VecNet Update

Tom Burkot on behalf of

The VecNet Consortium Institutions:

- James Cook University
- University of Notre Dame
- University of Oxford
- Pittsburgh Supercomputing Center
- Johns Hopkins University
- Swiss TPH
- Intellectual Ventures

R. Farlow Consulting, LLC
malERA- A Research Agenda for Malaria Eradication: Vector Control

To achieve elimination, need (1) to preserve the effectiveness of our current interventions, (2) to develop new paradigm tools to exploit vulnerabilities in the vectors’ biology. This requires (3) assembling all data and (4) making it available for analyses.

doi:10.1371/journal.pmed.1000401.g001
**Mission Statement:** To use spatially explicit data to understand and model the impacts of interventions on malaria transmission for control and eradication

**Objectives**

1. Establish a **Digital Library** of malaria-specific data,
2. Establish a **Modeling Platform**, and
3. Create a CI to facilitate **data analysis** on a temporal and spatially explicit scale to estimate the potential impact of vector control strategies

**Stakeholders/user groups:** Researchers, Malaria Control Program Managers, Product Developers, Policy makers and Funders
## VECNet Transmission Simulator

[Link to VECNet Transmission Simulator](https://www.vecnet.org/TS.html)

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### Equation
\[
H_{\text{temp}} = P_{\text{in}} K_{\text{temp}} D_{\text{cell}} - H_{\text{temp}} \left(\frac{\Delta t}{\tau_{\text{temp}}}\right)
\]

\[
\tau_{\text{temp}} = \left(5.1 \times 10^{10} \text{Ra}\right) e^{-\frac{-5628.1 K}{T_{\text{K}}}} k_{\text{temp}} \frac{0.018 \text{mol}}{2 R T_{\text{K}}(1 - RH)}
\]
**VecNet**

Vector-Borne Disease Network

**Our Work**

Though malaria remains both treatable and preventable, 350-500 million people worldwide are infected with the disease every year, with up to one million cases ending in death. Nearly 85 percent of the victims who die are younger than five years old.

Recent global efforts have contributed to declines in malaria-related sickness and death, but while the present available tools for controlling malaria are effective, they will not by themselves eliminate the disease. There is a need for new strategies to eliminate malaria.

VecNet is a consortium of institutions assembled to address the need for new strategies to eliminate malaria, which requires an understanding of how interventions affect the transmission of the disease across different geographic areas where the mosquitoes that transmit malaria differ in their behavior.

**Strategies to fight malaria**

To achieve the methods of analyzing new strategies and combinations of strategies to control and eventually eliminate malaria, VecNet is curating a Digital Library containing entomological, epidemiological, demographic, intervention and climate data. This database will be used to interpret malaria transmission risks in terms of ecology and vector behavior through a Modeling Platform that contains multiple mathematical models. These models analyze the potential of emerging vector control tools by accessing data from the Digital Library to simulate transmission dynamics at different spatial scales.

**VecNet Beta Release**

The VecNet website is currently in “Beta Release” during which new users have been invited to test the site’s design and functionality. If you received an invitation to be a Beta Tester, please register here.

We welcome your input. If you have a question, please check the FAQ to see if it has already been answered.

**Transmission Simulator**

The Transmission Simulator models changes in malaria transmission due to interventions or environmental changes.

[www.vecnet.org](http://www.vecnet.org)
Our Work

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VECNet User Tools, DL and Warehouse

- **Transmission Simulator**
  The Transmission Simulator models changes in malaria transmission due to interventions or environmental changes.
  (Researchers)

- **CIFER**
  The Computational Intervention portfolio Evaluator allows policymakers, funders, malaria control officials and product developers to compare the impact and value of different combinations of interventions in chosen locations.
  (Funders/Policy Makers)

- **Risk Mapper**
  Risk Mapper compares the distribution of interventions to specific mosquito species and maps the intervention's effectiveness.
  (NMCP)

- **Digital Library**
  The Digital Library contains all available data on malaria vectors, published and unpublished.
  (Product Developers)

- **PIE**
  The Product Impact Evaluator enables product developers to estimate the effect of new tools on malaria transmission, and to ask "what-if" questions about a tool's efficacy.
  (Product Developers)

- **Data Warehouse Browser**
  The Data Warehouse Browser is a secure way to access data to use with any of the Tools.
  (Product Developers)
Digital Library
Search and Curate Documents and Data

BROWSE BY
Author
Journal
Keyword
Publisher
Resource Type
Location
Species
Subject

What is VecNet Digital Library?

