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SMIDDY 2012

Case and basic reproduction number for a curable sexually transmitted infection

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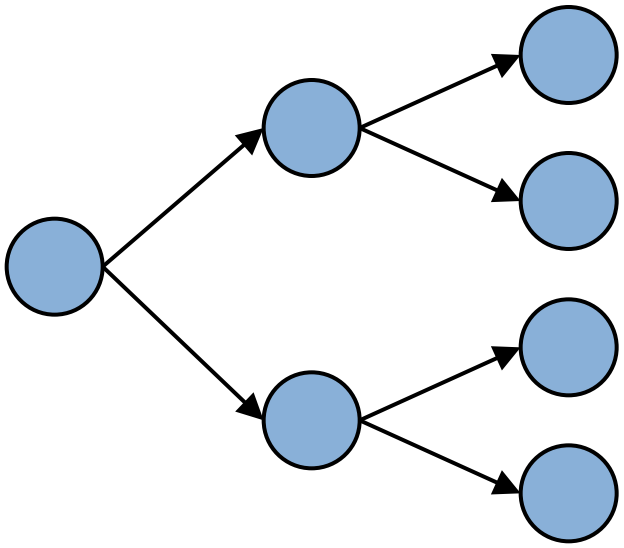
Basic reproduction number (R_0)

- R_0 is used to determine whether an infectious disease can invade in a susceptible population



$R_0 = 2$

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James O. Lloyd-Sm

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Mathematical Biosciences

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Sex Transm Infect 2002;**78**(

Analysis and simulation of a stochastic, discrete-individual model of STD transmission with partnership concurrency

Stephen E. Chick [a,*], Andrew L. Adams [b], James S. Koopman [c]

π_u in the unpartnered population. If the individual is partnered with an uninfected individual, then $R_0 = Y(0)$. A reasonable assumption [3] is to define $R_0 = Z(0)$ as the expected number of secondary cases, given that a newly infected individual was infected by a partner, but that the rest of the population is susceptible. This definition is used in the remainder of the paper.

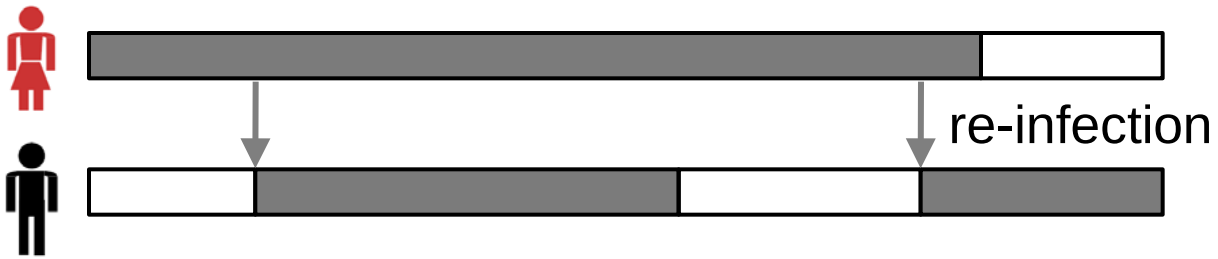
Sexually Transmitted Diseases • December 2005

the potential for spread of infection
as the number of new infections ca
age when an infection enters an ent
ble population.[2] Two things are worth noting from

The basic reproduction number (R_o) is fundamental to understanding infectious disease epidemiology. R_o describes the average number of secondary infections that an infected individual generates when entering a fully susceptible population, and when greater

Secondary infections vs. secondarily infected individuals (cases)

- Curable sexually transmitted infections (STI) → partners can re-infect each other



- Number of secondary infections (R_0) ≠ number of secondary cases (R_c)

Infected
Susceptible

Objectives

- To obtain expressions for the number of secondary **infections (R_0)** and the number of secondary **cases (R_c)** for curable STI
- To use R_0 and R_c to investigate the contribution of re-infection within partnerships to endemicity of curable STI

