A Structured Mathematical Model For Polio Virus In Nigeria

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Agenda

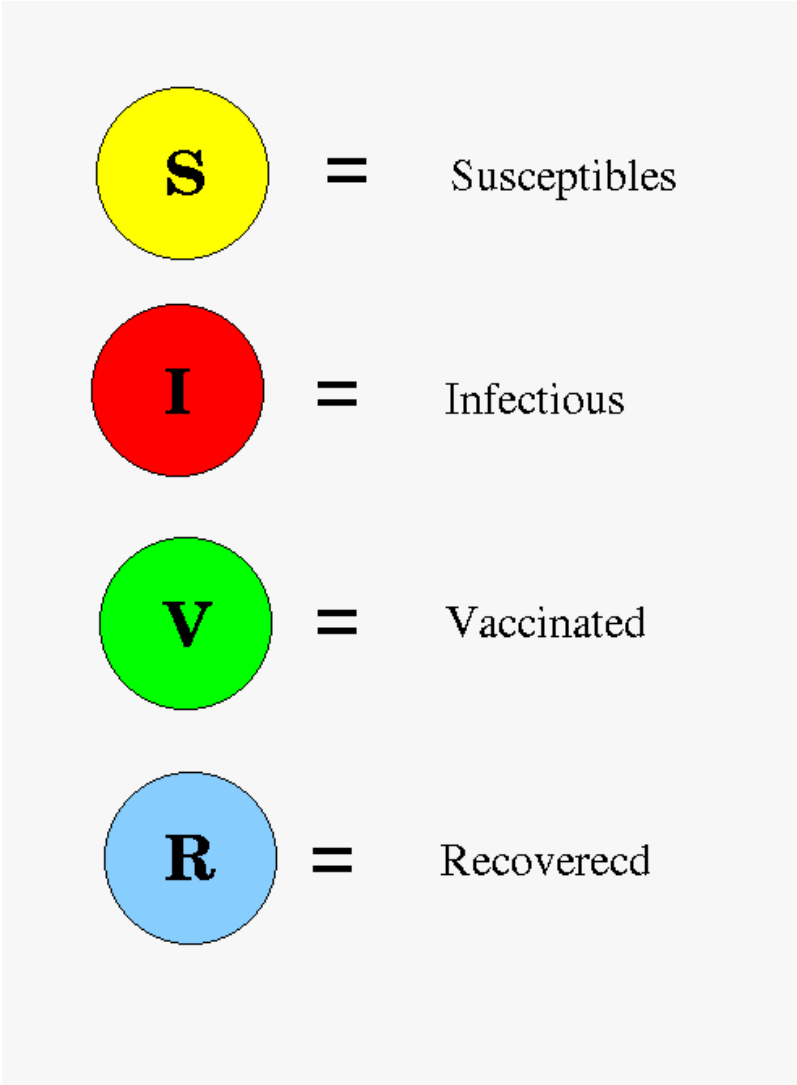
- Introduce Research Problem
- Modeling Approach
- Methodology
- Data
- Results
- Conclusions

Research Problem: Best Strategy for Eradication?