VecNet Digital Library contains curated data, tagged citations, articles and reports on entomology, epidemiology, demography, climatology, and interventions to support the analysis of malaria eradication.

VecNet members can ingest, tag, curate, search, retrieve, display and version information in the digital library. All users are invited to browse the digital library. If you have information to contribute, or need assistance please contact us so a VecNet digital librarian can help you.
1. Malaria in Honiara, Solomon Islands Vector studies
   Bell, D, Cameron, A, Fernando, M, Pholesyna, K, Foley, DH, Bakotee, B, Bryan, JH; Southeast Asian Journal of Tropical Medicine and Public Health 27(2), 372-377. (1996);

2. Malaria vector mosquitoes in the Solomon Islands
   Suzuki, H; Malaria research in the Solomon Islands, 104-113.;

3. The Fauna of Rennell and Bellona, Solomon Islands
   Wolff, T; Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 255(800), 321-343. (1969);

4. A new species of Anopheles from the Solomon Islands
   Belkin, JohnN, Schlosser, RJ; Journal of the Washington Academy of Sciences 34(8), 268-273. (1944);
Full text search, filter searches, fully downloadable
14. Solomon Islands Tagged Bibliographic Citations database

- Title: Solomon Islands Tagged Bibliographic Citations database
- Subject: Malaria
- Creator: Russell, Tanya
- Location: Solomon Islands, , Solomon Islands
- Keyword: Solomons
- Date: 2013-06-20
- Modified:

15. Summary of tags used in Solomon Islands Tagged Bibliographic Citations

- Title: Summary of tags used in Solomon Islands Tagged Bibliographic Citations
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- Keyword: Solomons
- Date: 2013-06-20
- Modified:

16. NZ52000 Solomon Islands HendersonWeather station site description
46 Tags
(including location, vector behaviours, epidemiology, weather)
Welcome to Transmission Simulator

Transmission simulator is an extensible modelling platform that allows web users access to complex models and high performance compute infrastructure. Quantitative analysis of the simulated output enables the use of data driven computer models as decision-making tools in efforts to test disease transmission hypotheses or to control or eradicate infectious diseases.

Currently VecNet users can use Transmission Simulator to run simulation-based experiments on two models: the Institute for Disease Modeling’s EMOD Disease Transmission Kernel and the Swiss Tropical and Public Health Institute’s OpenMalaria.

The EMOD malaria model couples a detailed description of the vector life cycle with a comprehensive, mechanistic representation of the intra host parasite and immune dynamics.

EMOD’s vector transmission model can be run as a vector cohort model or as an individual mosquito model and facilitates modeling multiple vector species simultaneously. This allows for a mechanistic description of vector abundances and behavior through the effects of climate and weather on different preferred larval habitats. EMOD

OpenMalaria is an open source C++ program for simulating malaria epidemiology and the impacts of interventions against malaria on that epidemiology. It is based on microsimulations of Plasmodium falciparum malaria in humans, originally developed for simulating malaria vaccines. These models simulate the dynamics of malaria parasitaemia in the course of an infection, of transmission, of immunity, and of the processes leading to illness and death. The system is set up to simulate malaria in village, or district size human populations. The original models have been extended to include simulation of the
Step 1 of 11: Select Template

Template is a set of recommended default settings for building EMOD simulations. EMOD model takes about 100 parameters, and template provides default values for all of them, weather files, demographics and migration files. You can change input parameters later.

Name/Description

- Priority Solomon Island Baseline
- Kenya baseline (no interventions)

Next Step →
Template config.json:
Priority Baseline Config

{
   "parameters": {
      "Acquisition_Blocking_Immunity_Decay_Rate": 0.01,
      "Acquisition_Blocking_Immunity_Duration_Before_Decay": 90,
      "Age_INITIALIZATION_DISTRIBUTION_Type": "DISTRIBUTION_SIMPLE",
      "Air_Migration_Roundtrip_Duration": 7,
      "Air_Migration_Roundtrip_Probability": 0.8,
      "Air_Temperature_Filename": "Honiara_temperature_daily10y.bin",
      "Air_Temperature_Offset": 0,
      "Air_Temperature_Variance": 2,
   }
}
Step 3 of 11: Weather Data

Select a weather data set to use for this run:

honoi, solomon islands: 2003 - 2033

Note:
Weather data will be repeated as necessary for Simulations with durations longer than the duration of the weather data set.
Please review the weather data.

