

# Examining Treatment Strategies for Cholera Incorporating Spatial Dynamics

Group: Plague Doctors

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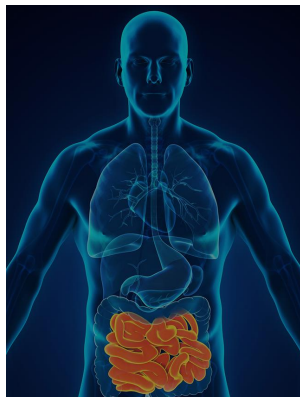
Instructor: Dr. David Earn

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- Treatments have not always gone as planned in history
- Cholera

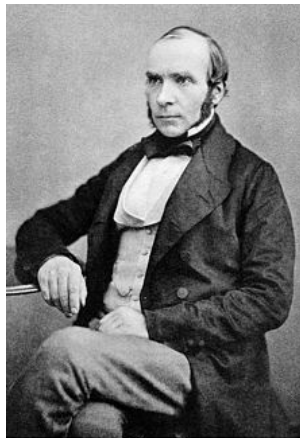
# Some Biology on Cholera

- *Vibrio cholerae*
- Colonize small intestines
- 10
- Causes dehydration



# Outbreaks in London (19<sup>th</sup> Century)

- 1832, 1849, 1854, 1866
- Miasma Theory
- John Snow



*John Snow*

# Single-Patch Model

- Entire population ( $N$ ) included
- 3 Compartments : S, I, R
- Compartment values are proportional
- Environment (Water)

# SIRW Model Assumptions

- Birth Rate = Natural Death Rate and is constant
- Homogenous susceptibility to cholera across population
- No waning immunity
- No latency period
- Only infected individuals can infect the water sources
- Water source is still

# SIRW Model



# SIWR Model Phase Portrait



- Using the method of Next Generation Matrix (van den Driessche and Watmough, 2002)

$$F = \begin{pmatrix} \beta_i & \beta_w \\ 0 & 0 \end{pmatrix}$$
$$V = \begin{pmatrix} \frac{1}{\gamma + \mu + \alpha} & 0 \\ \frac{1}{\gamma + \mu + \alpha} & \frac{1}{\sigma} \end{pmatrix}$$

- $R_0$  is computed as the spectral radius of  $FV^{-1}$ :

$$\begin{aligned} \mathcal{R}_0 &= \rho(FV^{-1}) \\ &= \frac{\beta_i + \beta_w}{\gamma + \mu} \end{aligned}$$

# Equilibria and Stability

# Final Size

# Effect of the 19th Century Treatments

# Multi-Patch Model

# Multi-Patch Model Assumptions

- No dispersal of individuals
- Infected individuals can infect the susceptible in neighboring patches
- All patches neighbouring  $i$  have the same transmission rate to patch  $i$

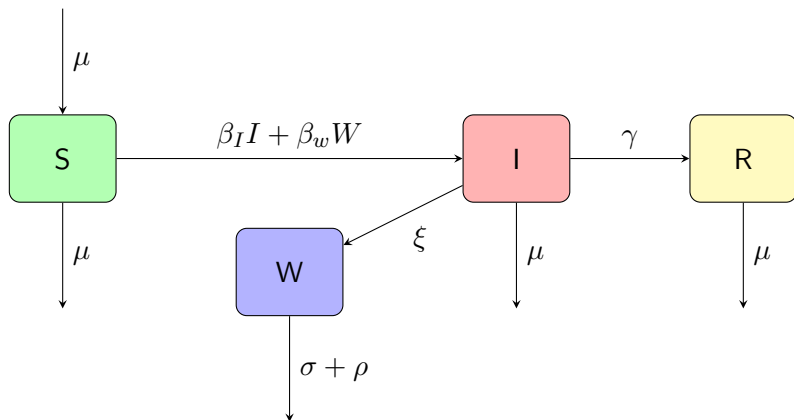
# Multi-Patch Model Simulation

# Treatment Strategies For Cholera

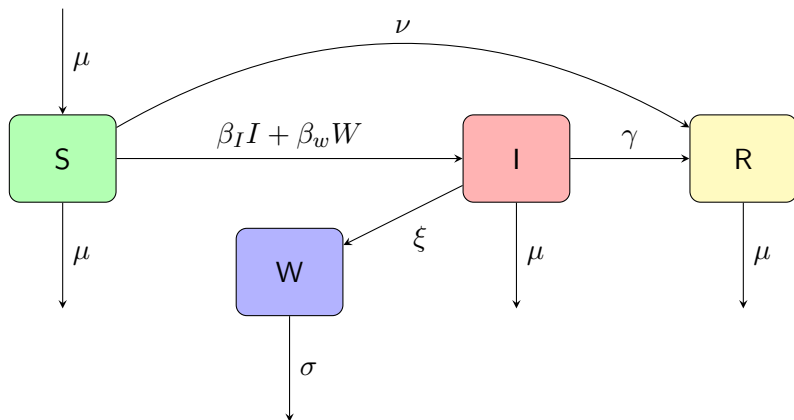
- 1 Sanitation of Water
- 2 Vaccinations
- 3 Antibiotics



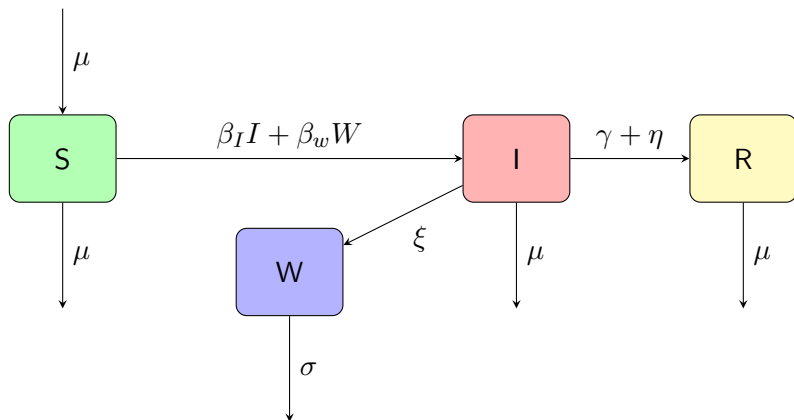
# Sanitation of Water



# Vaccinations



# Antibiotics



# Comparing the Treatment Strategies

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# Conclusions and Further Research

- 19th century outbreaks
- Significance of the using multi-patch model
- Our treatment simulations suggest. . .
- Further research on the spread of water borne diseases like cholera can be done in areas like. . .

Thank you!