Chlamydia trachomatis

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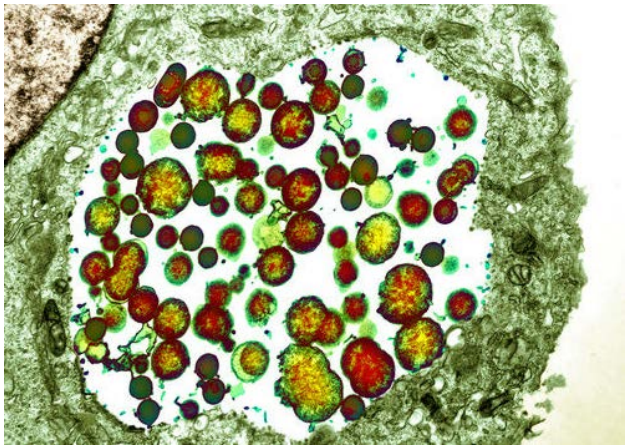
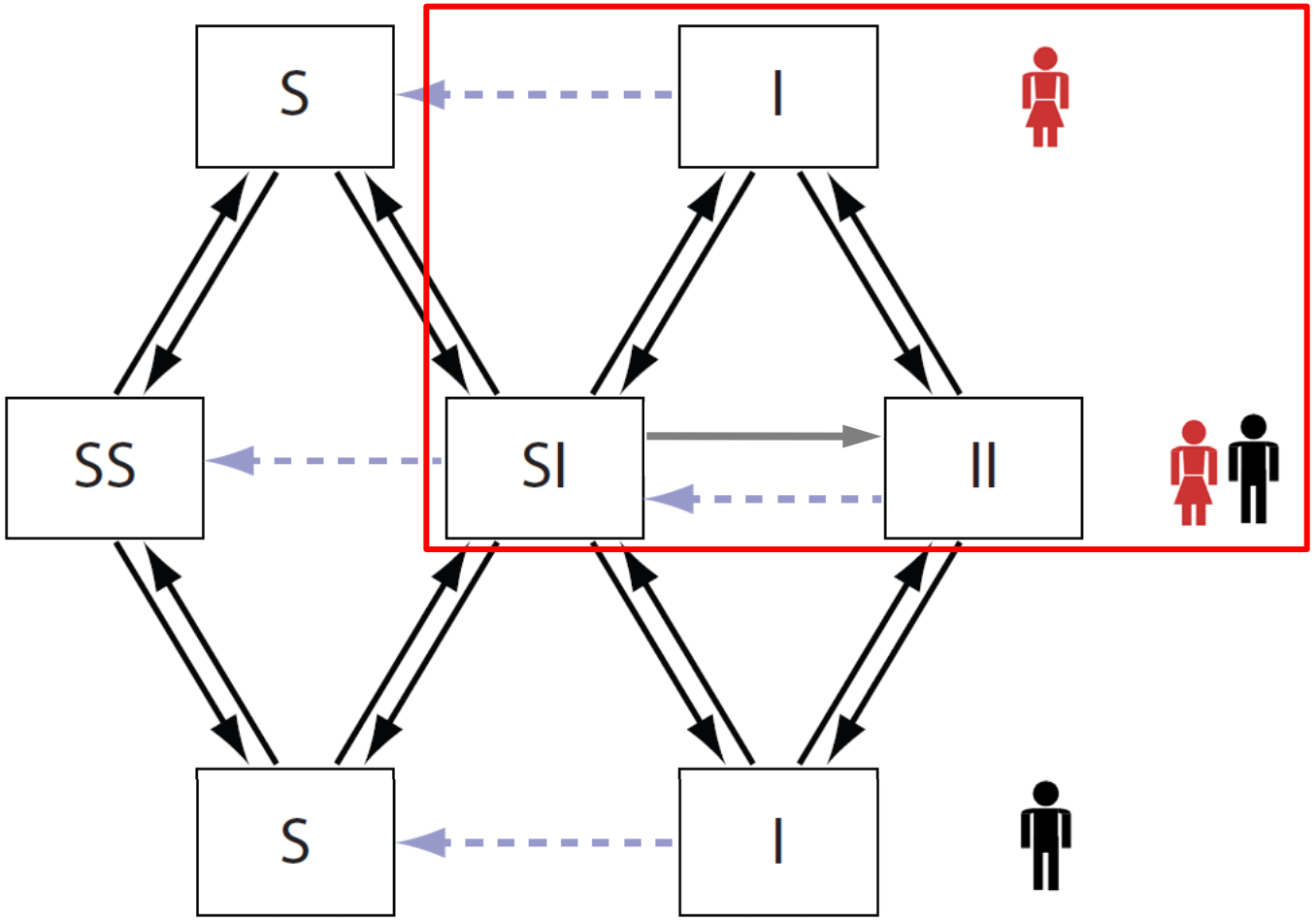
- Most commonly notified STI in many developed countries
- Duration of infection is long (on average one year)
- Mostly asymptomatic
- People can clear the infection naturally
- Antibiotic treatment is effective
- Long term complications