**Mean Temp**

Zoom 1m 3m 6m YTD 1y All

From Jan 1, 2003 To Oct 4, 2011

![Graph showing mean temperature from 2003 to 2011 with fluctuations over the years.](image-url)
Step 4 of 11: Date Parameters

Enter Start time (in days) of weather data to start the run and its duration in days.

Weather data's start date is: 2003-01-01.
Weather data's end date is: 2033-01-01.
Weather data's duration is: 10957 days.

Start time: 0 days

Start date: 2003-01-01

Simulation duration: 10950 days

Note:
Weather data will be repeated as necessary for Simulations with durations longer than the duration of the weather data set.
Step 5 of 11: Vector Selection

Drag or click on a Species in the lower box to add it to the Experiment. Drag Species within the Experiment (upper box) to reorder. If no appropriate Species exists, Create a new one.

Species selected for Experiment

farauti

Species available for selection

farauti

+ Template defined species.

Create New Species
Step 5 of 11: Vector Selection

Drag or click on a species in the lower box below within the Experiment (upper box) to select it or a new one.

Species selected for Experiment: farauti

Species available for selection:

farauti

+ Template defined species.

Parameters:

- Anthropophily: 0.95
- Days Between Feeds: 2.45
- Indoor Feeding Fraction: 0.16
- Egg Batch Size: 120
- Adult Life Expectancy: 5.75
- Transmission Rate: 0.4
- Required Habitat Factor: 12500000000.0
- Aquatic Arrhenius 1: 8420000000
- Aquatic Arrhenius 2: 8328
- Infected Arrhenius 2: 8336
- Infected Arrhenius 1: 117000000000
- Immature Duration: 2
- Infectious Human Feed Mortality Factor 1.5
- Habitat Type: BRACKISH SWAMP
- Aquatic Mortality Rate: 0.1
- Acquire Modifier: 0.1
- Infected Egg Batch Factor: 0.8
Step 6 of 11: Vector Parameters

Please customize the Vector Parameters.

- **Egg Hatch Delay Distribution**
  - EXPONENTIAL_DURATION
  - Mean Egg Hatch Delay
    - 0
    - Range: 0 to 120

- **Egg Saturation At Oviposition**
  - NO_SATURATION

- **Enable Temp Dep Feeding Cycle**

- **Enable Vector Aging**

- **Enable Vector Migration**

- **Enable Vector Migration Human**

- **Enable Vector Migration Local**

- **Enable Vector Migration Wind**

- **HEG Facundity Limiting**

- **Mosquito Weight**
  - 1
  - Range: 1 to 2.14749e+308

- **Semipermanent Habitat Decay Rate**
  - 0.01
  - Range: 0.0001 to 100

- **Temporary Habitat Decay Factor**
  - 0.05
  - Range: 0.001 to 100

- **Vector Larval Rainfall Mortality**
### Step 7 of 11: Malaria Parameters

Please customize the Malaria Parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anemia Mortality Inverse Width</td>
<td>20</td>
<td>0.1 to 1e+06</td>
</tr>
<tr>
<td>Anemia Mortality Threshold</td>
<td>1.5</td>
<td>0 to 100</td>
</tr>
<tr>
<td>Anemia Severe Inverse Width</td>
<td>20</td>
<td>0 to 1,000,000</td>
</tr>
<tr>
<td>Anemia Severe Threshold</td>
<td>3</td>
<td>10 to 100</td>
</tr>
<tr>
<td>Antibody Csp Decay Days</td>
<td>90</td>
<td>1 to 3.40282e+38</td>
</tr>
<tr>
<td>Antibody Csp Killing Inverse Width</td>
<td>1.5</td>
<td>1e-06 to 1e+006</td>
</tr>
<tr>
<td>Fever Mortality Threshold</td>
<td>3</td>
<td>0 to 1,000</td>
</tr>
<tr>
<td>Fever Severe Inverse Width</td>
<td>10</td>
<td>0.1 to 1e+006</td>
</tr>
<tr>
<td>Fever Severe Threshold</td>
<td>1.5</td>
<td>0 to 10</td>
</tr>
<tr>
<td>Gametocyte Stage Survival Rate</td>
<td>1</td>
<td>0 to 1</td>
</tr>
<tr>
<td>Merozoites Per Hepatocyte</td>
<td>150000</td>
<td>0 to 3.40282e+38</td>
</tr>
<tr>
<td>Merozoites Per Schizont</td>
<td>16</td>
<td>0 to 1000</td>
</tr>
<tr>
<td>Base Gametocyte Fraction Male</td>
<td>0.2</td>
<td>0 to 1</td>
</tr>
<tr>
<td>Base Gametocyte Survival Rate</td>
<td>0.01</td>
<td>0 to 10,000</td>
</tr>
<tr>
<td>Base Gametocyte Production Rate</td>
<td>0.02</td>
<td>0 to 1</td>
</tr>
</tbody>
</table>
Step 9 of 11: Interventions

