Using mathematical models for health economic analyses

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Outline

- Introduction to modeling
- Infectious disease modeling
  - Introduction; Ro
- How models can be used to estimate health outcomes
  - Example: Potential impact of ART for prevention
  - What study data can you use to parameterize models
- When to use which model

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An introduction to Mathematical Models

- Framework for understanding and communicating infectious disease*
- Explicit assumptions help delineate which parameters are based on evidence
- Quantitative or qualitative results are compared with observed or experimental data
- Validated models can be used to estimate the potential impact of interventions (e.g. ART for prevention) on health outcomes
  - HIV incidence cases
  - HIV associated death
  - HIV associated disability adjusted life years (DALYs)

*Garnett, G. P. (2002). Sex Transm Infect 78(1): 7-12.

Models in health economic analyses

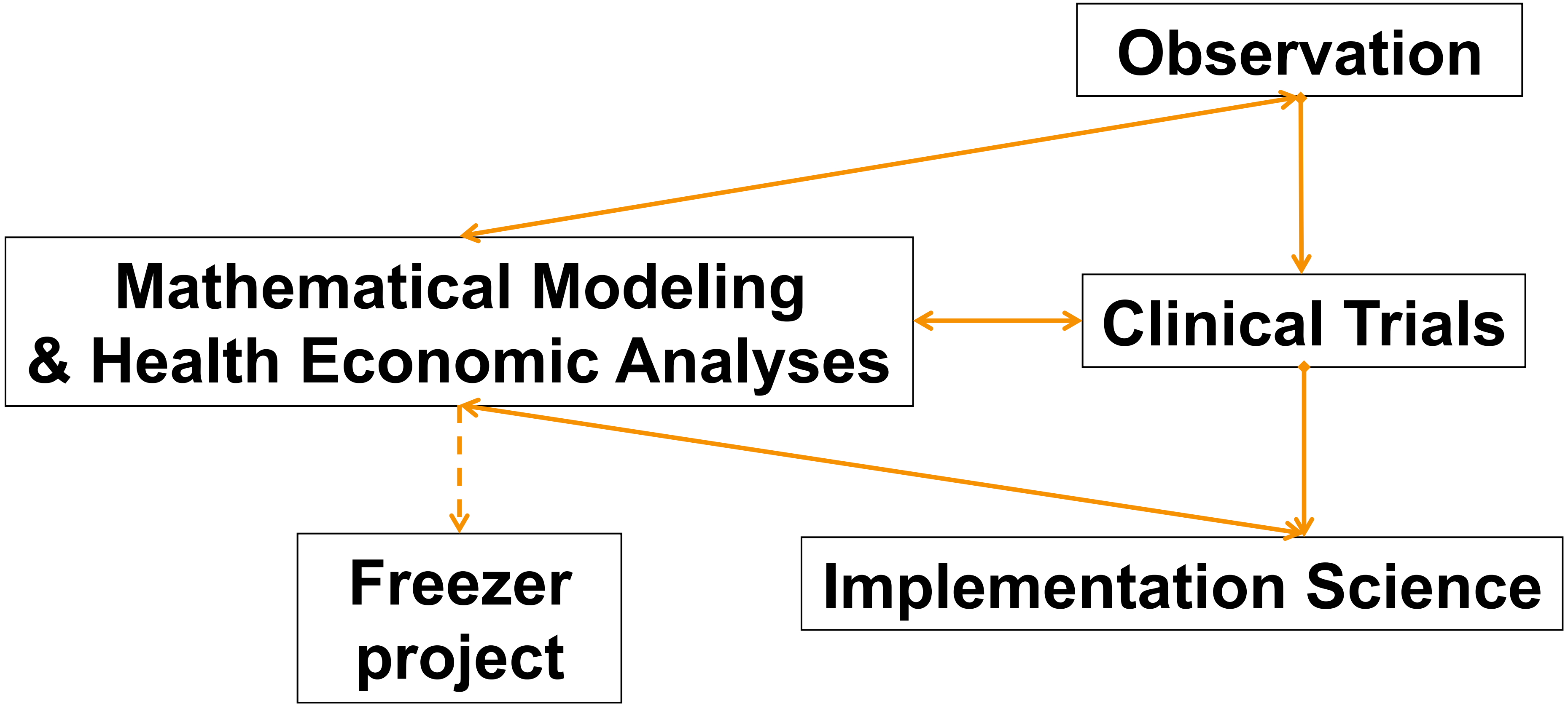
- Used to structure the economic question and compare all relevant alternatives
- Extrapolate beyond observed data
- Link intermediate and final endpoints
- Generalize results to other settings/patient groups
- Synthesize evidence to simulate comparisons where RCTs don't exist
- Indicate the need for further research

HERC short course, Oxford, 2012

Types of models

- Static models – equilibrium (time-invariant)
- Dynamic models – time dependent change
  - Force of infection can change over time
  - Includes herd immunity
- Both static and dynamic models can be either deterministic or stochastic (constrained random variables)
- Choice of model depends on scientific question

Where do models fit in the path from discovery to implementation?



