Modeling Schistosomiasis Transmission in Togo's Ogou District

Olivia Kern
Fulbright Student — Togo, 2017

June 10, 2018

Background

Despite six years of continuous mass drug administration (MDA) activities at the national level, prevalence of three neglected tropical diseases–Schistosomiasis, Soil-transmitted Helminths and Onchocerciasis–has increased in Togo's Ogou district. Determining the factors contributing to low rates of MDA success is key to improving the outcomes of future control programs. I followed MDA activities across six villages in two peripheral health units (USP) and generated a (descriptor) probabilistic model (S_{MDA}) based on my observations to assess the logical statement of a given person's compliance to MDA. Let a person be eligible for MDA if boolean model

$$C_{MDA} = p \wedge a \wedge r \wedge f \tag{1}$$

boolean values For a person to be eligible for MDA compliance, he or she must be present in his or her own household during PZQ distribution activities and have true values for all elements a (wakefulness), r (no past adverse reaction to Praziquantel) and f (meal within 4 hours before MDA) and have taken the full required d. Because a true value for each element corresponds to a value of 1, the likelihood of MDA compliance for an individual who is successfully reached by a community health worker given factors a, r, f is $\frac{1}{8}$.

Until now, MDA has been the sole intervention used for Schistosomiasis control in Togo. Given the challenges of achieving high coverage rates and therefore high rates of control with MDA alone, it may be desireable to explore the implementation of addtional strategies for Schistosomiasis control, focused on snail to human transmission dynamics. Many recent studies(cite) have highlighted the effectiveness of a combination of MDA and snail control strategies for Schistosomiasis control.

To simulate the benefits of such interventions for control in Ogou, I will apply a set of ordinary differential equations adapted from Ciddio et al. 2017 which model the dynamics of Schistosomiasis transmission between snail and human populations. I have incorporated my own unique variables to reflect local phenomena affecting infection rates observed during my fieldwork in Ogou. These are ι_H representing net immigration into Ogou, which we assume is >0 given a stable influx of Ghanian immigrants into the region (2)

The system of differential equations is expressed in terms of the human population size N_v and the total number of parasites P_v within human hosts living in each village $_v$, the

density of susceptible, exposed, and infectious snails S_w, E_w, I_w in the freshwater point $_w$, and the concentration of cercariae C_w and miracidia M_w in the freshwater body. n_v villages and n_w water points The first equation (2) describes the rate of human population change in endemic villages. the per capita natality rate μ_H represents population growth, to which I incorporated a variable ι_H representing net migration given the importance of an influx of untreated persons to the transmission dynamics offset by parasite-incduced death given α parasitic pathogenicity. including the mating pair dynamics (?) and the impact of poor sanitation (variable) This N_v is the symbol for the population...

$$\dot{N}_v = \mu_H \iota_H (H_v - N_v) - \alpha P_v \tag{2}$$

$$\dot{P}_v = F_v N_v - (\mu_H + \mu_P + \alpha) P_v - \alpha \frac{k+1}{k} \frac{P_v^2}{N_v} \tag{3}$$

$$\dot{S}_w = v S_w [1 - \gamma_w (S_w + E_w + I_w)] - \mu_S S_w - \rho M_w S_w + D_w^s \tag{4}$$

$$\dot{E}_w = \rho M_w S_w - (\mu_s + \eta) I_w + D_w^E \tag{5}$$

$$\dot{I}_w = \delta E_w - (\mu_s + \eta) I_w + D_w^I \tag{6}$$

$$\dot{C}_w = \zeta I_w - \mu_c C_w + L_w^I \tag{7}$$

$$\dot{M}_w = \varrho M_w + L_w^M \tag{8}$$

$$F_v = \beta \sum_{j=1}^{n_w} \Omega_v w C_w \tag{9}$$

$$F_v = \beta \sum_{j=1}^{n_w} \Omega_v w C_w \tag{10}$$

n_v villages
n_w water points
N_v human population size in each village
P_v total number of parasites in human hosts in each village
S_w susceptible snails in freshwater source
E_w exposed snails in freshwater source
I_w infected snails in freshwater source
C_w concentration of cercariae in freshwater source
M_w concentration of miracidia in freshwater source
P_v total number of adult parasites
μ_H natural human host mortality
μ_P per capita parasite mortality
v intrinsic natality rate

γ_w site-specific effect of density dependence
μ_s mortality rate of susceptible snails
: human contamination rate