

# Mathematical Modeling for Malaria Transmission Dynamics

---

Amirhessam Tahmassebi, Joel Gonzalez-Santiago,  
Bobby Hollingsworth, Feng Li, Sergio Rivera,  
Wei-Kang Hsu

A close-up photograph of a young child with dark skin and short hair, looking intently to the right. The child is wearing a blue and yellow striped tank top. Their right hand is resting on a light-colored, textured surface, possibly a ledge or table. The background is softly blurred, showing other people in a similar setting.

**2015 malaria caused 212 million clinical episodes, and 429,000 deaths.**

# Model

---

Describes the transmission of malaria

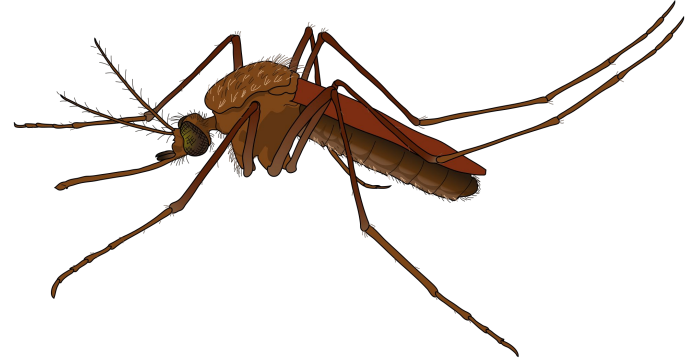
Plots the time series for useful groups

Mosquitoes

People (Healthy, Sick, Immune)

Total deaths

Applications to other disease



# Assumptions

---

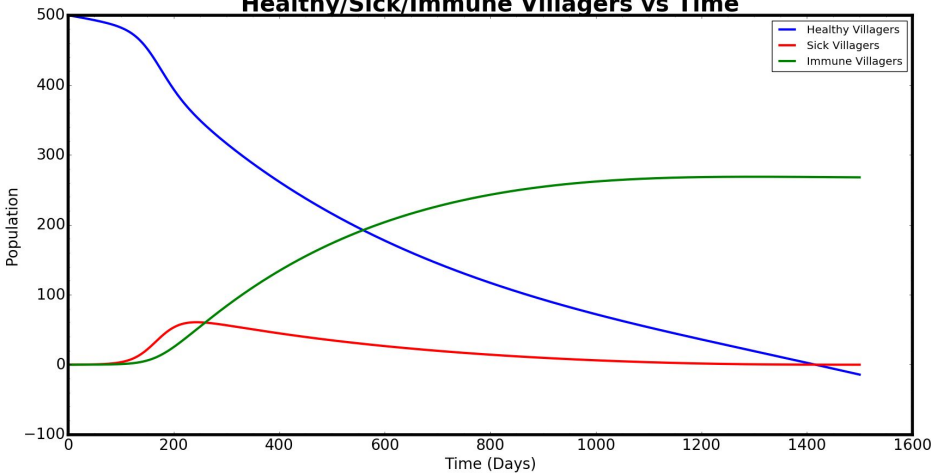
Original model does not intake a flux of mosquito population

