SIRE Model

“The Influence of Education in Reducing the HIV Epidemic”

MATH 333 Differential Equations
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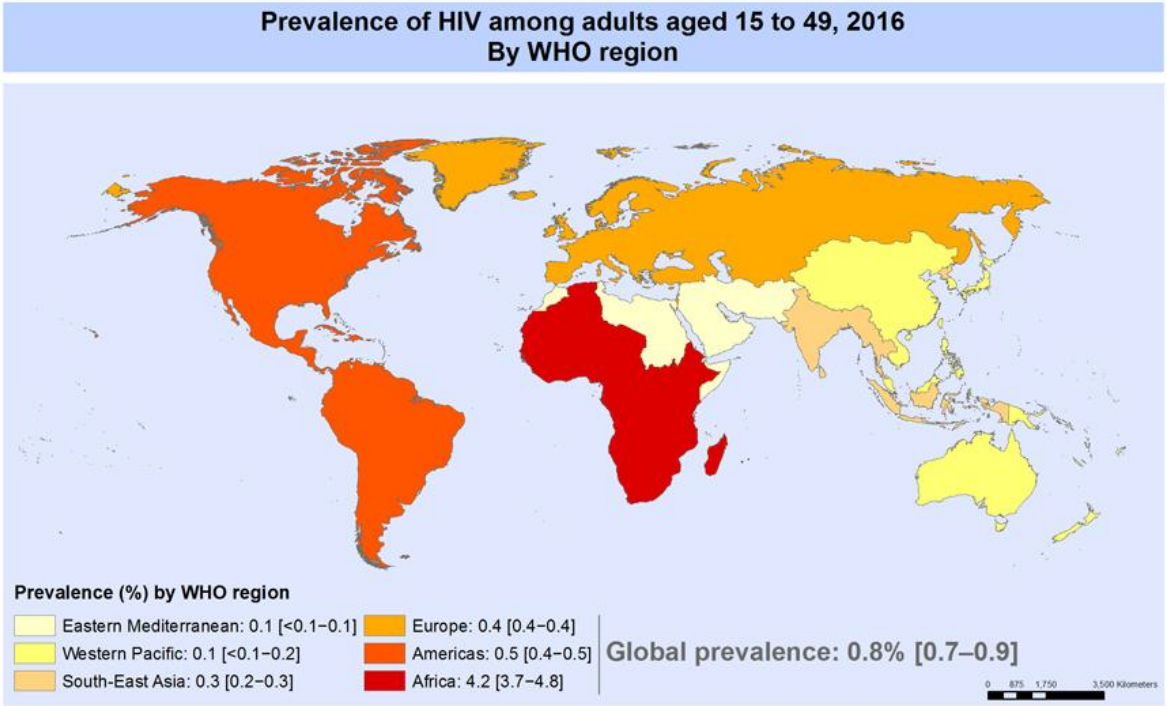
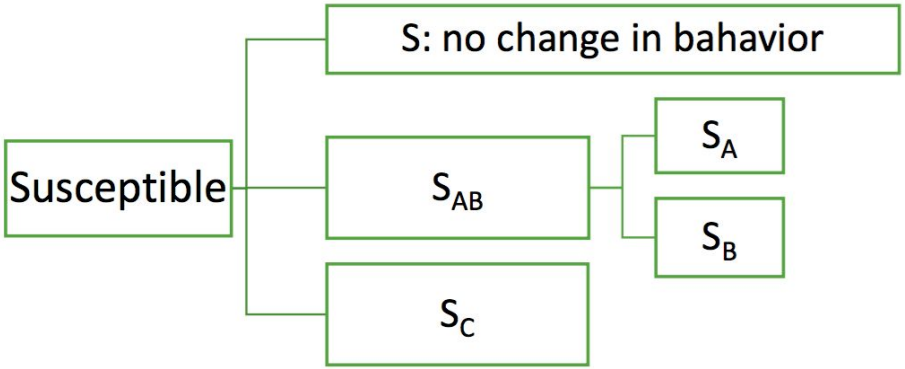
HIV in Uganda