- Vaccinations
- Environmental Clean Up Efforts

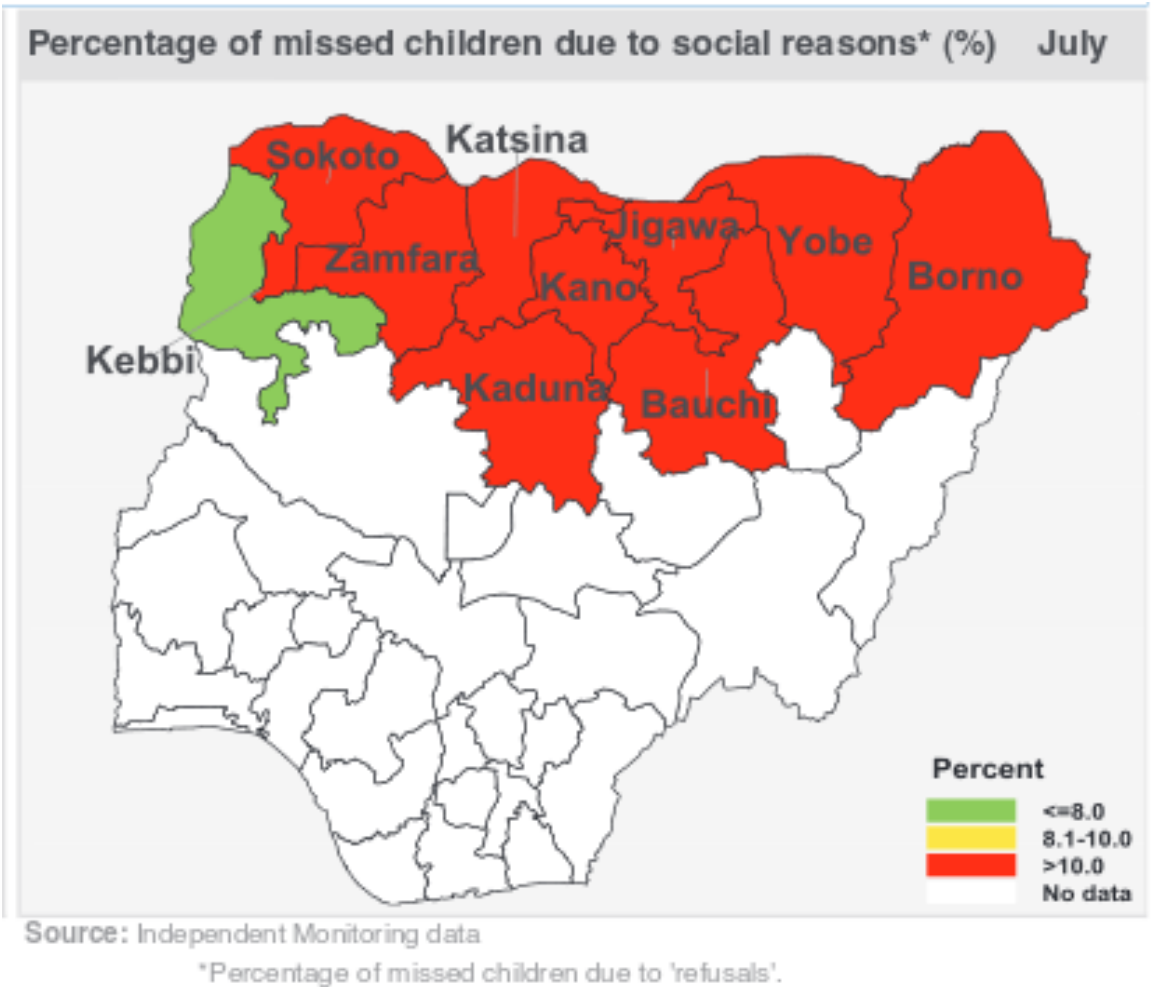
Modeling Approach

Compartmental Models

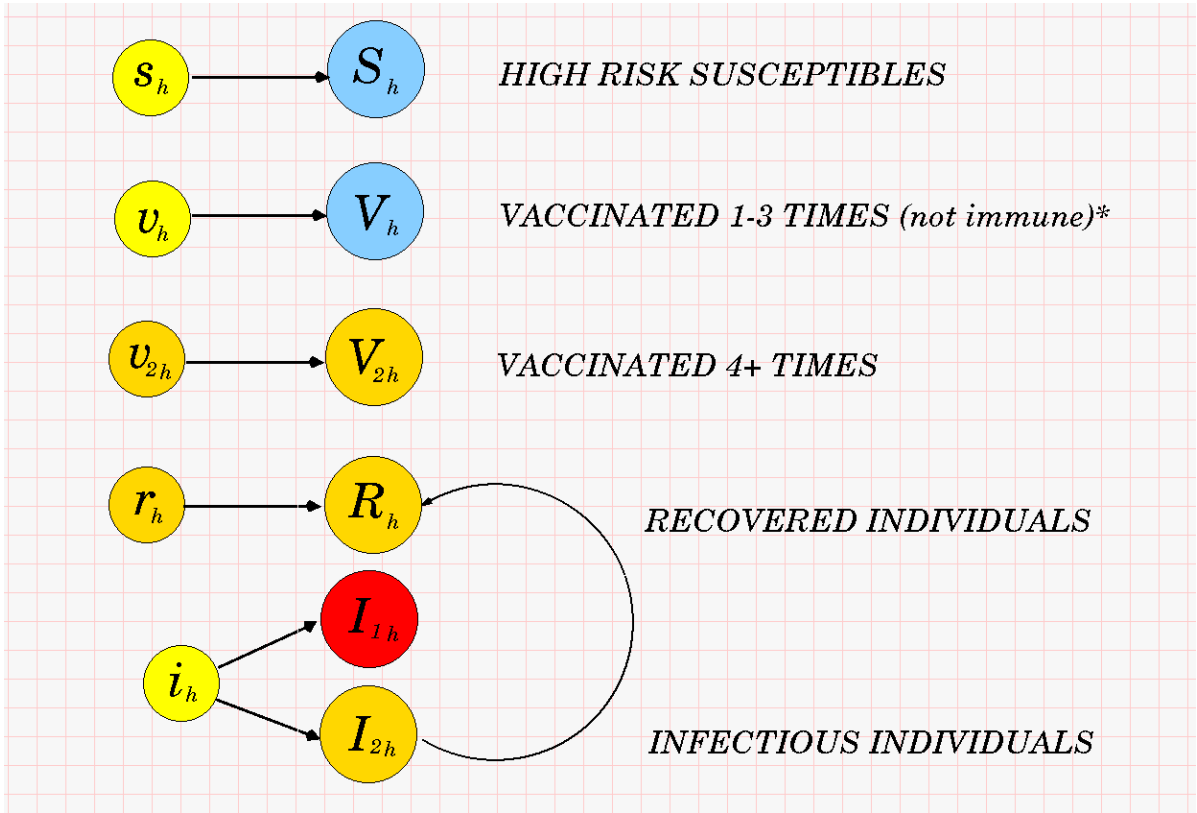