There is no change in healthcare at the time

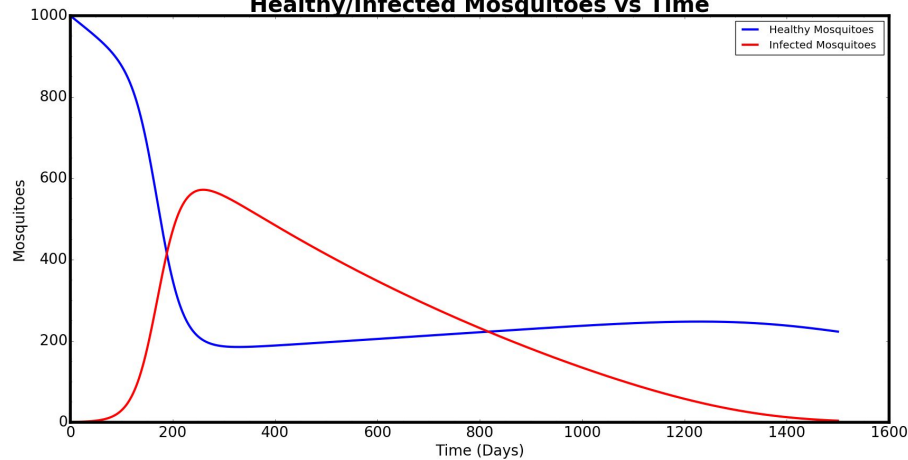
The rate of immunity does not change

# Results

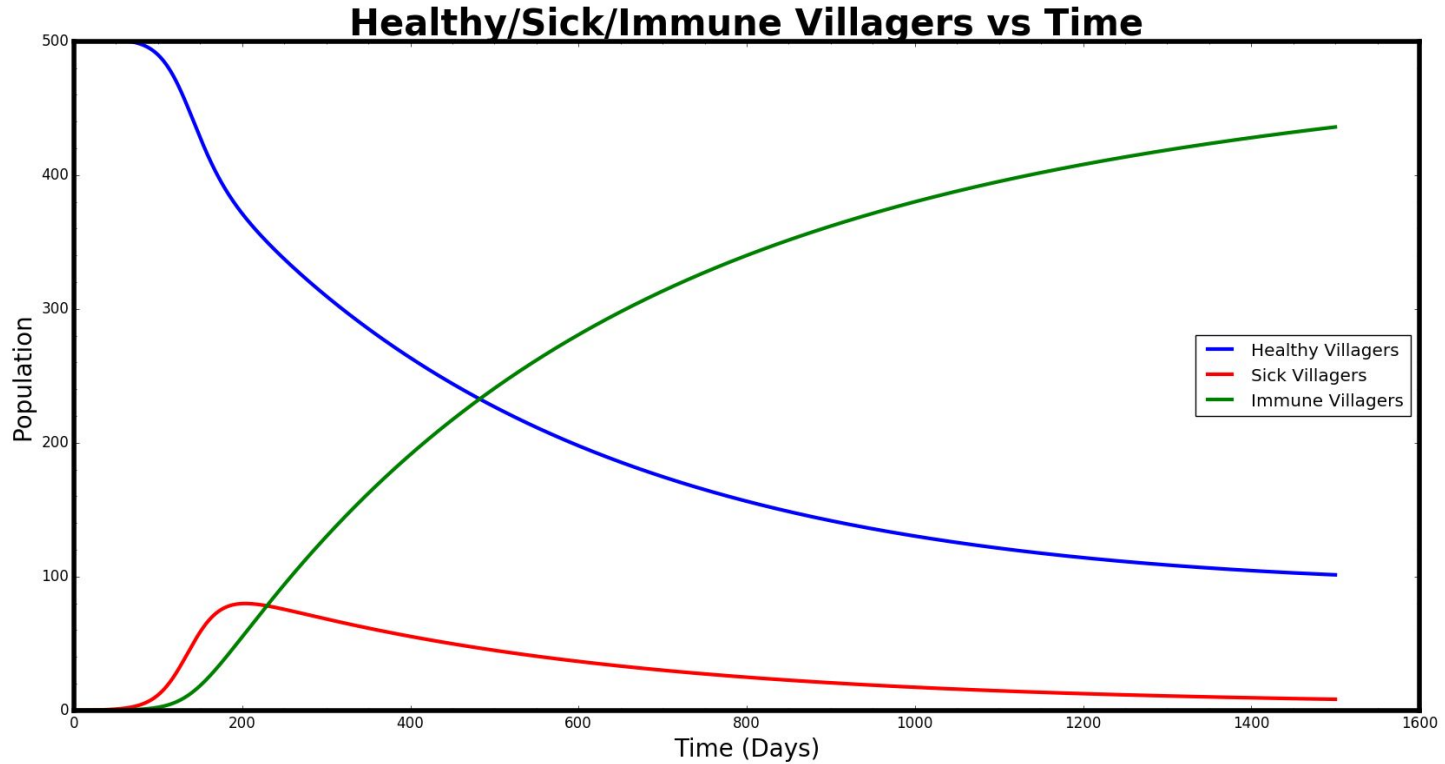
### Healthy/Sick/Immune Villagers vs Time



