* can be effective to reduce dengue transmission, particularly in areas with low to moderate transmission level.

Keywords: *Wolbachia; mathematical model; dengue; stochastic; probability; extinction.*

Mathematics Subject Classification (2010): 93E03, 92B05, 37N25.

1 Introduction

Dengue is a vector-borne disease transmitted via the bite of mosquitoes. Over half of the world's population is at risk of dengue, particularly in tropical and subtropical areas. Around 390 million cases happen annually [1] and can result in a higher fatality rate when no proper treatment is conducted [2].

The traditional strategies such as insecticide have been found less effective and hence an innovative biological strategy by the use of the *Wolbachia* bacterium has been proposed [3–6]. *Wolbachia* reduces the level of dengue virus in salivary glands, which lower

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