Risk Structure

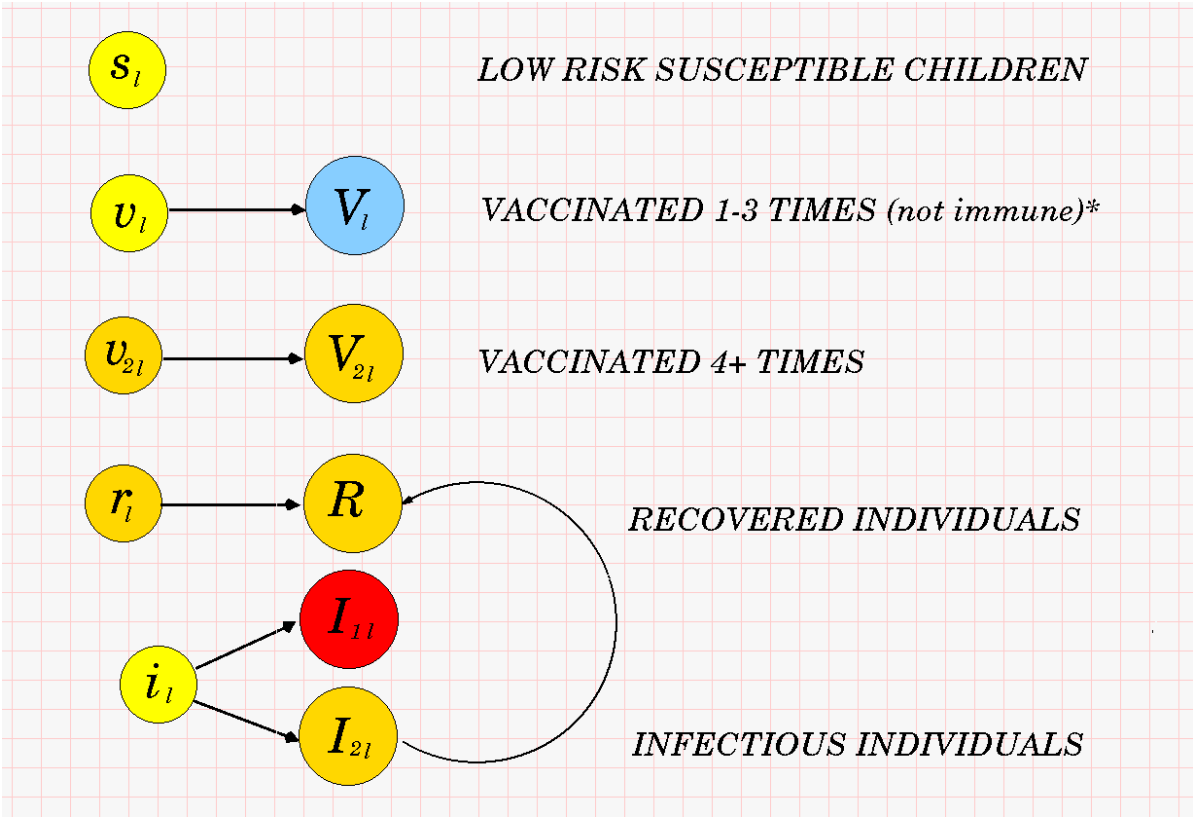
- *Kano: 11 million→ #1 most populous state
- 45 million high risk, 135 million low risk