SIRE Model

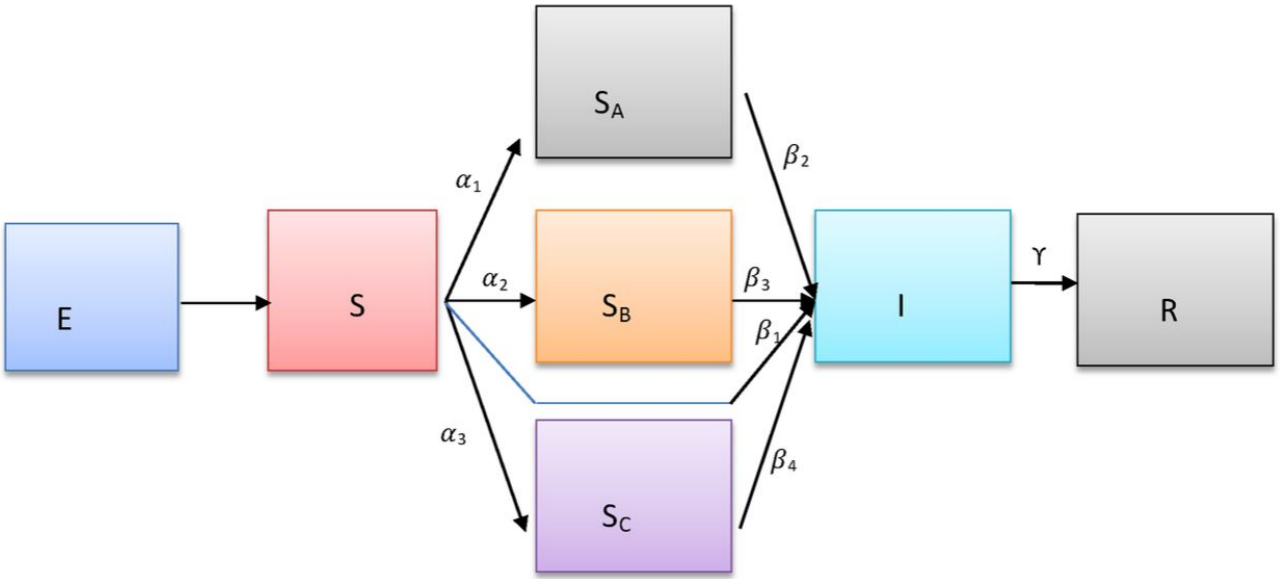
Susceptible, Infected, Removed, Educated



ABC Program:

- **A**bstinence
- **B**eing faithful
- Use of **C**ondoms

Schematics of SIRE model



SIR

$$S' = -\beta SI + b(S+I) - dS, \quad I' = \beta SI - \gamma I, \quad R' = \gamma I,$$

SIRE

$$\begin{aligned}
S' &= -\alpha_1 ES - \alpha_2 ES - \alpha_3 ES - \beta_1 SI + b(S + S_A + S_B + S_C + I) - dS, \\
S'_A &= \alpha_1 ES - \beta_2 S_A I - dS_A \quad (\alpha_1 = 0.02), \\
S'_B &= \alpha_2 ES - \beta_3 S_B I - dS_B \quad (\alpha_2 = 0.08), \\
S'_C &= \alpha_3 ES - \beta_4 S_C I - dS_C \quad (\alpha_3 = 0.8), \\
I' &= \beta_1 SI + \beta_2 S_A I + \beta_3 S_B I + \beta_4 S_C I - \gamma I, \\
R' &= \gamma I, \\
E' &= \frac{I}{I + S + S_A + S_B + S_C} r E(1 - E),
\end{aligned}$$

SIRE Parameters

- The time period is from 1996-2007 (12 years)
- The researchers assumed that the rates *b*, *d*, *r*, β_1, β_2, β_3, β_4, and γ are all constant
- Using UN&WHO data they assigned:
  - b=0.055 (entering rate)
  - d=0.0176 (natural death rate)
  - γ=0.14 (death rate due to HIV)
- Then they assigned β_2, β_3, and β_4 in terms of β_1, with $0.0001 \leq \beta_1 \leq 0.1$
  - $\beta_2 = 0.01\beta_1$
  - $\beta_3 = 0.03\beta_1$
  - $\beta_4 = 0.4\beta_1$
- Lastly, they assigned $0.2 \leq r \leq 2$

Initial conditions

$S(0) = 8.37$

$S_A(0) = 0$

$S_B(0) = 0$

$S_C(0) = 0$

$I(0) = 1.16$

$R(0) = 0.11$

$E(0) = 0.30$

Year	Susceptible	Infected	Removed	Education
1997	9.99	1.046	0.1195	600/1,200
1998	10.42	1.021	0.1205	
1999	10.72	0.975	0.121	
2000	10.96	0.921	0.1215	700/1,200
2001	11.27	0.879	0.120	717/1,200
2002	11.61	0.824	0.118	
2003	12.05	0.807	0.113	
2004	12.47	0.773	0.104	
2005	12.82	0.756	0.089	778/1,200
2006	13.25	0.755	0.084	
2007	14.22	0.754	0.079	

Table 1. Historical data table (population numbers in millions).

