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Comparing malaria surveillance with periodic spraying in the presence of insecticide-resistant mosquitoes

There is an urgent need for more understanding of the effects of surveillance on malaria control. Indoor residual spraying has had beneficial effects on global malaria reduction, but resistance to the insecticide poses a threat to eradication. We develop a model of impulsive differential equations to account for a resistant strain of mosquitoes that is entirely immune to the insecticide. The impulse is triggered either due to periodic spraying or when a critical number of malaria cases are detected. For small mutation rates, the mosquito-only submodel exhibits either a single mutant-only equilibrium, a mutant-only equilibrium and a single coexistence equilibrium, or a mutant-only equilibrium and a pair of coexistence equilibria. Bistability is a likely outcome, while the effect of impulses is to introduce a saddle-node bifurcation, resulting in persistence of malaria in the form of impulsive periodic orbits. If certain parameters are small, triggering the insecticide based on number of malaria cases is asymptotically equivalent to spraying periodically.