Modeling Infection and Treatment Rates in Malaria

New Mexico

Supercomputing Challenge

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Team 27

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Executive summary

This program uses Star Logo TNG to model the effect of malaria on humans based on the access of people to medical clinics for diagnoses and doctors for treatment. This agent-based model allows the user to vary the activity of infected agents and the starting populations for mosquitoes, humans, health care workers, and doctors. This model shows the importance of having enough doctors within a certain area to treat the disease in order to prevent death. Malaria still kills many people around the world, especially children; therefore this type of model continues to be important for protecting the lives of people around the world.

Introduction

Statistics of Malaria

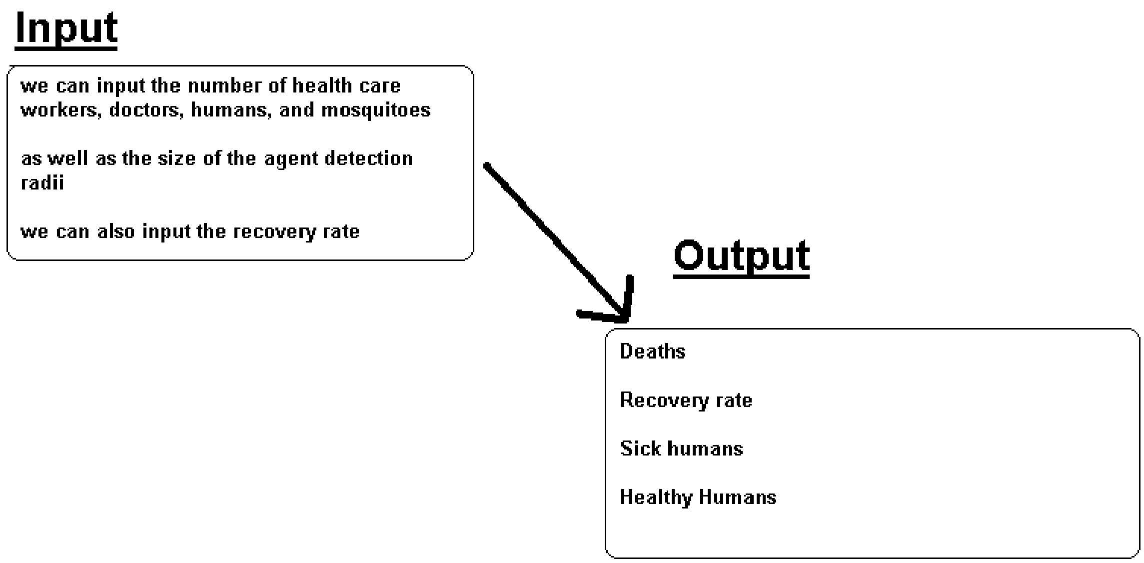
Malaria is a disease that is old yet still very common. It is also a potentially deadly disease. In the United States alone there were 1,337 cases of malaria, including eight deaths that were reported in 2002. Each year, 300-500 million cases of malaria occur world wide and over one million people die, most of them young children in Sub-Saharan Africa. About 40% of the world's population, about two billion people are at risk in about ninety countries and territories. Eighty to ninety percent of malaria deaths occur in Sub-Saharan Africa.

In our research, we found out how important the spread of malaria is from the American Journal of Epidemiology which said, "Reliable maps of the prevalence or transmission intensity of malaria are urgently needed, especially in endemic areas of sub-Saharan Africa. Such maps are fundamental for estimating the scale of the problem, and hence the resources needed to combat malaria. They provide benchmarks for assessing the progress of control and indicate which geographic areas should be prioritized." The problem we are addressing in our model is how a person's ability to contact a healthcare worker or doctor affects the death and recovery rate of a population.

Problem Definition

How does a person's ability to contact a healthcare worker or doctor affect the death and recovery rate of a population?

Mathematical Model



Our model is a discrete model showing certain events from when a person gets infected until the person finds a doctor or dies. Our model does not show a shift of disease status, since no base line was established. Instead of the drug effect mechanisms being modeled as in “Modeling of Disease and Disease Progression” by Nick Holford, our program shows a shift in disease status based on encounters with clinics, doctors, and mosquitoes. Therefore, our program is based on modeling Population Death Rate, incorporating sick individuals and healthy individuals.

Our program is similar to PopMod used by the World Health Organization to model “incidence / prevalence, remission and case-fatality associated with a given disease or risk factor” (Lauer), except our model does not include birth rates and includes prevalence as a user variable called “infection rate,” but views remission rate as cure rate only. Our program is also far simpler since, at this time, it does not model variation in mosquito populations due to changes in weather and it does not actually represent a particular country or location.

Software Design

In star logo TNG we use commands such as wiggle and smell to control how the agents interact in our program. We use the wiggle command to direct the agents' movement.

Agents: health care workers, doctors, humans, and mosquitoes.

Smell radiuses: doctor detection radius, sick smell radius, and mosquito smell radius.

Assumptions

- All mosquitoes are infected
- Infected people can be diagnosed by both the healthcare worker and the doctor, but can only be cured by the doctor
- Doctors and healthcare workers are immune
- Mosquitoes never die or reproduce
- All mosquitoes are females
- When people are diagnosed, they speed up

Constants

- Wiggle of the uninfected humans are fast
- Wiggle of the infected humans is slower, unless they are diagnosed
- Wiggle of mosquitoes more erratic and faster than humans

Collisions

- When a mosquito collides with a human, the human becomes infected
- When a sick human collides with a health care worker, it gets diagnosed and begins to search for a doctor
- When a sick human collides with a doctor, the human is cured

Results

The article, "Pros and cons of modeling malaria transmission" by L. Molineaux points out that the "calculation of the expected impact of an intervention commonly assumes too much uniformity (e.g. of human vector behaviour) and this commonly leads to exaggerated expectations" (Molineaux, L). This may be a problem in our program because even with a very high resistance rate of 99%, and with 30 doctors and 20 healthcare workers, and after many iterations, 48 individuals have died, 45 remain healthy, and 7 are sick and have not found a doctor. These rates are not validated by data we have researched, which shows much lower death rates, except in very young children and elderly.

Conclusion

In conclusion, this program shows a good way of modeling the impact of a disease, such as malaria, upon human populations. In “A climate-based distribution model of malaria transmission in sub-Saharan Africa,” M.H. Craig states that, “Malaria remains the single largest threat to child survival in sub-Saharan Africa and warrants long-term investment for control.” In the future, we would like our program to more realistically model the spread of this disease based on location, climate, and the mosquito reproduction rate. It can also be improved by the human population growth rate to give a realistic overall picture of chronic effects of this and other diseases.

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