Why does schistosomiasis rebound? Sources of resilience to mass drug administration and implications for control strategies

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# Introduction

### Global burden and current control/elimination strategies/progress

* Global burden
* Guidelines rely on MDA
* MDA successful in many areas (examples)
* but not so much in other areas …

### “Persistent hotspots”, rapid rebound, and resilience to control/elimination

* Logistical challenges coordinating drug donation and administration in areas where it’s most needed
* MDA alone successful in many places, while others rapidly return to pre-MDA infection levels even before the next round of MDA
* Persistent hotspots in SCORE trials, finescale variation in “responder” vs. “hotspot” communities

### “Environmental” control: history, recent evidence, explanations

* Summary of current (WHO, other agencies?) guidelines/strategies for control options other than MDA
* Sanna’s paper on history of schisto elimination
* Contradiction(s) between current guidelines and evidence base? What can models tell us?…

### Modeling schistosomiasis control: density dependence, breakpoints, non-linearities

* History of modeling schistosomiasis dynamics in the context of control
* Density dependence and presence of a transmission breakpoint
* Importance and implications of the breakpoint
* Sources of resilience and brief explanations:
* Non-linear man-to-snail transmission dynamics
* Density-dependent fecundity
* Acquired immunity
* Changes in worm burden distribution among infected individuals

### Framing of the problem

* Systematic investigation of sources of resilience and their implications for control
* Quantifying the influence of sources of resilience
* Identifying (optimal?) control strategies when accounting for sources of resilience

# Methods

We expand on classic “MacDonald-type” models and our more recently published models incorporating logistic snail population growth to explore the role of X, Y, and Z on schistosomiasis transmission dynamics as the parasite population is affected by routine MDA.

### Infection dynamics in intermediate host snails

Schistosome infection among intermediate host snails follows a susceptible-exposed-infected (S-E-I) framework in order to account for the delay (pre-patent period) between infection and active shedding of cercariae (patency). Logistic population growth

### Infection dynamics in human hosts

### Sources of resilience and their representation in the model

#### Non linear snail FOI

Man-to-snail transmission is a saturating function of miracidial density, , as in Gurarie, Lo, Ndeffo-Mbah, Durham, and King (2018)

#### Reservoirs of infection

Miracidial input estimated as the sum of infectious input across all definitive human host populations:

where mean worm burden, , is modeled separately for different age groups, , and treatment groups, ; is the number of individuals in the group; is the mating probability of adult worms in each population with the dispersion parameter of the negative binomially distributed worm population, , estimated as a function of the mean worm burden, (see below); and is an estimate of the amount of infectious material from each group that reaches the intermediate host snail population.

MDA in the affected population is modeled as a reduction in the mean worm burden by , the efficacy of the drug intervention, in the following timestep of the model: . Mean worm burden in the other populations remain unaffected except via reductions in the man-to-snail FOI as a result of treating the affected population.

#### Dispersion parameter responsive to worm burden in each population

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#### Density dependent fecundity

#### Acquired immunity

## and : derivation, estimation, and response to different control strategies

## Stochastic model simulating control strategies and probability of elimination as a metric of potential success

* No intervention (baseline)
* School-based MDA (coverage informed by estimates from Senegal? Score?)
* Community-wide MDA (coverage informed by estimates from Senegal? Score?)
* Each MDA strategy with snail control
* Initial \_% reduction in snail habitat followed by \_\_\_ MDA strategy
* Gradual \_% reduction in snail habitat in conjunction with \_\_\_ MDA strategy
* Gradual improvements in sanitation and hygiene in conjunction with MDA

# Results

### Potential Figures (in no particular order)

#### - curve pointing out ,

#### - time series

Shows that MDA except at extremely high levels of coverage increases transmission (as measured by ) by reducing influence of negative density dependence, leads to return towards pre-intervention levels of infection

#### - comparisons between models to show influence of sources of resilience on the breakpoint population size. e.g. what is breakpoint with no PDD, with PDD, with PDD+non-linear huma-snail FOI, etc…

#### - across values of parameters that can be changed via control measures

#### - Example stochastic time series from different control strategies, delineate chains that successfully control/eliminate (based on WHO definition) from those that rebound with different colors

### Table (further divided by intervention strategy):

|  |  |  |  |
| --- | --- | --- | --- |
|  | Probability.of.transmission.control | Probability.of.elimination.as.a.public.health.problem | Probability.of.outright.elimination |
| High prevalence setting | NA | NA | NA |
| Medium prevalence setting | NA | NA | NA |
| Low prevalence setting | NA | NA | NA |

# Discussion