

# Multistage Spatial Model for Informing Release of Wolbachia-Infected Mosquitoes as Disease Control

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Wolbachia is a natural bacterium that can infect *Aedes* mosquitoes and block the transmission of mosquito-borne diseases, including dengue fever, Zika, and chikungunya. Field trials have been conducted worldwide to suppress local epidemics. We present a new partial differential equation model for the spread of Wolbachia infection in mosquitoes. The model accounts for both the complex Wolbachia vertical transmission cycle and detailed life stages in the mosquitoes, and it also incorporates the spatial heterogeneity created by mosquito dispersion in the two-dimensional release domain. Field trials and previous modeling studies have shown that the fraction of infection among mosquitoes must exceed a threshold level for the infection to persist. We use the spatial model to identify a threshold condition for having a self-sustainable Wolbachia infection in the field. When above this threshold, the model gives rise to a spatial wave of Wolbachia infection. We quantify how the threshold condition and invasion velocity depend on the diffusion process and other model parameters, and we study different intervention scenarios to inform the efficient releases.

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