OpenMalaria, a simulator of malaria transmission and morbidity, and the use of BOINC for high-throughput computing

http://code.google.com/p/openmalaria

Diggory Hardy
July 1st, 2014
Malaria — *Plasmodium falciparum* Life Cycle
Observables:

- Prevalence
- Burden
- Elimination
- Intervention effectiveness
- Cost effectiveness
- Target Product Profiles
- Resistance
Malaria — what do we model

Interventions:

- Health system
- MDA, IPT, MSAT
- Vaccines
- Bed nets, insecticides, deterrents
- Larval control
- Ivermectin, sugar baits
Simulator:

- Integrates multiple models
Simulator:

- Integrates multiple models
- Transmission: forced, compartment
uninfected mosquitoes ➔ emerging larvae ➔ death
infected mosquitoes ➔ infectious mosquitoes ➔ death

OpenMalaria
Figure from Paul Libiszowski
Simulator:

- Integrates multiple models
- Transmission: forced, compartment
- Human agents (immunity, infections, interventions, heterogeneity)
Population modeling by microsimulation of malaria in humans.

- Discrete time, stochastic, individual-based simulations for malaria in humans.
- Stochastic, empirical simulation of *Plasmodium falciparum* densities
- Calibrated by formal fitting to data from field studies
Simulator:

- Integrates multiple models
- Transmission: forced, compartment
- Human agents (immunity, infections, interventions, heterogeneity)
- Parasites: empirical, compartment
Course of an untreated malaria infection

- *P. falciparum* erythrocyte membrane protein 1 (Variant surface antigen)
- Antigenic switching (18-24 hours into cycle)
- Recrudescences may result from expression of novel pfemp1/variant

Collins & Jeffery, 1999
Simulator:

- Integrates multiple models
- Transmission: forced, compartment
- Human agents (immunity, infections, interventions, heterogeneity)
- Parasites: empirical, compartment
- Vector larvae, infection incidence, immunity, vaccines, health system, ITNs, IRS, larvicides, diagnostics
- PK/PD, genotype tracking
Why agent based modelling?

- heterogeneity
- detailed parasite models
- detailed immunity models
- health outcomes
Why integrated modelling?

- health outcomes
- emergent behaviour:
  - interaction of interventions
  - vector-based interventions against malaria
Problems:

- Processing requirements
- Unknowns
- Bugs
What is BOINC?

- Berkeley Open Infrastructure for Network Computing
- 1999: SETI@home
- 2002: BOINC
- “free” cluster
Experiments:

- intervention strategy
- coverage
- timing
- health system
- transmission level
- models
- stochastic variance
Fitting unknowns:
- immunity
- case incidence, pathogenesis

Field data:
- loss function
- genetic algorithm
- iterate...
Optimisation
With thanks to ...