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The basic and effective reproductive numbers

R_o The Basic Reproductive Number - The number of new infections caused by one infection in an entirely susceptible population

R_t The Effective Reproductive Number - The number of new infections caused by one infection at a given time

$$R_0 = D \, . \, C \, . \, \beta$$

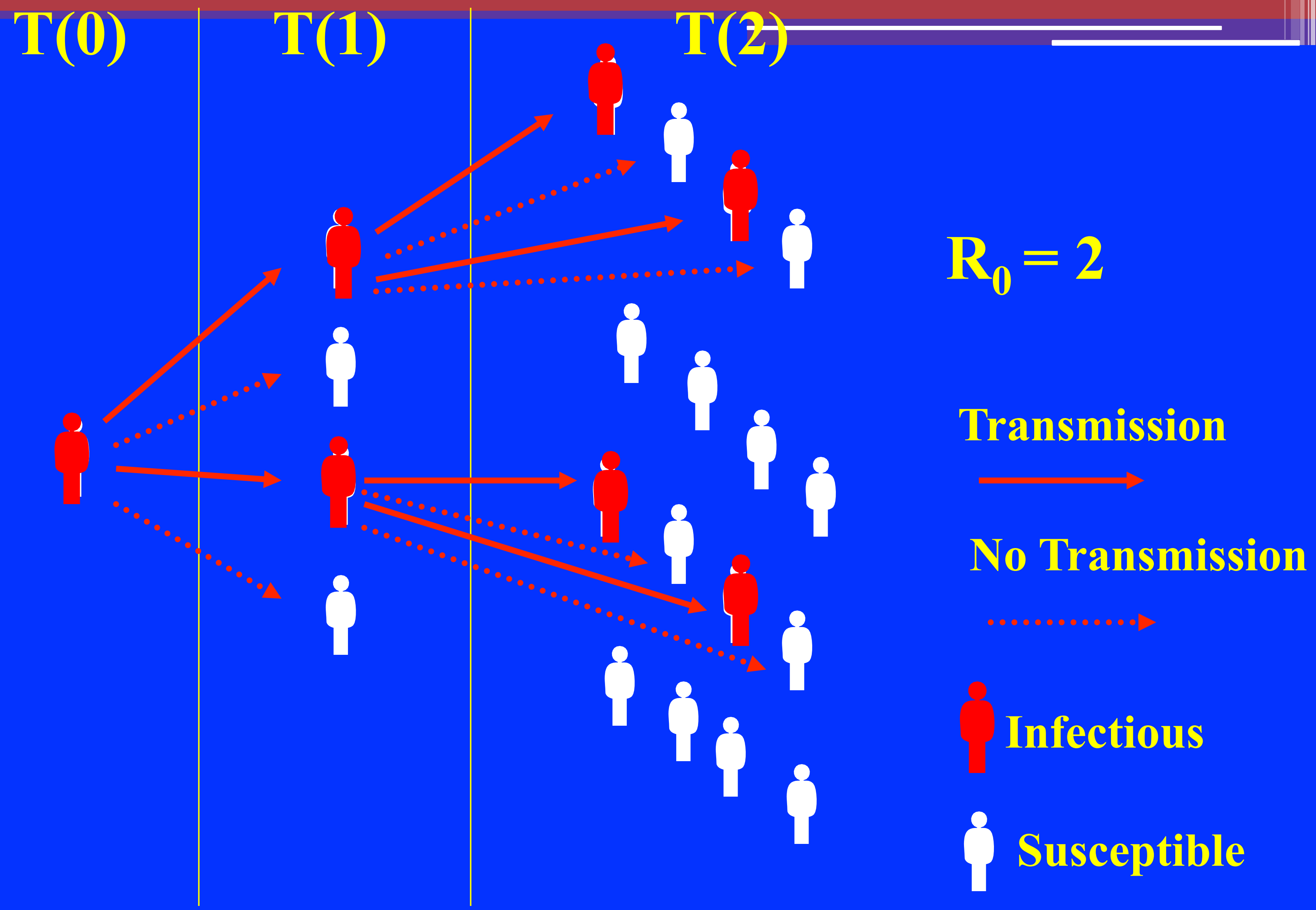
Mean length of time infectious (D)

