Why killing mosquitoes doesn't control dengue, and how to do it better

Tom Hladish

Abstract

Controlling mosquito populations has long been the primary tool for reducing the burden of vector-borne diseases, but as the worldwide dengue burden grows, even ambitious vector control programs seem to have failed. We developed an agent-based dengue model that describes the movements and transmission dynamics of people and infected mosquitoes in Yucatan, Mexico, and investigated both the long term dynamics of dengue under vector control, and evaluated how indoor residual spraying (IRS), a method used to control malaria, might best be used to control dengue.

Our approach integrates satellite imagery, census and economic data, and 35 years of dengue case and serotype data to model the locations and movement of 1.8 million people in 375,000 households and 100,000 workplaces and schools. In order to fit certain important parameters that are poorly known, like the number of mosquitoes in Yucatan and their movement and biting behavior, we have developed a Bayesian parameter estimation toolkit in C++ called AbcSmc (Approximate Bayesian Computation - Sequential Monte Carlo).

We find that vector control programs can be highly effective in controlling dengue in the short term, but over decades, much of the early benefit disappears as populations lose naturally-acquired immunity. The best IRS programs are those that are seasonally timed to start well before the annual epidemic is expected, but even off-season vector control can have surprising benefits by eliminating low-probability winter transmission. Finally, although it may be tempting to cease apparently ineffective vector control, it's possible for extremely large epidemics to result as mosquito populations rebound, and thus ending vector control should be done with care.