Treating the Spread of Malaria

New Mexico

Supercomputing Challenge

Final Report

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Team 110

Saturday Science and Math Academy

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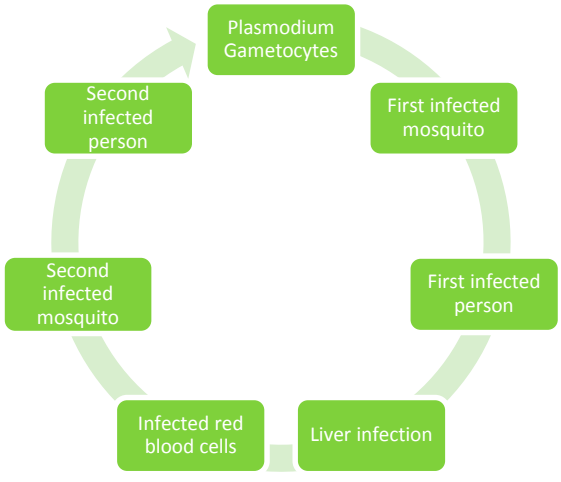
SUMMARY

Malaria is a disease that affects people of all ages around the globe, so we created a model to show the benefits of a new kind of treatment that utilizes genetically modified mosquitoes (GMM) to treat the spread. We created two different simulations: one including the traditional treatments of bed nets and antimalarial tablets, and one including the GMMs. We modeled this using NetLogo, and agent based coding platform. When using NetLogo, we set up graphs to clearly visualize the data. It showed that after a certain number of days, the healthy and unhealthy population evened out. In the simulation that modeled traditional treatments, the infected population consistently turned out to be the greater of the two populations, but in the GMM model, the healthy humans ended up with a greater population than the infected ones.

DEFINITION OF PROBLEM

Malaria is a mosquito borne-disease caused by the parasite Plasmodium. The disease is transmitted through the bites of infected female mosquitoes. Recently, scientists have created genetically modified mosquitoes that cannot transfer the plasmodium parasite. Anthony James at the University of California, Irvine developed a different mosquito that cannot hold or transmit the plasmodium parasite. This alternative mosquito would slow and even stop the spread of malaria if permitted to breed with the natural insects and spread the trait throughout the population. The problem with this solution is that it may negatively impact the delicate ecosystem. Our project will model the effectiveness of the genetically modified mosquitoes (GMM) over the current treatment plans.

Malarial Transmission Process →



METHOD

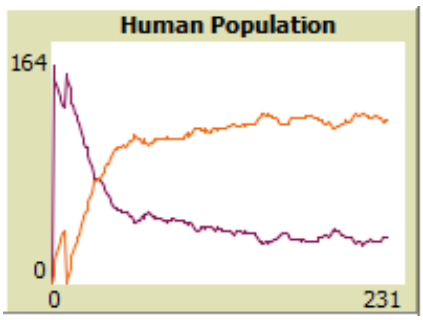
To demonstrate the effectiveness of genetically modified mosquitoes, we developed two different simulations using NetLogo. Both simulations had the same basic functions for humans and mosquitoes. Humans randomly walked around the world, but mosquitoes actively targeted humans. When a mosquito and a human shared a patch, they had a 2 in 5 chance of contracting malaria. In Cameroon, the place where our code is based, 40% of citizens experience at least one case of malaria each year. After being sick for 9 days(an abbreviated real life time), humans have a 1 in 10 chance of dying from malaria, which is the accurate death rate for malaria. After 25 ticks, the mosquitoes die but their offspring remains. Healthy humans are depicted by a maroon color and infected humans are orange to exaggerate the difference between the two types. First generation mosquitoes are a lime green while second generation onward are a turquoise green. This becomes most important during the second simulation, when the offspring of the mosquitoes are what determine the outcome of the malaria outbreak.

In the first simulation, the only methods of treatment were bed nets and antimalarial tablets. Humans had to actually travel over the patch that symbolized these treatments to get the chance to be cured. In an attempt to parallel reality, humans that went on bed net patches had a 1 in 4 chance of a cure, since that is the prevention rate for bed nets. Interaction with an antimalarial patch led to a 9 in 10 chance of cure, again modeling real life data. Mosquitoes die when they enter a treatment patch.