Pair model

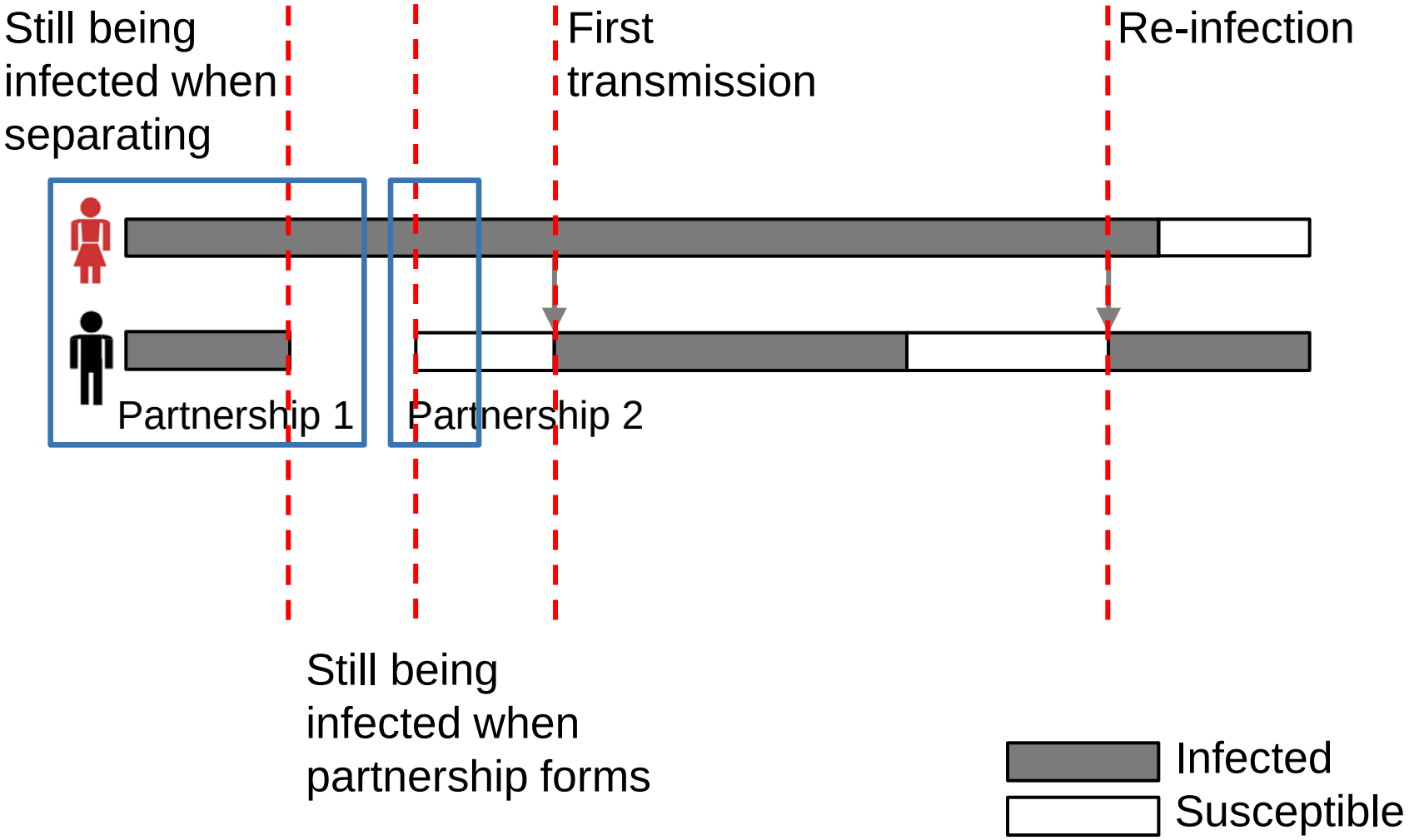


Pair formation/ separation rate

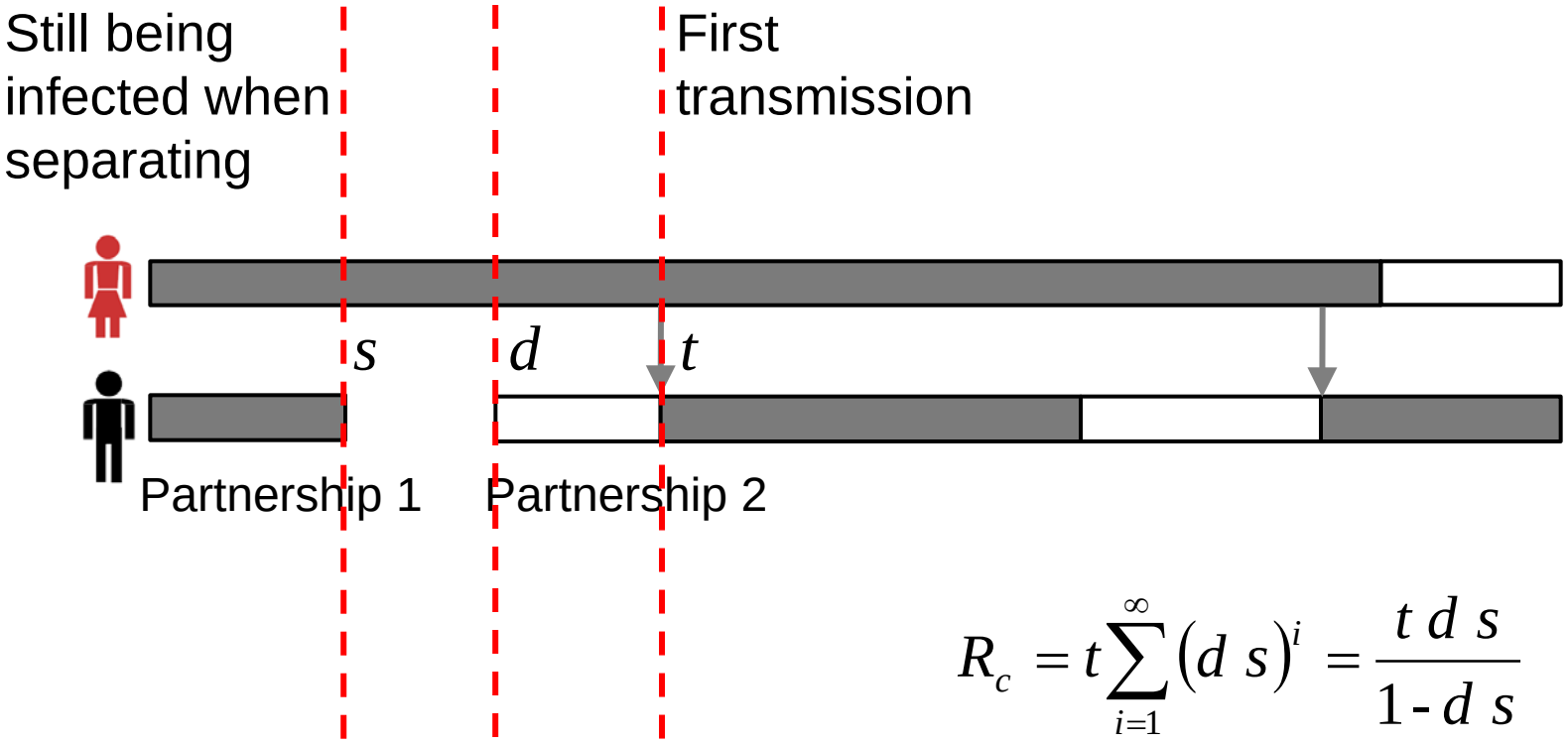
Transmission within partnership

Recovery by natural clearance

Assumptions and probabilities

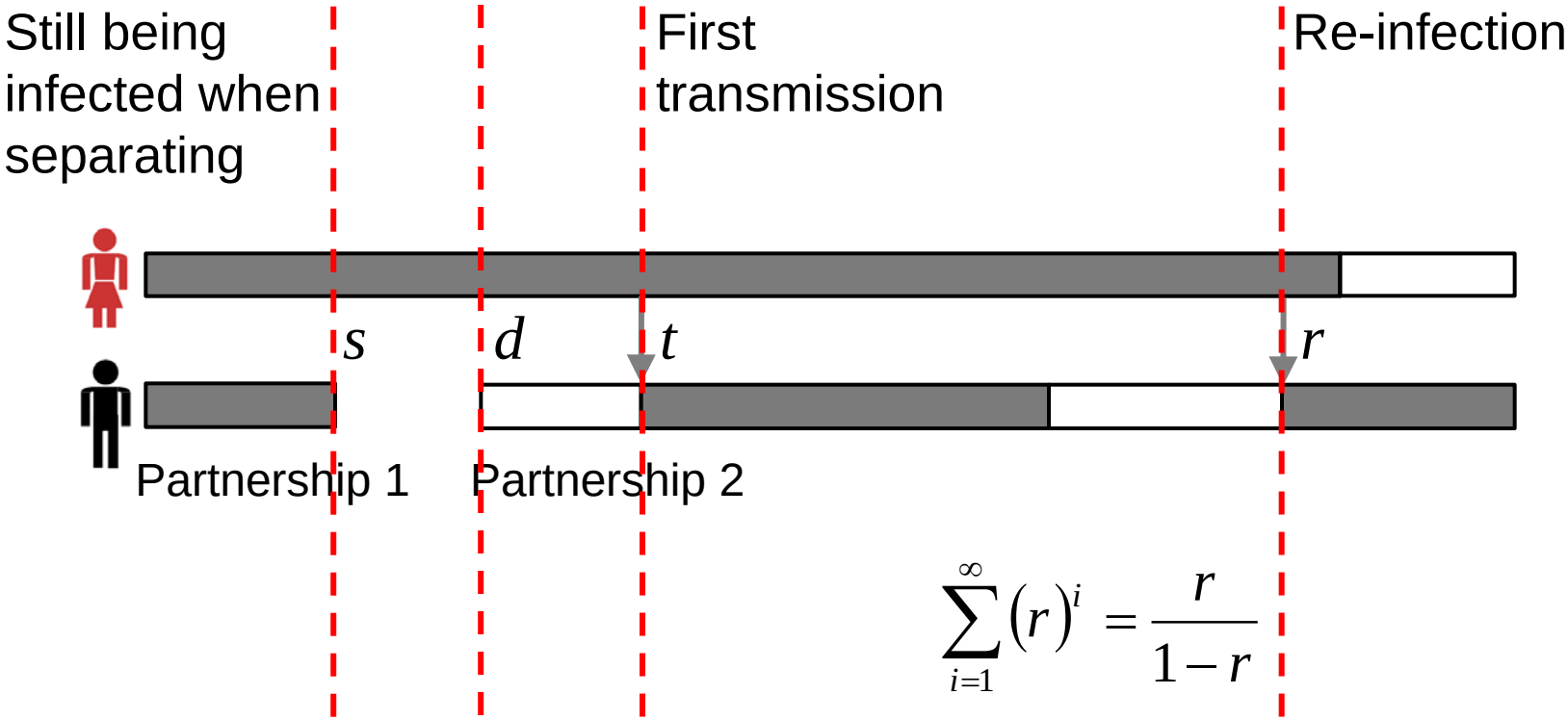


