Assessing the Risk of Dengue Outbreaks in Southern U.S. Cities

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Background/Objectives. Dengue is a mosquito-borne viral disease that is estimated to infect approximately 400 million individuals worldwide each year. Dengue transmission depends on mosquitoes. Two key temperature-dependent mosquito life traits are: (1) the extrinsic incubation period (EIP) or the period of time from when a mosquito is infected by a human to when that mosquito can infect another human; and (2) mosquito lifespan. These traits exhibit complex dependence on temperature. Summer outbreaks are now possible in Los Angeles, Houston, and Phoenix, cities where dengue's primary vector, *Aedes aegypti*, has been observed. The goal of this study is to assess the risk of dengue outbreaks in these cities under current mean temperatures, as well as under a climate change scenario of mean temperature increase of 3°C.

Approach/Activities. To assess dengue risk in three U.S. cities, we developed a Susceptible-Exposed-Infectious-Recovered (SEIR)-type, mechanistic, epidemic model that consists of ordinary differential equations. This system of equations describes the dynamics of dengue transmission between mosquitoes and humans, and enables us to explore the impact of temperature, EIP, and mosquito lifespan on potential outbreaks. We conducted simulations that begin with one infectious traveler under a range of temperatures. We compared epidemic outcomes using four quantities of interest: basic reproduction number, final epidemic size, maximum infections at epidemic peak, and time to epidemic peak. We carried out global sensitivity analyses to evaluate how uncertainty in the temperature-dependent mosquito life traits affects dengue dynamics.

Results/Lessons Learned. We found that the largest simulated dengue outbreaks occurred between 27 and 31°C. This is a temperature range where mosquito EIP is relatively short and lifespan is relatively long. Based on our model structure and assumptions, we found that a risk of summer dengue outbreaks currently does exist for Los Angeles, Houston, and Phoenix. Of these cities, Houston has the greatest risk. With a 3°C temperature increase, in potential summer outbreaks we expect Los Angeles and Houston to see faster disease spread and greater numbers of total infections. With the same temperature increase, we expect Phoenix to see decreased risk. According to our sensitivity analysis, mosquito biting rate and carrying capacity are important to epidemic outcomes for most temperatures considered; thus, interventions that target mosquitoes should be prioritized.