The main difference between the two simulations is the breeding result of mosquitoes. Both simulations have the mosquitoes reach a certain breeding age, then, if another breedable mosquito occupies the same patch, they hatch a new turquoise green mosquito. This mosquito performs all the same functions as the parent mosquito. However, in the second simulation, the second generation mosquitoes are the genetically modified mosquitoes. These are classified as a whole new breed (to make the coding easier) “babies”. These mosquitoes still chase humans, suck blood, and reproduce, but they are no longer spreading the plasmodium parasite

RESULTS

When the baby generation is born, there are no new infections. This leaves time for the infected humans to either die out or reach a treatment center and become healthy again. In the first simulation, there is first a huge decrease in the healthy population as more and more people become infected, then the lines even out with the infected people taking up more of the population.



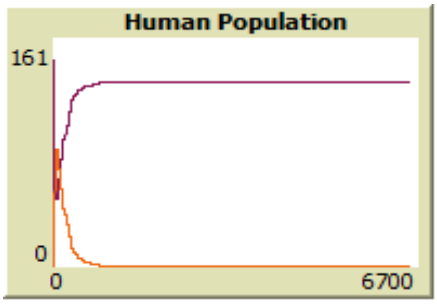
Key

Purple: Healthy Humans

Orange: Sick Humans

1. Humans and Mosquitoes: Amount of healthy humans on a steady decline

In the second simulation, the same decrease in healthy population tries to occur, but the malaria-resistant offspring are born, so the healthy human number evens out again. As the mosquitoes begin to cover more ground, the infected mosquito population briefly overtakes the healthy, but the infected population soon plummets as all the first generation mosquitoes die out.



Key

Purple: Healthy Humans

Orange: Sick Humans

2. Humans and GM Mosquitoes: Steady increase in healthy human population

CONCLUSIONS

The simulations show the ineffectiveness of modern treatments being the bed nets and tablets based off the real world statistics. Genetically Modified Mosquitoes are beneficial in stabilizing the mosquito population thus reducing malarial transmission. Although these modified mosquitos keep malarial transmission to a standstill longer tests will need to be conducted to determine the long term effects of the mosquitos in regards to the environment and overall mosquito population. The infection rate was greatly decreased since the mosquitoes could no longer maintain the parasite. This comes to prove that the release of Genetically Modified Mosquitoes could potentially be the solution in sustaining the mosquito population and eradicating malarial transmission. When analyzing the data the entire system will have to be scaled up and incorporate other factors such as climate, in order to see the effects on a global scale.

REFERENCES

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4. TheAtlantic.com (The Genetically Modified Mosquito Bite)
5. Euro Clinix
6. Hope Foundation Cameroon
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SIGNIFICANT ACHIEVEMENT

The biggest achievement with this project was figuring out how to incorporate real world statistics and embed them into our simulation. Once referring back to our coding class and seeing how we performed probabilities in old assignments, we were able to break it down step by step and make our simulation compete with real world data. Once identifying the effects of the current treatments on malarial transmission we were then able to start realizing that long terms effects much be measured to truly determine the impact. Just being able to brainstorm ideas for future plans shows how much we have invested in understanding the potential of our simulation.

ACKNOWLEDGEMENTS

A big thank you goes to Ms. Janeen Anderson who was our advisor and mentor for this project. She kept us in full gear and gave us a new outlook on how to approach problems regarding the code and model. Ms. Debra Johns, our program director, helps fund our project and introduces us to those who can takes us further into the coding world. She is an excellent cheerleader and motivator. Mr. Michael Steele, our Computer Science for All instructor, was one of the people Ms. Debra Johns introduced us to. He taught us how to use Netlogo and the different ways in which this coding language can be applied to real world problems. Last but not least our parents. Always giving us that extra push to apply prior knowledge, have confidence, and turn our work in on time! Without these individuals this project would not exist.