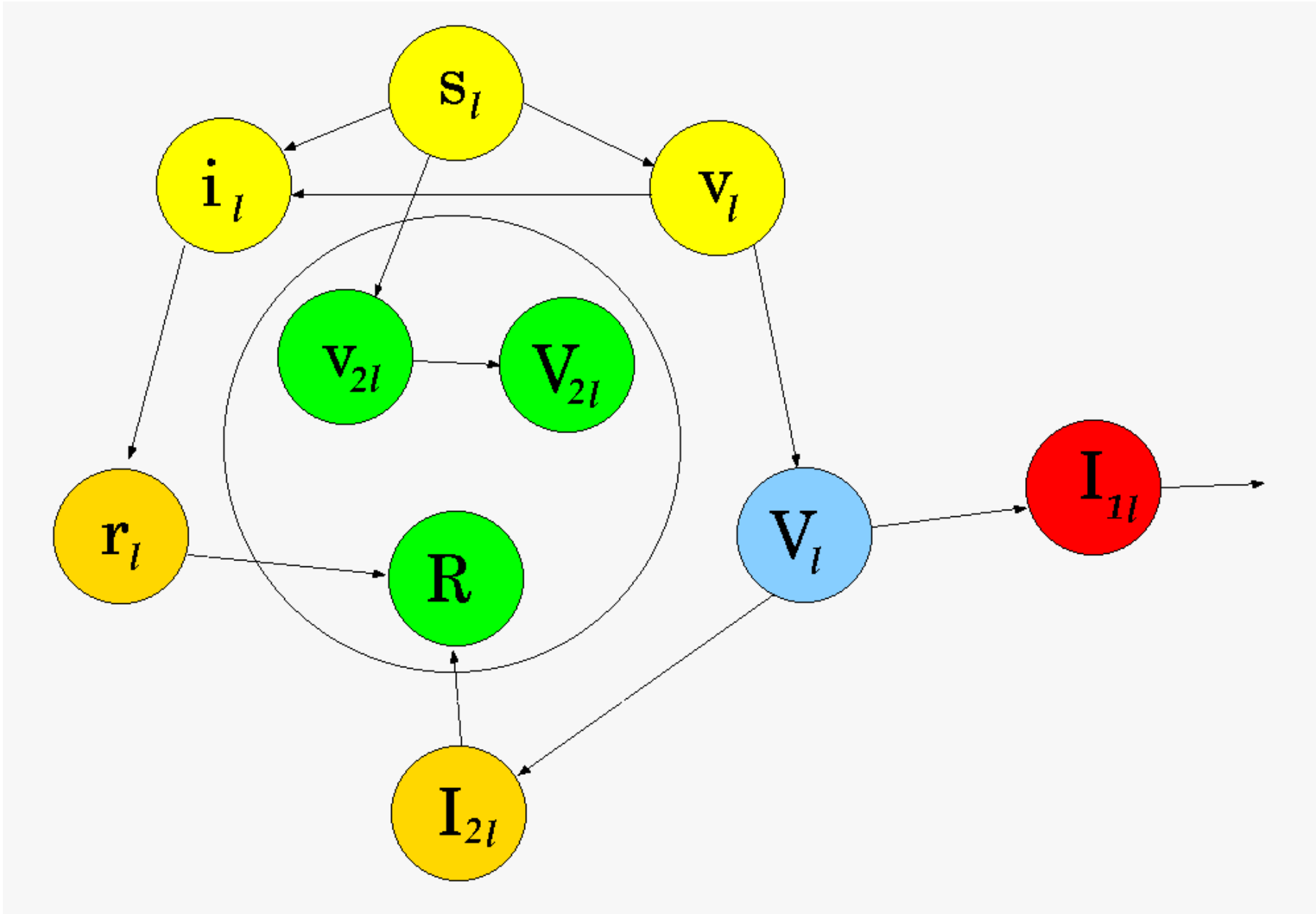
Model Key


s_h
S_h
HIGH RISK SUSCEPTIBLES
v_h
V_h
VACCINATED 1-3 TIMES (not immune)*
v_{2h}
V_{2h}
VACCINATED 4+ TIMES
r_h
R_h
RECOVERED INDIVIDUALS
I_{1h}
i_h
I_{2h}
INFECTIOUS INDIVIDUALS

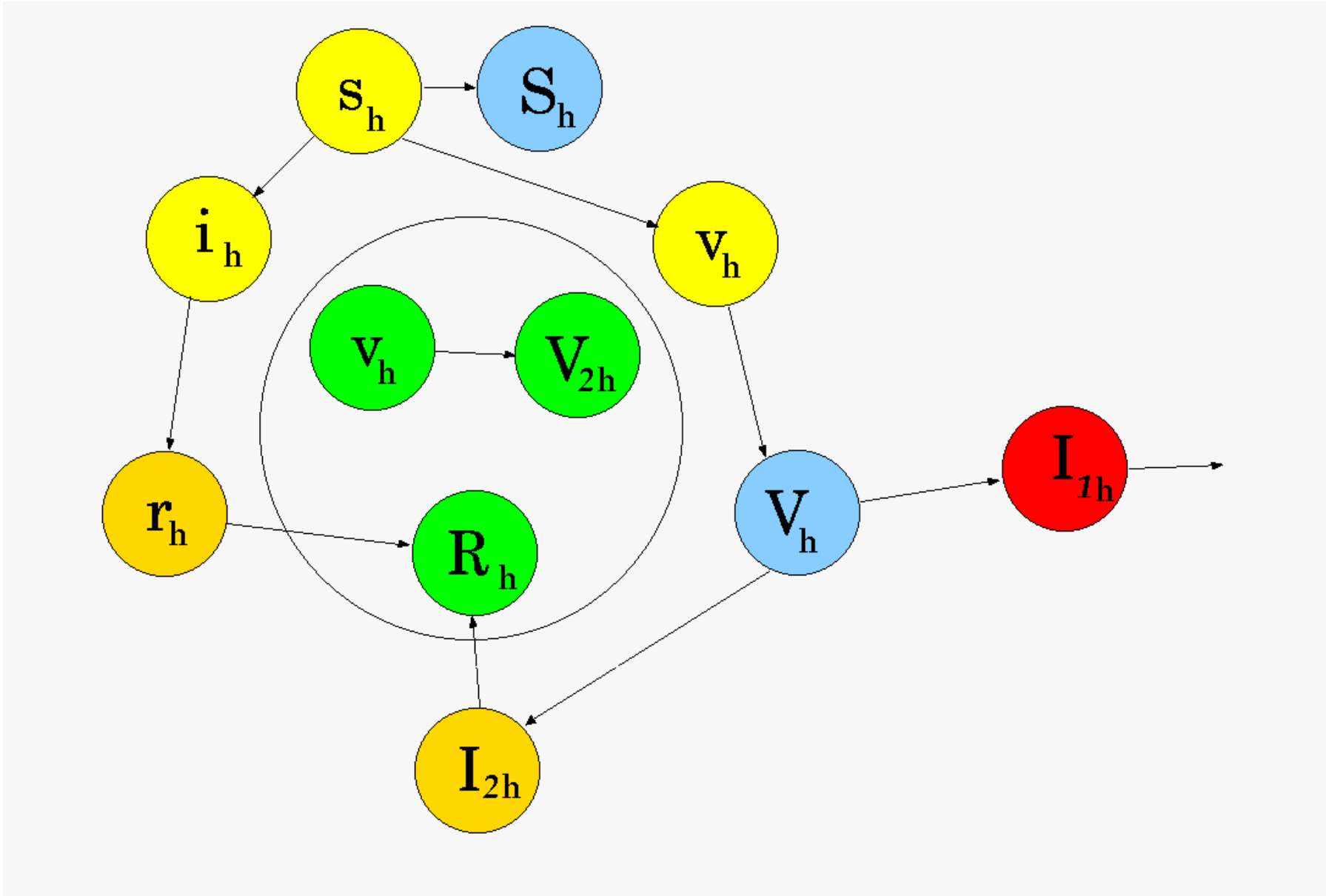
Model Key


s_l
LOW RISK SUSCEPTIBLE CHILDREN
v_l
V_l
VACCINATED 1-3 TIMES (not immune)*
v_{2l}
V_{2l}
VACCINATED 4+ TIMES
r_l
R
RECOVERED INDIVIDUALS
I_{1l}
i_l
I_{2l}
INFECTIOUS INDIVIDUALS