Case reproduction number



$$R_c = t\sum_{i=1}^{\infty}(d\ s)^i = \frac{t\ d\ s}{1 - d\ s}$$

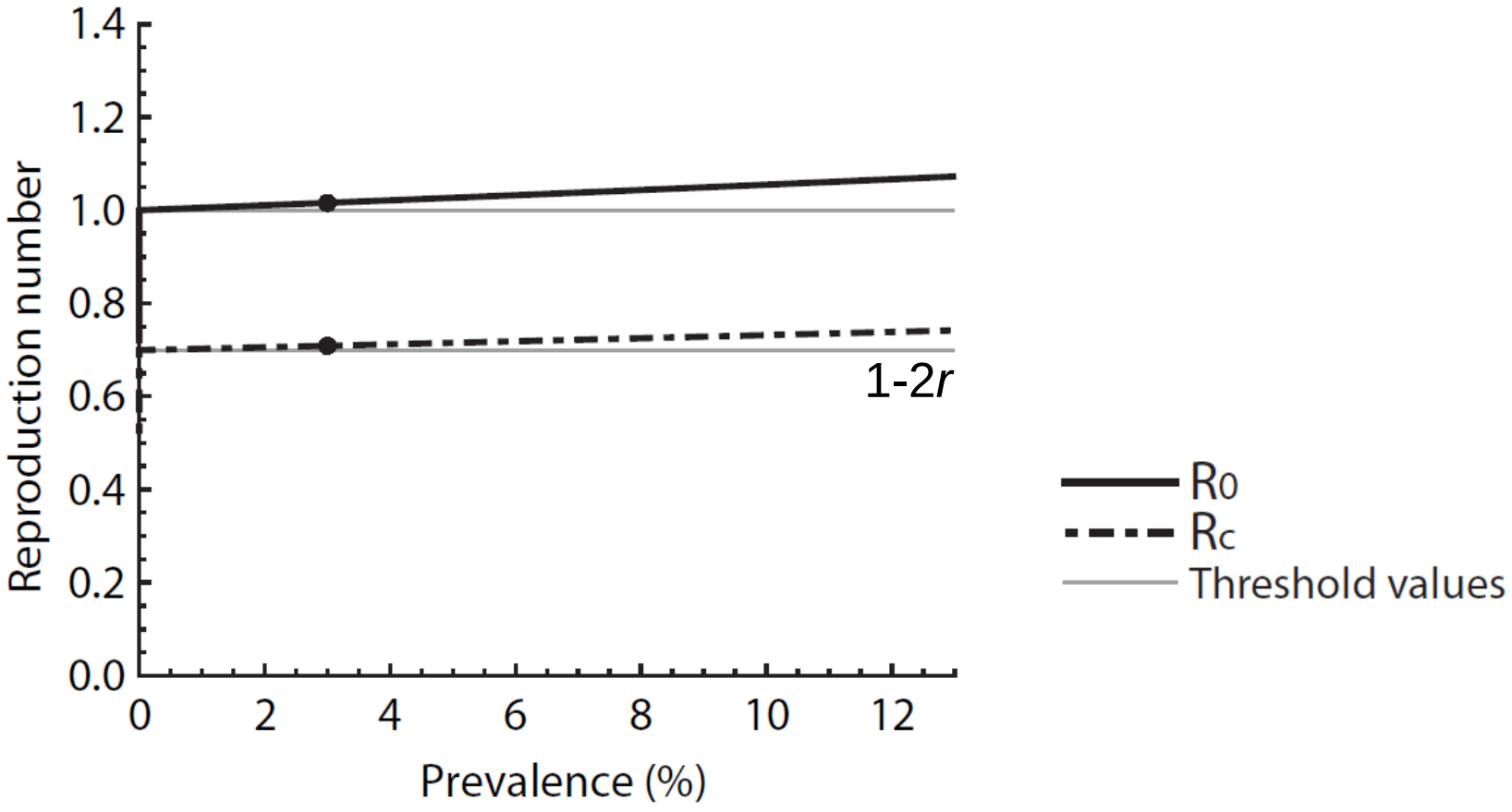
Basic reproduction number



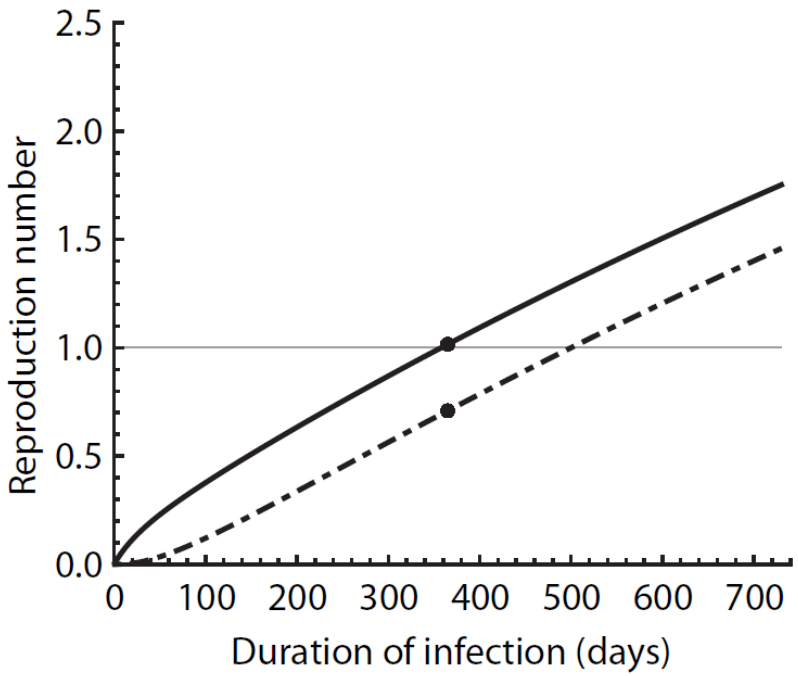
$$\sum_{i=1}^{\infty}(r)^i = \frac{r}{1-r}$$

