CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

34798

Project Title

Using Agent-Based Modeling to Simulate the Transfer of Zoonotic Pathogens

Abstract

Objectives/Goals

Replicable experiments of zoonotic diseases are impossible due to the transient, chaotic nature of natural environments and the large scale of dynamics involved. I hypothesized that an agent-based model of the spread of malaria that simulates sufficient variable complexity and the new containment strategy of introducing genetically-modified mosquitoes would help effectively conduct experiments on possible treatment plans and accurately predict a lower human fatality rate than that for current treatments.

Methods/Materials

I designed a computer simulation backed by mathematical equations that models the spread of malaria from vectors to targets under various conditions. My model took several variables into account including temperature, humidity, amount of standing water, extent of urbanization, sickle-cell allele frequency and efficacy of current malaria control. Using a range of constants for each factor, I devised mathematical equations that calculated values for variables such as larval maturation rate, mosquito biting rate, and infection probability per bite, which were then used to determine population change rates for each group of agents: individuals that represent a certain class of mosquito or human. I also devised a possible treatment plan, where genetically-modified mosquitoes that cannot carry malaria were introduced into the population. Ultimately, I was able to run my model with 180 different combinations of variables. The graphs of infected humans over time produced were compared with actual infection rates, and the mathematical equations were refined to reflect realistic behavior.

Results

For a typical Kenyan city, my model predicted that 17% of the human population would be infected after a year, which is quite close to the actual proportion of around 20%. Analyzing the outputs I gathered for various combinations, I determined that my simulation is fairly accurate, with an average percent error of only 15%. With the addition of my treatment plan, my model predicted for the same Kenyan city that only 5% of individuals would be infected each year.

Conclusions/Discussion

The accuracy and efficiency of my agent-based model at predicting infection rates suggest that agent-based models offer tremendous promise as the tool of choice for determining the best eradication strategy for diseases transferred through intermediate vectors that involve complex, dynamic interactions.

Summary Statement

To evaluate the efficacy of simulations to study zoonotic diseases and eradication techniques, I created a complex agent-based model that accurately predicted the transfer of malaria and tested inclusion of genetically-modified mosquitoes.

Help Received

Mr. Sutton, Environmental Science teacher at The Harker School, recommended relevant reading and provided feedback.