Model Picture: Low Risk



Model Picture: High Risk



Methodology: Monte Carlo Simulation

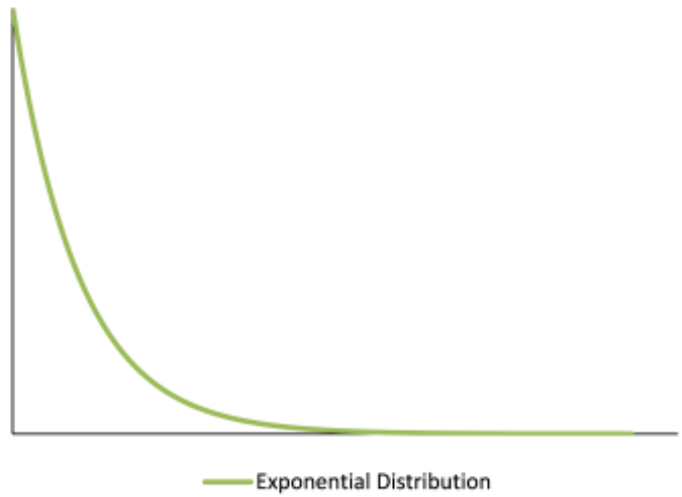
Data: Parameter Values and Initial Conditions

- $\gamma =$ the length of the infectious period
- $\beta_1 =$ high risk contact rate with environment
- $\beta_2 =$ low risk contact rate with environment
- $h =$ viral concentration in the environment

Exponential Distribution

γ=exponential distribution

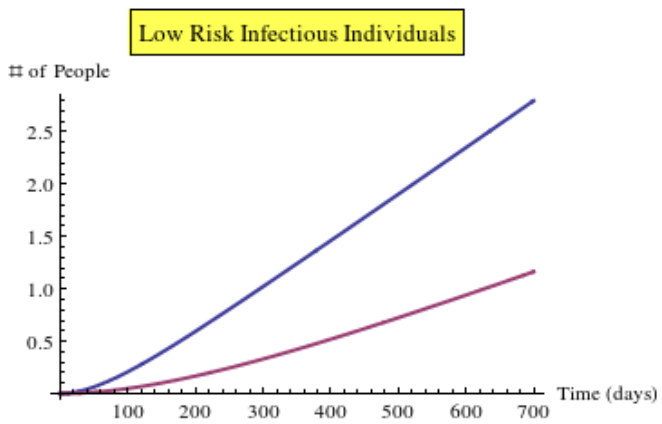
$Pr[a < \gamma < b] = \int_a^b e^{\frac{-r}{\sqrt{\mu}}} dr$ for a,b>0

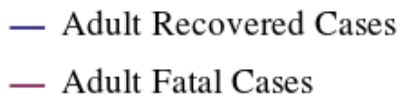


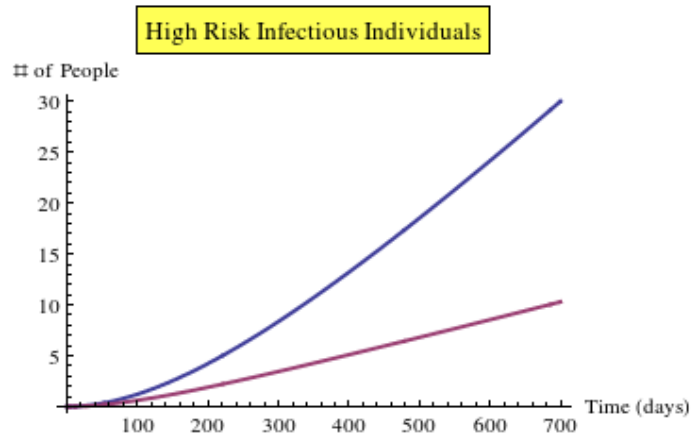
$\mu = \int_0^\infty f(r)dr = \int_0^\infty re^{\frac{-r}{\sqrt{\mu}}} dr$

Outbreak Cases with Zero Initial Infectious Individuals

Case 1: Initial infectious class set to zero. Environmental efforts set to zero. Vaccines set to normal level.

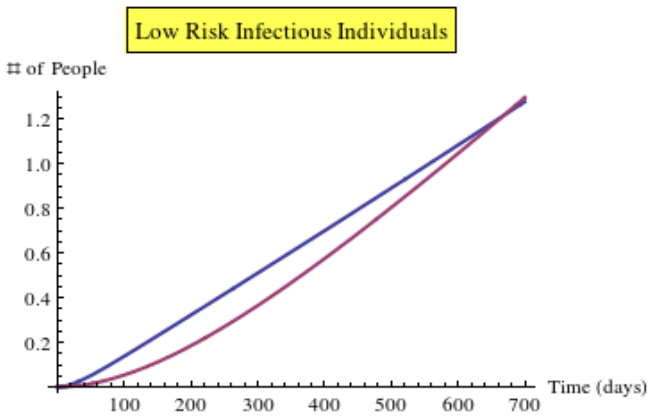


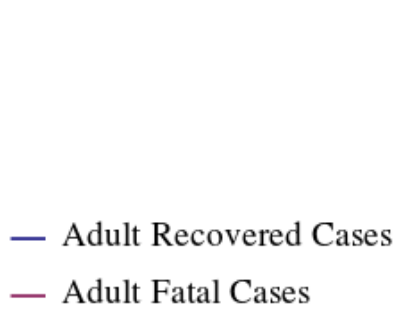


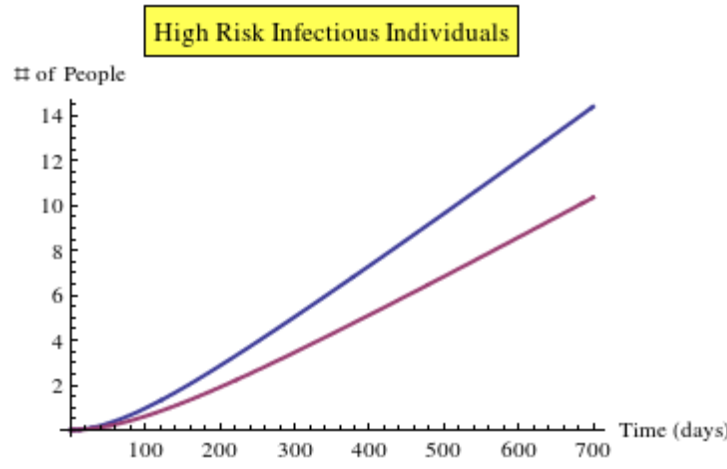


Disease seems to be taking off.