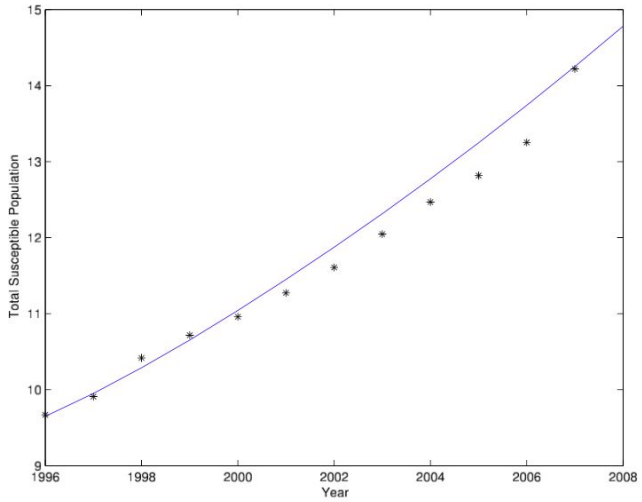


Figure 2. Susceptible population, in millions: model prediction (solid line) and data (∗).

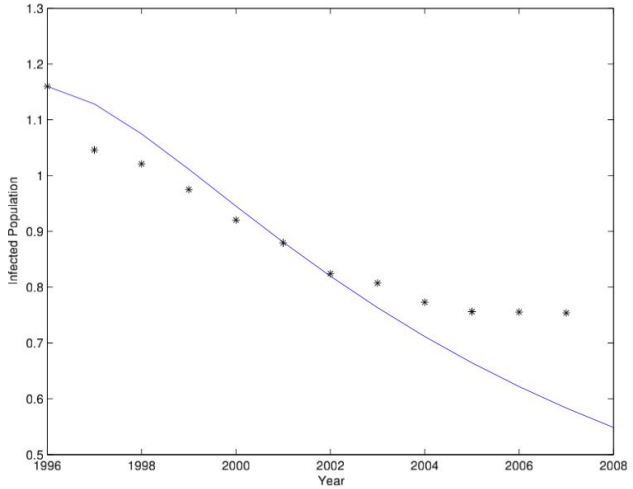


Figure 3. Infected population, in millions: model prediction (solid line) and data (∗).

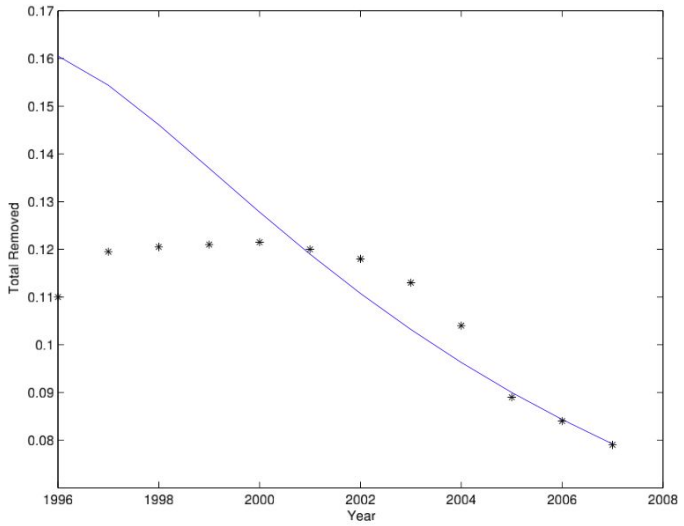


Figure 4. Number of HIV related deaths, in millions: model pre diction (solid line) and data (∗).

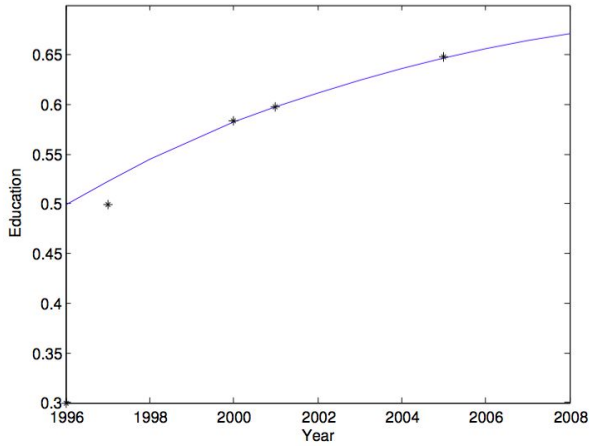


Figure 5. Education influence: model prediction (solid line) and data (∗).

SIRE Model Simulation

Switch to MATLAB

Conclusions

- The SIRE model generally captures the effect of education in reducing HIV in Uganda.
- Include more factors
  - Age
  - Gender
  - Stage of Disease
- Future Directions:
  - Include data after 2007 to further optimize the model
  - Expand the model to other countries
  - Change “Education” to other diseases and factors
    - Immunization
    - Malaria: access to mosquito nets


THANK
YOU