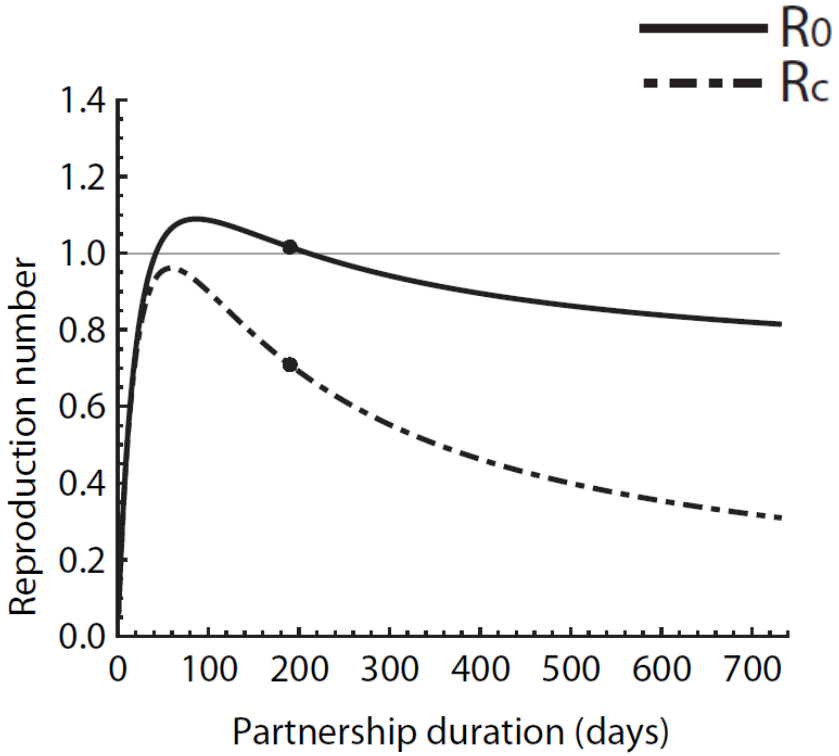
$$R_0 = R_c + \frac{r}{1-r}(R_c + 1)$$

Results
Epidemic threshold levels



Results
Duration of infection and partnerships





Strengths and limitations

- Strength:
  - Simple Model
- Limitations:
  - Homogeneous mixing
  - No immunity