Case 2: Initial infectious class set to zero. Environmental efforts set to zero. Vaccines increased 5%.

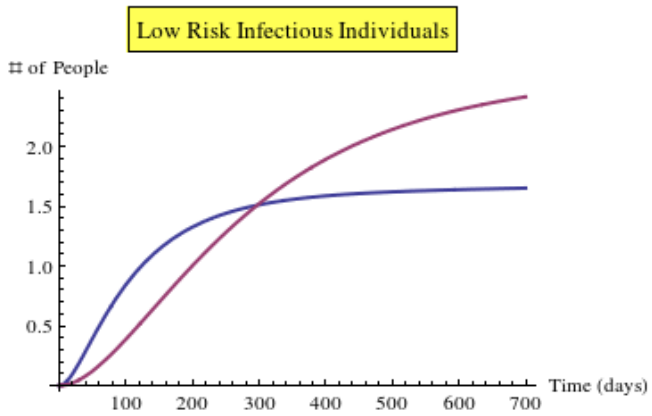


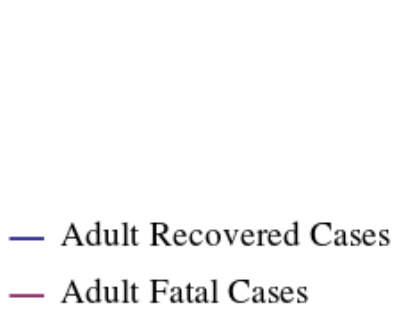


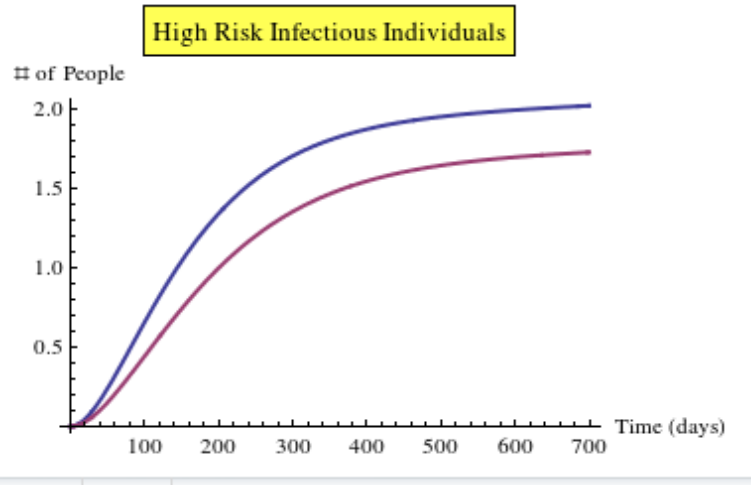


Number of infectious decreased by half.

Case 3: Initial infectious class set to zero. Vaccines restored to normal levels. Environmental efforts increased 1%



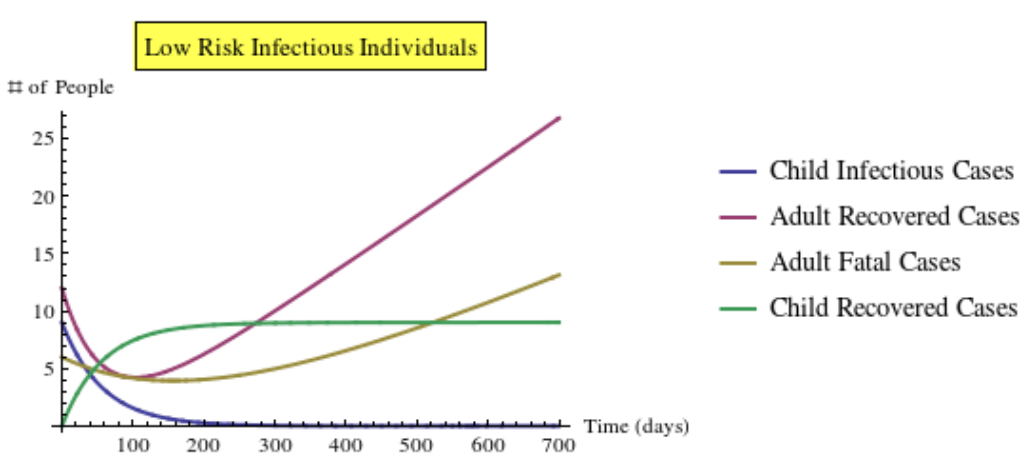


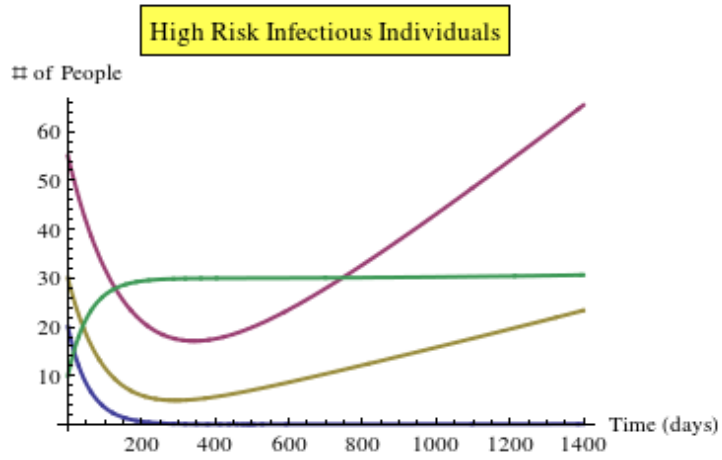


Infectious class nearly eradicated!

