

Base Single Patch Model (with vital dynamics)

$$\begin{aligned}\frac{dS}{dt} &= \mu N - \mu S - \beta_i SI - \beta_w SW \\ \frac{dI}{dt} &= \beta_i SI + \beta_w SW - I(\gamma + \mu + \alpha) \\ \frac{dR}{dt} &= \gamma I - \mu R \\ \frac{dW}{dt} &= \xi I - \sigma W\end{aligned}$$

- μ = natural death rate
- β_i = transmission rate between S and I class
- β_w = transmission rate between I and W class
- γ = recovery rate (I to R class)
- α = death rate from cholera
- ξ = Shedding rate of cholera from I to W class
- σ = Removal rate of cholera from W class (depends on what we define as our water source)

Single Patch Model: Severity of Shedding dependent on Intensity of Symptoms (Low and High)

$$\begin{aligned}\frac{dS}{dt} &= \mu N - \mu S - \beta_L SI_L - \beta_H SI_H - \beta_w SW \\ \frac{dI_L}{dt} &= \beta_i S(I_L + I_H) + \beta_w SW - I_L(\mu + \delta + \alpha_L) \\ \frac{dI_H}{dt} &= \delta I_L - I_H(\gamma + \mu + \alpha_H) \\ \frac{dR}{dt} &= \gamma I_H - \mu R \\ \frac{dW}{dt} &= \xi_L I_L + \xi_H I_H - \sigma W\end{aligned}$$

- This model assumes that you start off with low intensity symptoms (lower rate of shedding) and the symptoms reach a high intensity with a greater rate of shedding.
- α_i = death rate by cholera in low or high intensity
- δ = rate at which symptoms increase in severity

Treatment Plan 1: Sanitation of water over time

$$\begin{aligned}\frac{dS}{dt} &= \mu N - \mu S - \beta_i SI - \beta_w SW \\ \frac{dS}{dt} &= \beta_i SI + \beta_w SW - I(\gamma + \mu + \alpha) \\ \frac{dR}{dt} &= \gamma I - \mu R \\ \frac{dW}{dt} &= \xi I - \sigma W - \rho(I)W\end{aligned}$$

- $\rho(I) = \begin{cases} 0 & I \geq 0.1 \\ \lambda & 0 \leq I \leq 0.1 \end{cases}$

Represents the sanitation (increased removal of cholera) rate of λ , implemented at certain threshold of infected (in this case the threshold is based on I but can be based on W (i.e. testing water levels for cholera))

Treatment Plan 2: Vaccinations on Base Model

$$\begin{aligned}\frac{dS}{dt} &= \mu N - \mu S - \beta_i SI - \beta_w SW - \nu S \\ \frac{dI}{dt} &= \beta_i SI + \beta_w SW - I(\gamma + \mu + \alpha) \\ \frac{dR}{dt} &= \gamma I - \mu R + \nu S \\ \frac{dW}{dt} &= \xi I - \sigma W\end{aligned}$$

- ν = is vaccination rate on S class

Treatment Plan 3: Antibiotics on Base Model

$$\begin{aligned}\frac{dS}{dt} &= \mu N - \mu S - \beta_i SI - \beta_w SW \\ \frac{dI}{dt} &= \beta_i SI + \beta_w SW - I(\gamma + \eta + \mu + \alpha) \\ \frac{dR}{dt} &= (\gamma + \eta)I - \mu R \\ \frac{dW}{dt} &= \xi I - \sigma W\end{aligned}$$

- η = is antibiotic rate on I class