Discussion

- Applicability to other infections:
  - Infections that are curable and transmitted within households
  - Hospital infections
- Estimating reproduction numbers from other study designs such as contact tracing data

Conclusions

- The precise meaning of reproduction numbers and how they incorporate re-infection should be stated clearly by modellers
- Re-infection within partnerships means that curable STI can be sustained endemically even when the number of secondary cases (R_c) is below one

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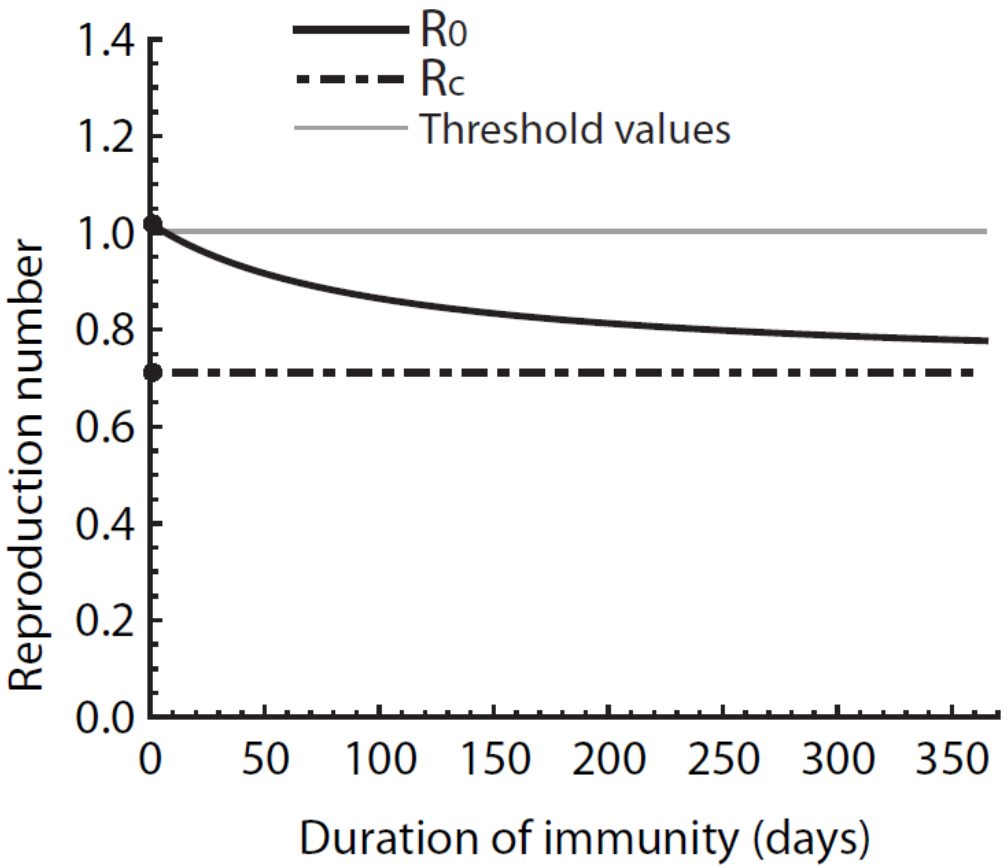
SWISS NATIONAL SCIENCE FOUNDATION

Reproduction numbers

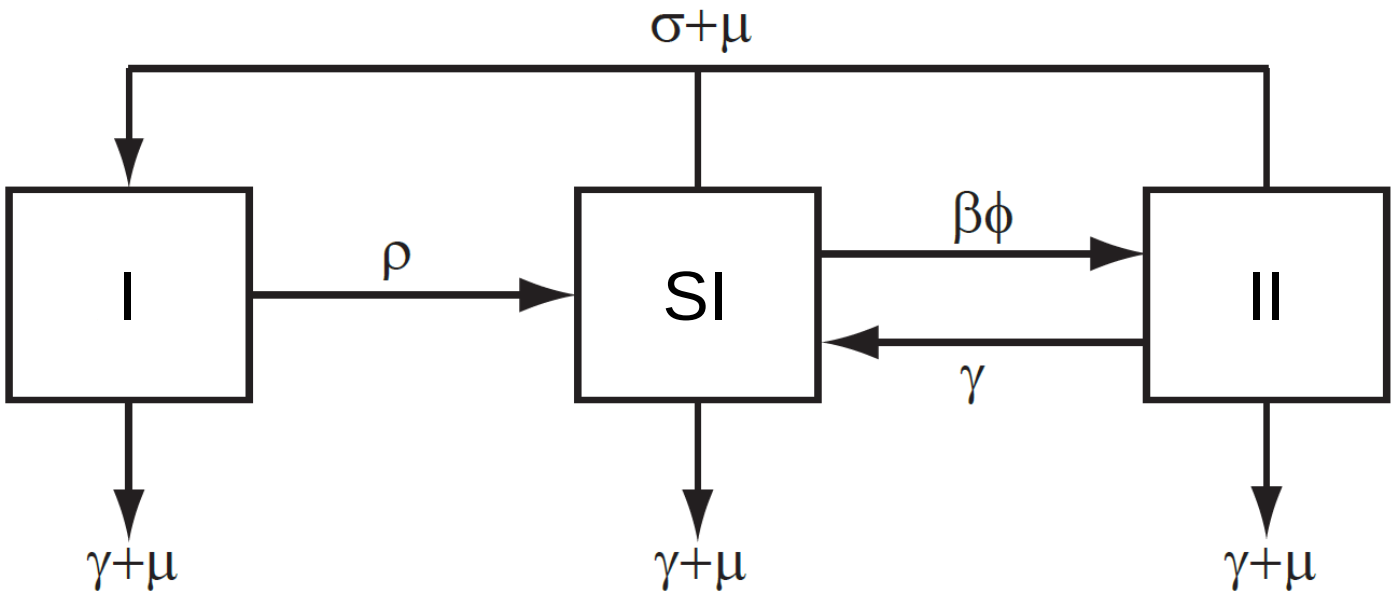
$$R_0 = \frac{\beta\phi\left(\gamma^2 + \gamma(\mu+\rho) + \rho(\sigma+\mu)\right)}{(\gamma+\mu)(\sigma+2\mu+2\gamma+\beta\phi)(\sigma+2\mu+\gamma+\rho)}$$