Drag or click on an Intervention in the lower box to add it to the Experiment. Drag Interventions within the Experiment (upper box) to reorder. If no appropriate Intervention exists, Create a new one. Note: Interventions are optional.

Intervention(s) selected for Experiment

Intervention(s) available for selection

- **InsectKillingFence**
  - Defined in template
- **Simple_Bednets_(predefined)**
  - An intervention using Simple Bednets.
- **Insect_Killing_Fence_(predefined)**
  - An intervention using an Insect Killing Fence.
- **IRS_(predefined)**
  - An IRS intervention.
Parasite Prevalence
Solomon Islands

Zoom: 1m 3m 6m YTD 1y All

From Dec 13, 2008 To Dec 28, 2015

Years

Infected %


Burkot – Solomon Island Analysis – Baseline 1
Burkot – Solomon Island Analysis LLINs 1
Burkot – Solomon Island Analysis Fence Killing 0.01
Burkot – Solomon Island Analysis Fence Killing 0.02
Burkot – Solomon Island Analysis Fence Killing 0.03
Burkot – Solomon Island Analysis Fence Killing 0.04

Highcharts.com
Risk Mapper
Map the impact of vector control interventions

Risk Mapper / Existing Scenarios / Priority scenario 1 (Solomon Isl...

Priority scenario 1 (Solomon Islands). Universal bednet use

What would be the impact on malaria transmission if there is universal bednet use? Interventions applied:
LLIN Coverage: 100%, Usage: 70%

See experiment in transmission simulator

Location: Solomon Islands

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Current Coverage</th>
<th>Simulated Future Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLIN</td>
<td>Not used</td>
<td>70%</td>
</tr>
<tr>
<td>IRS</td>
<td>Not used</td>
<td>0%</td>
</tr>
</tbody>
</table>

End of Baseline (Year 2021)
Selected EIR = (hover to select)

Scenario Year 2031
Selected EIR = (hover to select)
Tool Overview

The Product Impact Evaluator (PIE) facilitates users to ask defined questions about the impact of different interventions on vector control and malaria transmission at specific geographic locations. Product developers can use PIE to estimate the effect of novel vector control interventions on malaria transmission, and to ask “what-if” questions about a tool’s efficacy.

PIE users can:

- Estimate the impact of new candidate tools on vector control and malaria transmission
- Develop and refine Target Product Profiles
- Explore implementation strategies for new products
- Conduct In-silico experiments to evaluate impact of varying product parameters which are needed for effectiveness
- Change the underlying assumptions of modes of actions of interventions as modified inputs in model simulations.
CIFER (the Computational PortFolio Evaluator), allows users (e.g., funders, policy makers, malaria control officials) to explore the impact of implementing different combinations of malaria control interventions in different locations.

![Diagram of CIFER workflow]

Figure 1: Schematic of how CIFER works

**CIFER**

**Malaria Transmission Models**

**Select intervention characteristics**

**CIFER Constructed Scenarios**

**Determine how each intervention is implemented**

**Select interventions**

**Select location**

**CIFER Models**

**Clinical Outcomes Model**

**Economic and Financial Model**

**CIFER Outputs**

**Examples: number of clinical cases, hospitalizations, deaths, DALYs, and other outcomes**

**Examples: cost per outcome and incremental cost-effectiveness**

**Examples: costs, return-on-investment, marginal costs, and other economic outcomes**
Current Status
Beta testing
Falciparum
Vector control interventions
Single model launch of OpenMalaria and EMOD

Next Steps (2014)
Drug-based Interventions
Multiple model simultaneous launch
User friendly, widely available

A bit later
Vivax models
Other vector borne diseases
VecNet - Vector-Borne Disease Network is a consortium of institutions developing new resources to aid in worldwide malaria elimination.
vecnet.org
Acknowledgments

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