Bull Math Biol. 2005 Sep;67(5):1107-33.

A mathematical model for assessing control strategies against West Nile virus.

Bowman C, Gumel AB, van den Driessche P, Wu J, Zhu H.

Institute for Biodiagnostics, National Research Council Canada, Winnipeg, Manitoba, R3B 1Y6, Canada.

Abstract

Since its incursion into North America in 1999, West Nile virus (WNV) has spread rapidly across the continent resulting in numerous human infections and deaths. Owing to the absence of an effective diagnostic test and therapeutic treatment against WNV, public health officials have focussed on the use of preventive measures in an attempt to halt the spread of WNV in humans. The aim of this paper is to use mathematical modelling and analysis to assess two main anti-WNV preventive strategies, namely: mosquito reduction strategies and personal protection. We propose a single-season ordinary differential equation model for the transmission dynamics of WNV in a mosquito-bird-human community, with birds as reservoir hosts and culicine mosquitoes as vectors. The model exhibits two equilibria; namely the disease-free equilibrium and a unique endemic equilibrium. Stability analysis of the model shows that the disease-free equilibrium is globally asymptotically stable if a certain threshold quantity (R0), which depends solely on parameters associated with the mosquito-bird cycle, is less than unity. The public health implication of this is that WNV can be eradicated from the mosquito-bird cycle (and, consequently, from the human population) if the adopted mosquito reduction strategy (or strategies) can make R0<1. On the other hand, it is shown, using a novel and robust technique that is based on the theory of monotone dynamical systems coupled with a regular perturbation argument and a Liapunov function, that if R0>1, then the unique endemic equilibrium is globally stable for small WNV-induced avian mortality. Thus, in this case, WNV persists in the mosquito-bird population.

PMID: 15998497 [PubMed - indexed for MEDLINE]