$$R_c = \frac{\beta\phi\ \rho(\sigma+\mu)}{(\gamma+\mu)(\sigma+2\mu+\gamma+\beta\phi)(\sigma+2\mu+\gamma+\rho)}$$

Duration of immunity



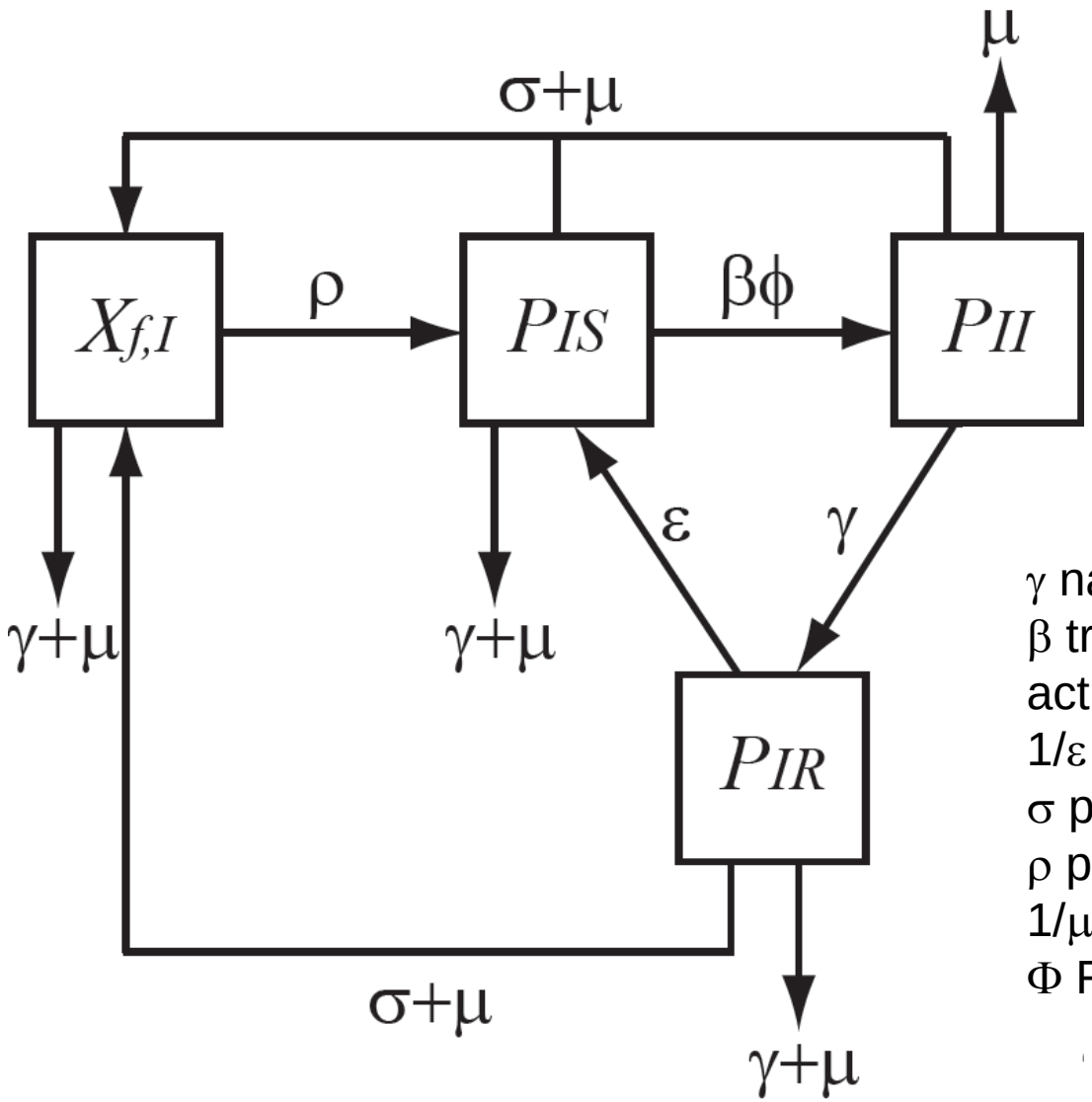
Pair model, infected women



1/γ	duration of infection
σ	pair separation rate
ρ	pair formation rate
1/μ	duration of sexually active life
β	transmission probability per sex act
Φ	frequency of sex acts