Eradication Cases with Nonzero Initial Infectious Individuals

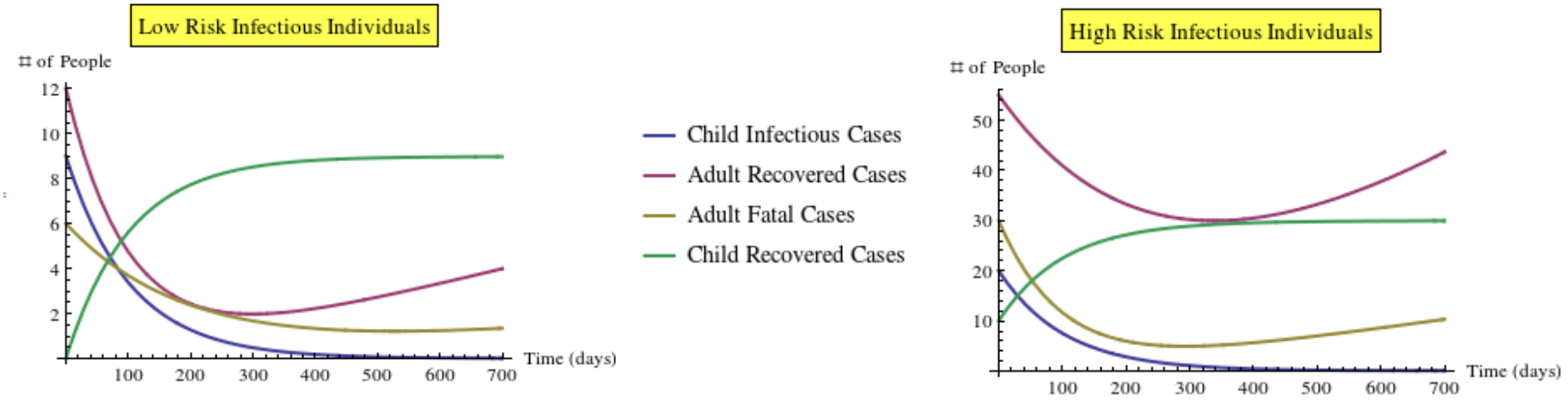
Case 4: Initial infectious class set to standard values. Vaccines restored to normal levels. Environmental efforts set to zero





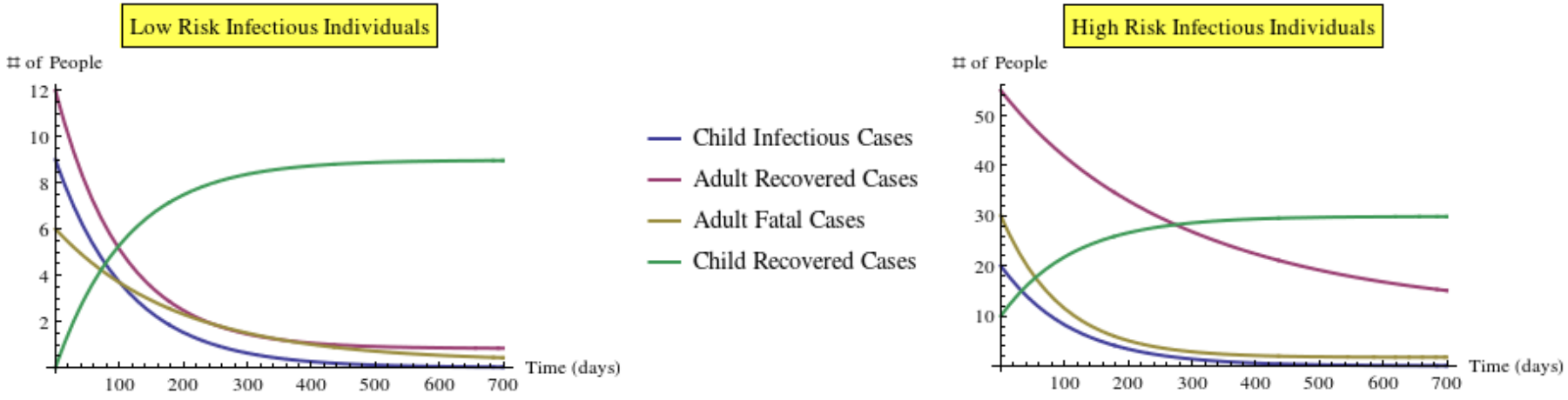
Infectious class remains high.

Case 5: Initial infectious class set to standard values. Vaccines increase 5%. Environmental efforts set to zero.



