Model - Structure & Design

STATE VARIABLES

S: susceptible individuals

V: vaccinated individuals

I: infected individuals → what is plotted

R: recovered individuals

→ for all 5 counties (total of 20)

MODEL STRUCTURE

- Deterministic, continuous
- Ordinary Differential equations (ODEs)
- Used package deSolve to model ODEs

MODEL DESIGN

➢ **Initial S:**
- For Gaines (total population*unvaccinated -1)
- For other counties (total population*unvaccinated)

➢ **Initial I:**
- For Gaines it is 1
- For other counties it is 0

➢ **Initial R** is 0 for every county

➢ Contact rates specific to each county
→ intra-county contact rates
→ inter-county contact rates with Gaines

➢ Constant parameters for recovery rate, vaccination efficiency, baseline transmission rate

Model Parameters

CONSTANT PARAMETERS

λ: Recovery rate

$\lambda = 1/4$ (4 day recovery from I → R)

ϵ: Vaccine effectiveness

$\epsilon = 0.97$ (3% can still get infected V → I)

(assumes all vaccinated received 2 doses)

β: Transmission coefficient

$\beta = 1.26$ (base transmission rate, changes depending on county specific contact rates)

CONTACT RATES

c_{gg}: Gaines → Gaines = 1.5

c_{dd}: Dawson → Dawson = 2

c_{aa}: Andrews → Andrews = 2

c_{tt}: Terry → Terry = 2

c_{yy}: Yoakum → Yoakum = 2

c_{gd}: Gaines → Dawson = 0.05

c_{ga}: Gaines → Andrews = 0.1

c_{gt}: Gaines → Terry = 0.05

c_{gy}: Gaines → Yoakum = 0.05

Model Parameters Cont

POPULATION SIZE

N_g: Gaines County pop size = 23,289

N_d: Dawson County pop size = 11,660

N_a: Andrews County pop size = 19,344

N_t: Terry County pop size = 11,753

N_y: Yoakum County pop size = 7,436

VACCINATION COVERAGES*

$vacCov_g$: Gaines County = 0.8197

$vacCov_d$: Dawson County = 0.8808

$vacCov_a$: Andrews County = 0.9768

$vacCov_t$: Terry County = 0.9552

$vacCov_y$: Yoakum County = 0.9250

*used to calculate susceptible/vaccinated initial counts

Flow Diagram and Differential Equations

* β multiplied by contact rates!

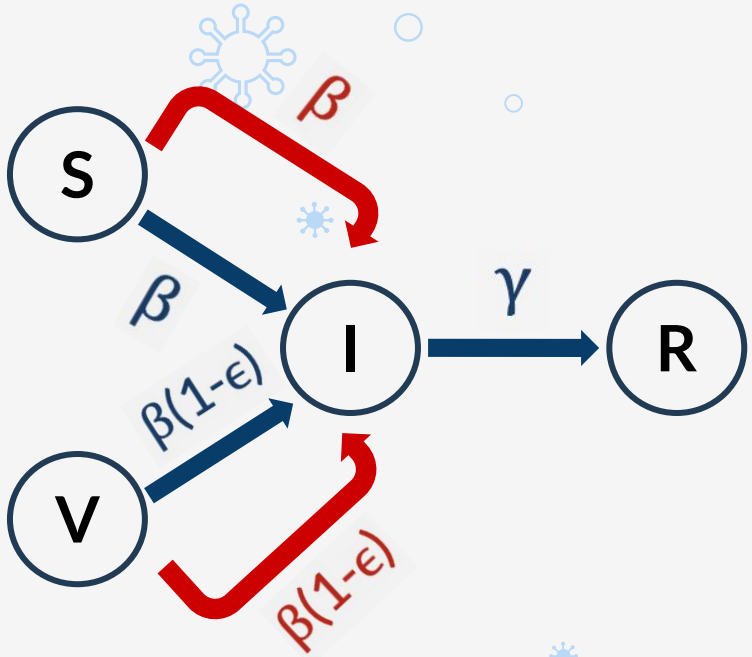
S-V-I-R Measles Model
(per county)

$$\frac{dS_i}{dt} = -\frac{\beta c_{ii} I_i S_i}{N_i} - \frac{\beta c_{ij} I_j S_i}{N_j}$$

$$\frac{dV_i}{dt} = -\frac{\beta c_{ii} I_j V_i (1-\epsilon)}{N_i} - \frac{\beta c_{ij} I_j V_i (1-\epsilon)}{N_j}$$

$$\frac{dI_i}{dt} = \frac{\beta c_{ii} I_i S_i}{N_i} + \frac{\beta c_{ii} I_j V_i (1-\epsilon)}{N_i} - \gamma_i I_i + \frac{\beta c_{ij} I_j S_i}{N_j} + \frac{\beta c_{ij} I_j V_i (1-\epsilon)}{N_j}$$

$$\frac{dR_i}{dt} = \gamma_i I_i$$



Blue: All counties (base model)
Red: Only outgroup counties (transmission from Gaines County)

Works Cited

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