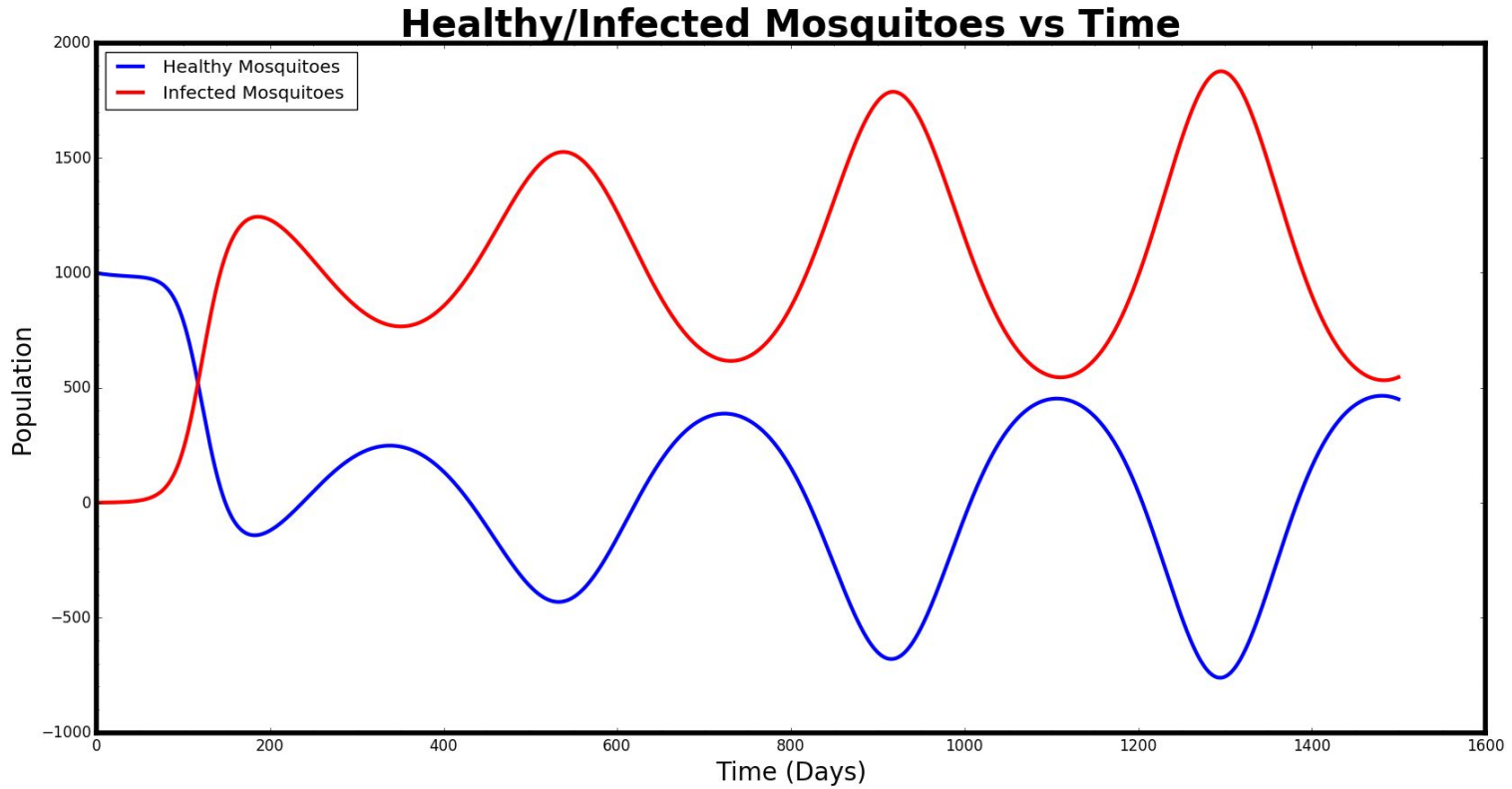
### Healthy/Infected Mosquitoes vs Time



# Relapse



# Seasonal Change



# Cost of Nets

Population = 500

- Net covers 2 people

Treated Nets = \$3.50

- Reduce infec. Rate 50%

Untreated Nets = \$2.50

- Reduce infec. Rate 39%



**Nets help to reduce infection rate by mosquitos**

photo from BBC: <http://www.bbc.com/news/uk-politics-23149073>

# Modeling the Number of Nets Needed

Original infection rate:  $R$

Percentage for **treated nets**:  $x$

Percentage for **untreated nets**:  $y$

Percentage for no nets:  $1-x-y$

Budget we have :  $B$

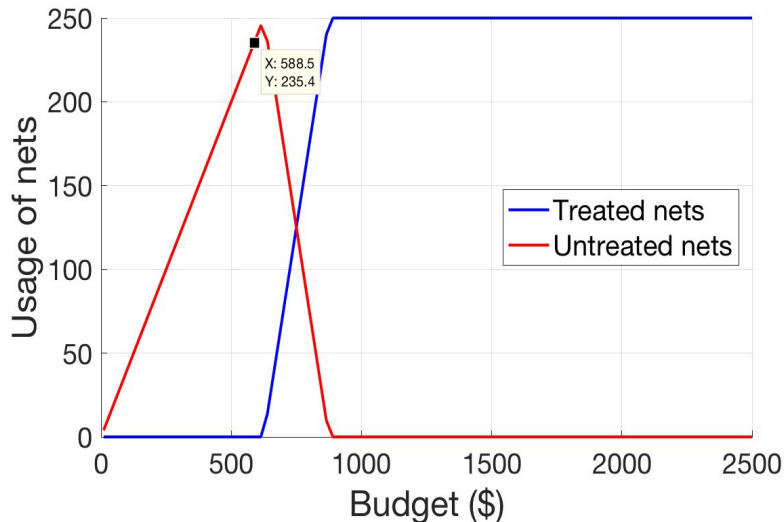
Infection\_rate\_reduction( $x,y$ ) =

$R - R(0.5x + 0.62y + (1-x-y))$

max. Infection\_rate\_reduction

s.t.  $x+y \leq 1$

$250(3.5x+2.5y) \leq B$



# Model to Zika

---

Very similar model with minor additions (such as standing water)