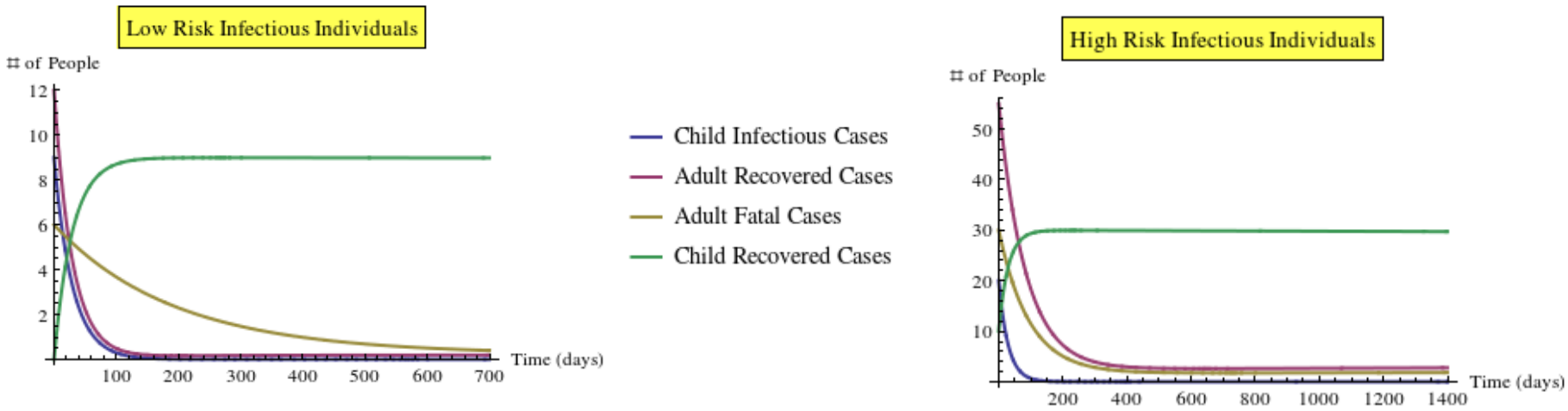
Infectious class is suppressed.

Case 6: Initial infectious class set to standard values. Vaccines normal. Environmental efforts increased 1%



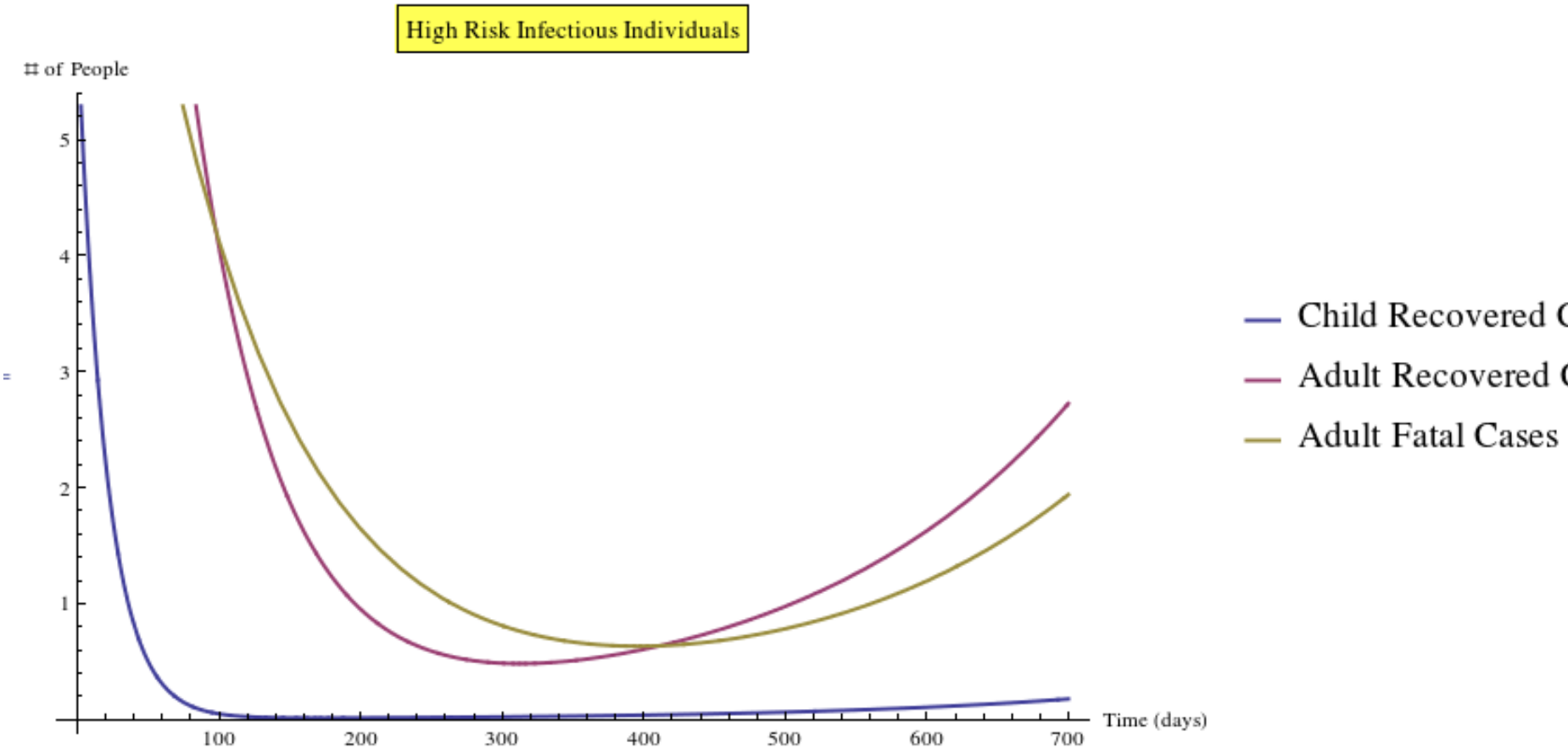
Effects more noticeable on high risk group.

Case 7: Initial infectious class set to standard values. Vaccines increase 5%. Environmental efforts increased 1%



Combined efforts most effective.

Case 8: No Environmental Efforts. Disease Comes Back



Conclusions

- Outbreak strategies differ from eradication strategies
- Vaccinations by themselves may not be enough for eradication
- Disease dynamics depend on gamma's distribution

Thank You!