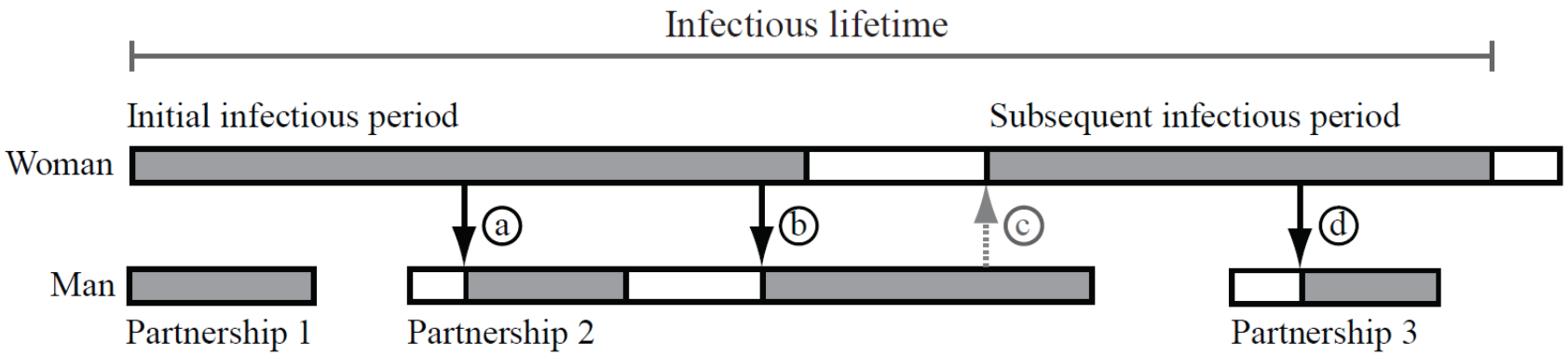
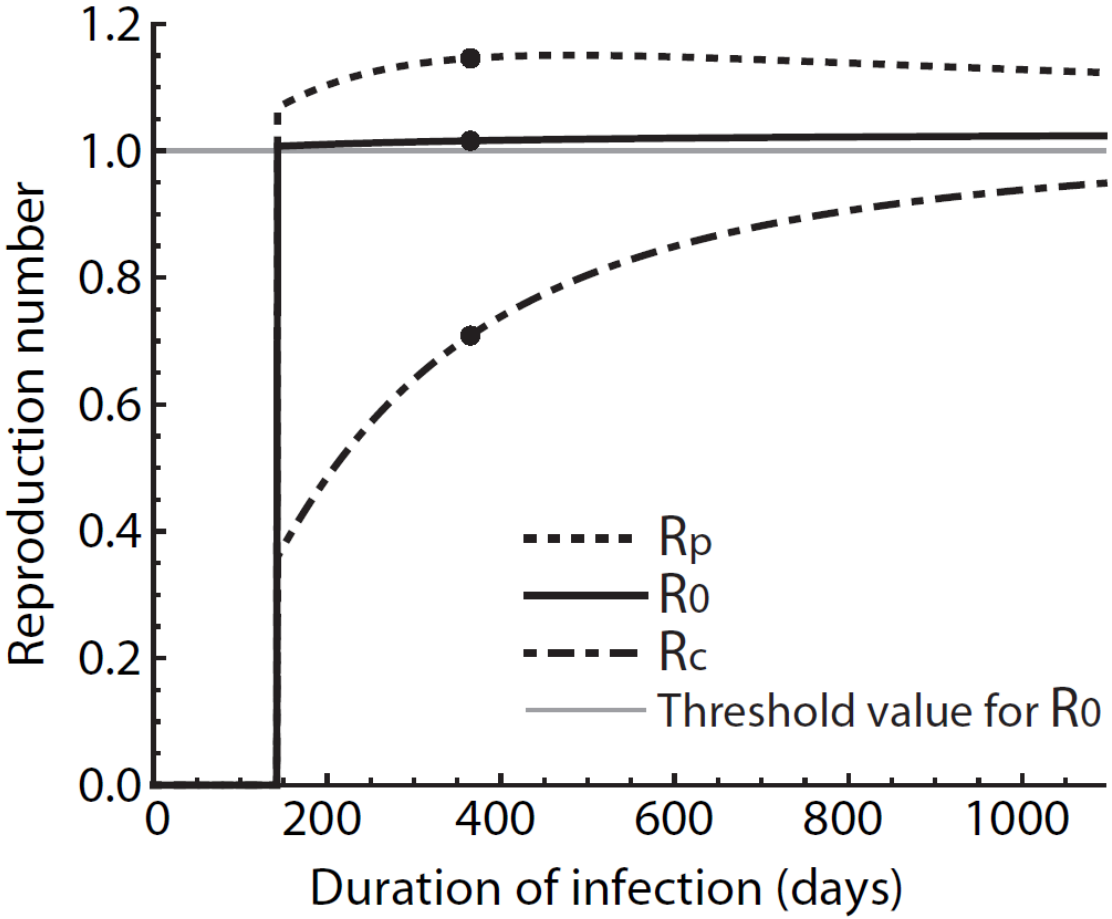
S	Susceptible
I	Infected

Pair model



γ natural clearance rate
β transmission probability per sex act
1/ε duration of immunity
σ pair seperation rate
ρ pair formation rate
1/μ duration of sexual active live
Φ Frequency of sex acts

Partnership reproduction number (Rp)



Partnership reproduction number