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An epidemiological model for West Nile virus: invasion analysis and control applications

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Infectious diseases present ecological and public health challenges that can be addressed with mathematical models. Certain pathogens, however, including the emerging West Nile virus (WN) in North America, exhibit a complex seasonal ecology that is not readily analysed with standard epidemiological methods. We develop a single-season susceptible–infectious–removed (SIR) model of WN cross-infection between birds and mosquitoes, incorporating specific features unique to WN ecology. We obtain the disease reproduction number, R_0, and show that mosquito control decreases, but bird control increases, the chance of an outbreak. We provide a simple new analytical and graphical method for determining, from standard public health indicators, necessary mosquito control levels. We extend this method to a seasonally variable mosquito population and outline a multi-year model framework. The model's numerical simulations predict disease levels that are consistent with independent data.

Keywords: arbovirus; emerging infectious disease; outbreak threshold; public health; reproduction number