The rates will have to be changed slightly but with dynamic programming this is an easy process

## Benefits from HPC

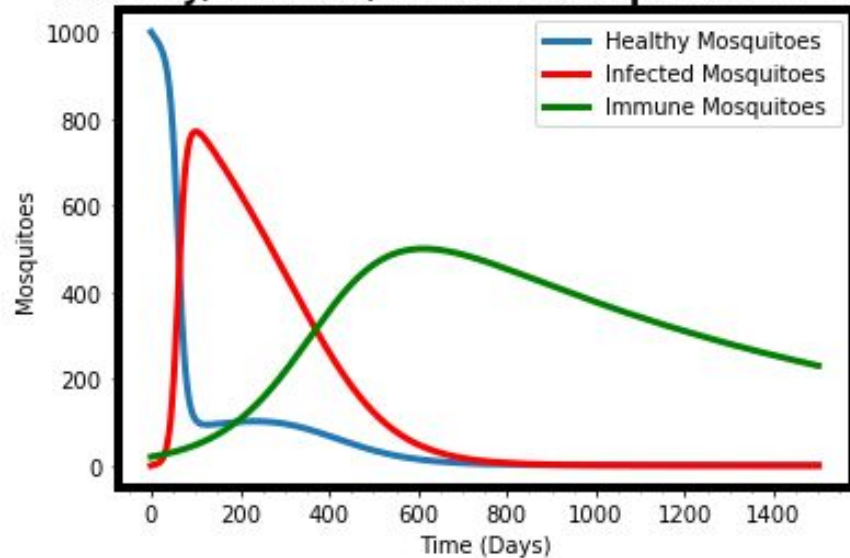
Greater amount of iterations per walltime

Larger scale tests

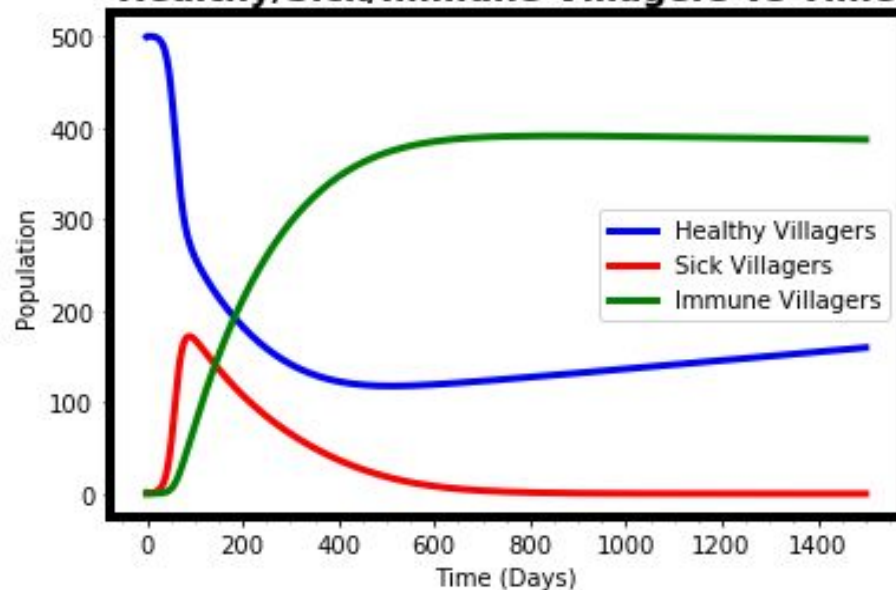
More complex models

# Immune Mosquitoes

### Healthy/Infected/Immune Mosquitoes vs Time



### Healthy/Sick/Immune Villagers vs Time



# Code

---

```
# update number of immune mosquitoes
def Immune_Mosquitoes (i, imM, drM, brM, M, prob):
    imM[i+1] = imM[i] - (imM[i]*drM) + (brM*(M[i]))*prob

# compute probability __
def Imm_Prob(i, imM, hM, iM, M):
    prob = (spmc.comb(int(imM[i]), 2, exact=True) + imM[i] * (hM[i] +
iM[i])) / spmc.comb(int(M[i]), 2, exact=True)

# Update current total mosquitoes
M[i+1] = hM[i] + iM[i] + imM[i]
```