

Exploring the interaction between models and data

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2016 Summer Course on Mathematical Modeling and Analysis
of Infectious Diseases

National Taiwan University

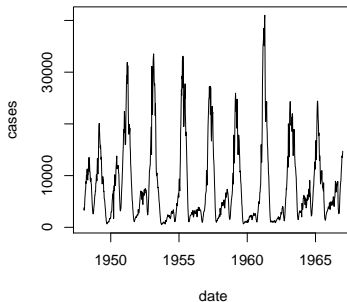
Goals

- ▶ Explore some ideas of using a model to explore disease data
- ▶ Use estimates of HIV prevalence from Zimbabwe as an example

Bridging

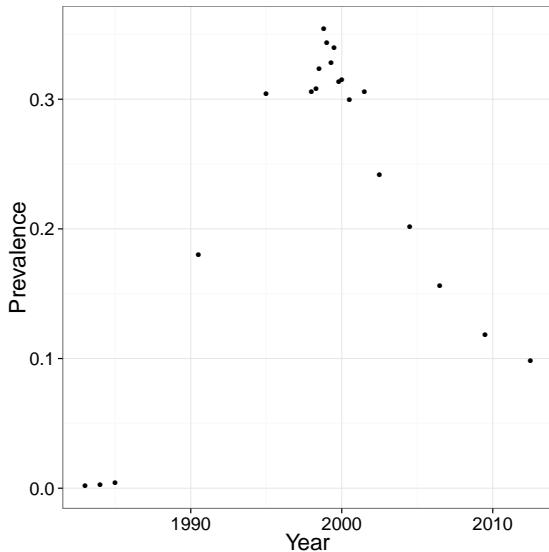


Measles reports from England and Wales



- ▶ Models are the tool we use to bridge between data and mechanisms
- ▶ In both directions

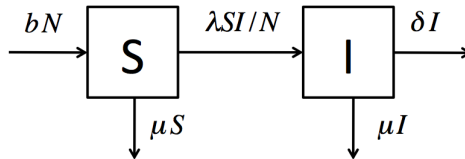
Estimated HIV prevalence in Zimbabwe



Experimental fitting

- ▶ We will fit by eye, for learning purpose only
- ▶ Later, we will talk about statistical frameworks
- ▶ Code online:

https://github.com/dushoff/SIR_simulations



$b =$ birth rate

$$N = S + I$$

$\lambda =$ rate at which new infections occur

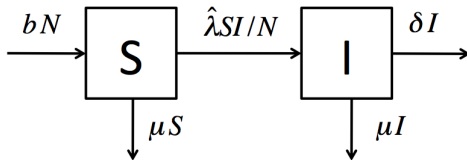
$\delta =$ disease induced mortality rate

$\mu =$ background mortality rate

The basic model

Phenomenological heterogeneity

- ▶ Just *assume* that you can approximate this complicated phenomenon with a simple functional form, $\beta = f(P)$
 - ▶ Original study used $\beta = \beta_0 \exp(-\alpha P)$
 - ▶ We will use $\beta = \beta_0(1 - P)^\kappa$
- ▶ Both forms start with $\beta = \beta_0$ and decline smoothly with prevalence



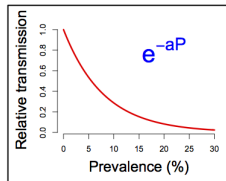
$b =$ birth rate

$$N = S + I$$

$$\hat{\lambda} = \lambda e^{-aP}$$

$\delta =$ disease induced mortality rate

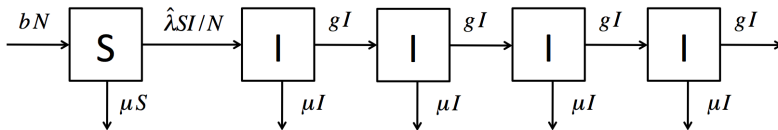
$\mu =$ background mortality rate



Heterogeneity in sexual behaviour

Realistic time distributions





b = birth rate

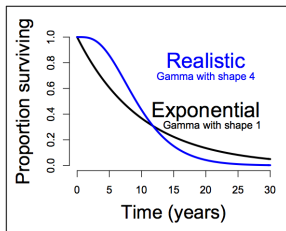
$$N = S + I$$

λ = rate at which new infections occur

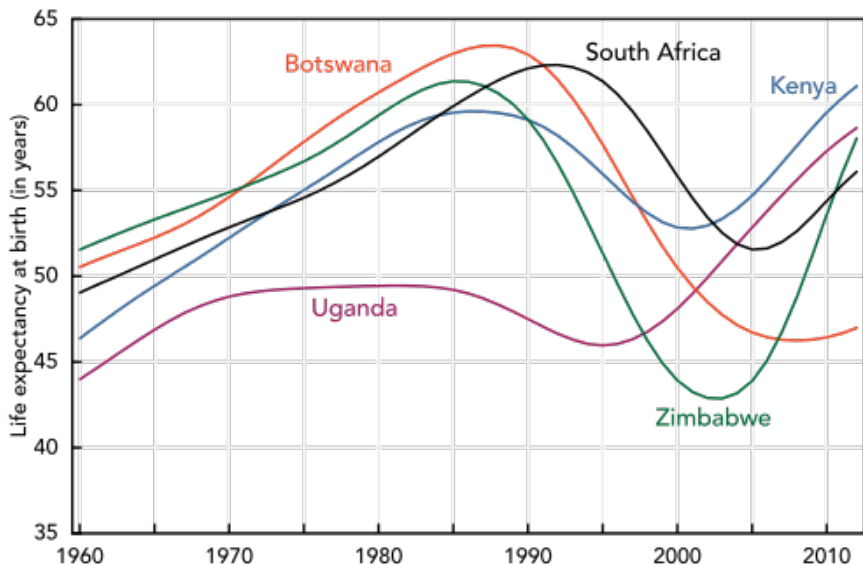
$$\delta = g/4$$

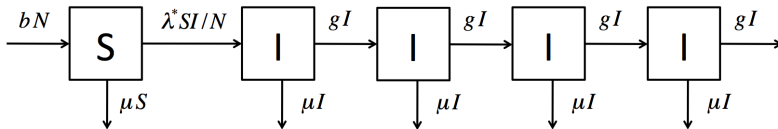
μ = background mortality rate

Realistic survival times



Are people *responding* to the epidemic?





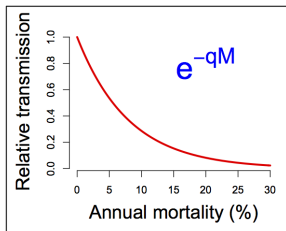
$b =$ birth rate

$N = S + I$

$\lambda^* = \hat{\lambda} e^{-qM}$

$\delta = g/4$

$\mu =$ background mortality rate



Mortality leads to behaviour change