Malaria Modeling and Surveillance In Thailand and Indonesia

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Meteorological & Climatological Parameters

Vector Ecology
Predator Ecology
Anthropogenic Factors

THE PROBLEM

• 40% of the world’s populations at risk
• 300-500 million cases per year
• 1-3 million deaths per year
• Highest risks for children, pregnant women, and people with depressed immunorespons
• One death every 30 seconds
• Counterfeit and substandard antimalarial drugs abound.
• ACT is becoming less sensitive.
• Previously unaffected regions may have outbreaks due to climate change.

OBJECTIVES

Risk detection
Detection of larval habitats
Textural-contextual classification

Risk prediction
Prediction of current and future endemicity
Neural network methods

Risk reduction
Identification of key factors that sustain or promote transmissions
Agent-based discrete event simulation

BENEFITS

Applying larval control as a preventive measure

Strengthening and mobilizing public health support

Cost-effectively curtail malaria transmission
**Value & Benefits**
- Reduced morbidity & mortality for US Forces
- Improved public health for local populations
- Reduced damage to the environment
- Reduced likelihood of larvicide, insecticide & antimalarial resistance

**Research Partners**
- NIAID
- DOD
- DOE
- EPA
- NOAA

**Earth Sci. Model**
- Climate Prediction Earth Sci. Model

**Earth Observation**
- ASTER
- MODIS
- TRMM
- AVHRR
- SIESIP
- Ikonos
- QuickBird

**Malaria Models**
- Local Habitat Detection
- Endemicity Estimation
  - Present
  - Future
- Dynamic Transmission
- Regional Spatio-Temporal
- Cross-Regional Estimation
-models

**Value & Benefits**
- Reduced morbidity & mortality for US Forces
- Improved public health for local populations
- Reduced damage to the environment
- Reduced likelihood of larvicide, insecticide & antimalarial resistance

**Decisions**
- Preventative measures
- Countermeasures

**DSS Users**

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**Malaria Incidence in Aceh Increased Significantly After the Tsunami Disaster in December 2004**

**Detection of Ditches using Pan-sharpened Ikonos Data**

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**The Greater Mekong Subregion is the world’s epicenter of multi-drug resistant falciparum malaria.**

**Most Thai provinces endemic with malaria are border provinces.**

**40% of the 245M Indonesians Live in Malarious Regions**

**Source: WHO SEARO**

**Malaria Incidence in Aceh Increased Significantly After the Tsunami Disaster in December 2004**

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**Detection of Ditches using Pan-sharpened Ikonos Data**

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**Source: WHO SEARO**
Classification Accuracy using Pan-Sharpened Ikonos Data (1 meter resolution)

Satellite-Observed Meteorological & Environmental Parameters For Four Thailand Seasons

Surface Temperature
MODIS Measurements

Vegetation Index
AVHRR & MODIS Measurements

Rainfall
TRMM Measurements

Actual Malaria Incidence
Hindcast Incidence

Dynamic Transmission Modeling Framework

Satellite & Remote Data

Local Environment

Microepidemiology

Population Site

Host Relations

Vector Biology

Vector Control

Draining

Modeling effects of climate & environmental parameters on malaria transmission.

Agent-based, spatially explicit, discrete-event simulation

Kong Mong Tha Test Site, Kanchanaburi, Thailand

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Malaria Surveillance Study (Jun 99 – Jan 04)
Blood films from ~450 persons/month
Microscopy and Polymerase Chain Reaction
Larval and adult mosquito collection

In Collaboration with AFRIMS and WRAIR

A. dirus
A. minimus
A. maculatus
A. barbirostris
A. campestris
A. sawadwongpori
A. maculatus
Example: A Small Hamlet

- 23 houses
- 2 cattle sheds
- 24 clusters of larval habitats
- 8 cows
- 69 adults
- 23 children
- 2 cattle sheds
- 24 clusters of larval habitats
- 8 cows

Modeled and Observed Prevalence

Modeled and Observed Sporozoite Rates

Modeled and Observed Entomological Inoculation Rates

Well Placed Farm Animal Sheds and Zoonotic Prophylaxis May Significantly Reduce Malaria Transmission

- Sheds relocated to where mosquitoes are more abundant
- Zoonotic prophylaxis also used

Sensitivity Studies and Simulations Performed

Using Agent-Based Discrete Event Simulation Model

- Abundance of larval habitats
- Access to health care and appropriate treatment
- Asymptomatic cases
- Acquired immunity
- Active and passive case detections
- Bednets or personal protections
- Improved dwelling construction
- Parasite infectivity in mosquitoes
- Zoonotic prophylaxis
- Arrival of non-immune populations (such as migrant workers, refugees, foreign military forces)
With over 18,000 islands and a decentralized government, it is challenging to implement malaria control policy.

Rainfall Pattern, Which Drives Malaria Transmission, Varies Significantly from Island to Island

Average Monthly Precipitation for the Major Cities on the 8 Islands 2000-2005

Precipitation Based on TRMM Measurements

Hindcasting Malaria Cases in Jawa Tengah, Indonesia

Actual (red), Modeled (blue), and Hindcast (green) Malaria Cases

Districts Involved in Menoreh Hills Project

─ A MOH-WHO-NAMRU2-USAID Collaboration

Comparison of Kulong Progo and Purworejo ACD Cases (blue) with Jawa Tengah PCD Cases (red)