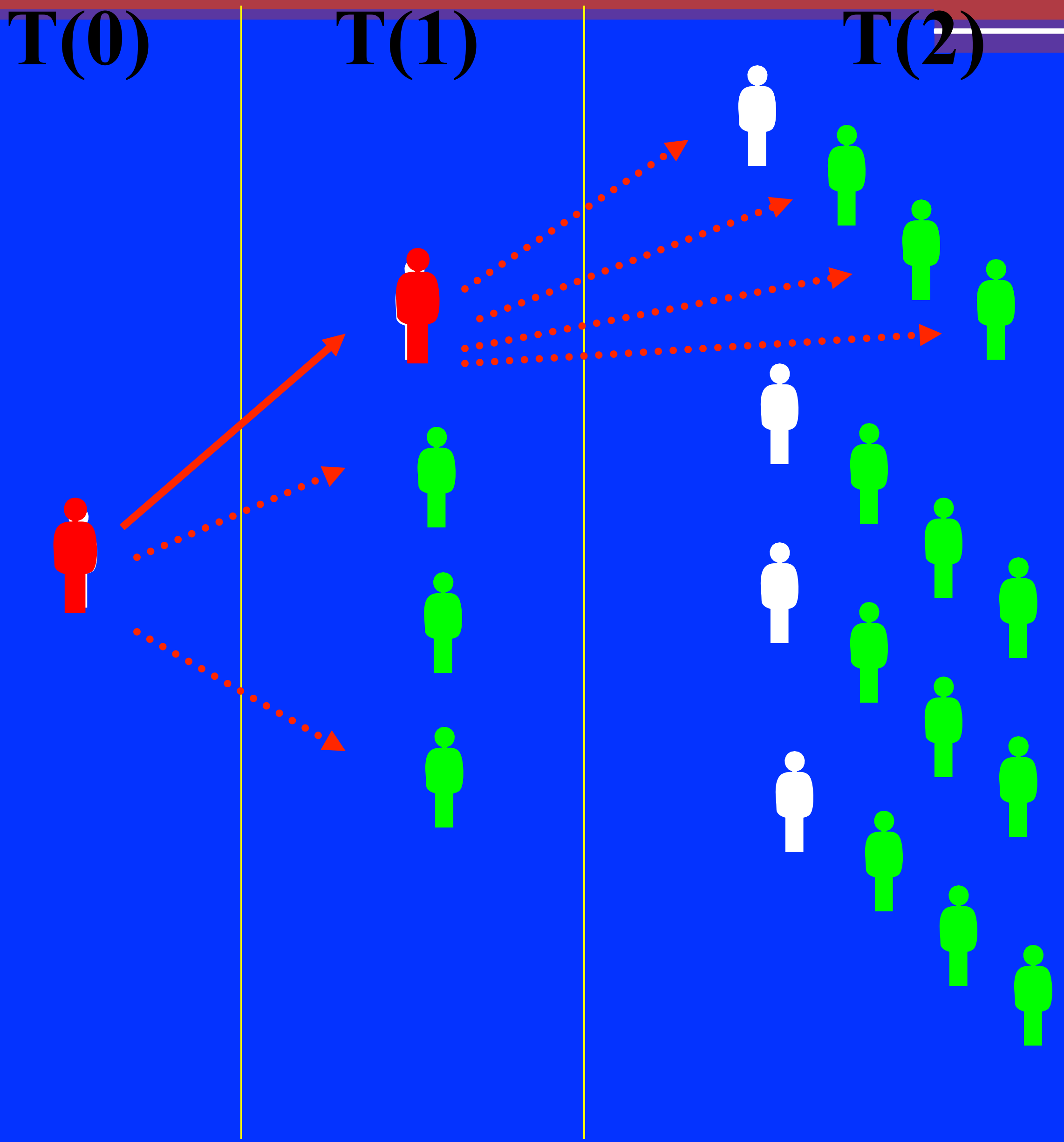
Rate at which sexual contact occurs (C)

Likelihood of transmission on a sexual contact (β)

$$R_t = R_0 \, . \, x$$

Proportion of contacts susceptible -Vaccination (x)


T(0)
T(1)
T(2)
$R_0 = 2$
Transmission
No Transmission
Infectious
Susceptible



$R_0 = 2$

$R_t = R_o.\text{prop susceptible} = 0.5$

Transmission

No Transmission

Infectious

Susceptible

Immune

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ART implementation

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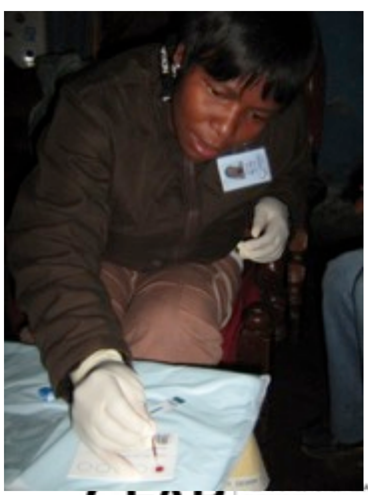
Methods: Intervention package (1)

Community Sensitization → **Household Consent** → **Individual**
- **Consent**
- **Questionnaire**
- **Pre-test counseling**
- **HIV test**

→ **HIV+**
Linkage to care and treatment

→ **HIV-**
- **Linkage to prevention**



Results

Initiation of antiretroviral therapy and viral suppression after home HIV testing and counselling in KwaZulu-Natal, South Africa, and Mbarara district, Uganda: a prospective, observational intervention study

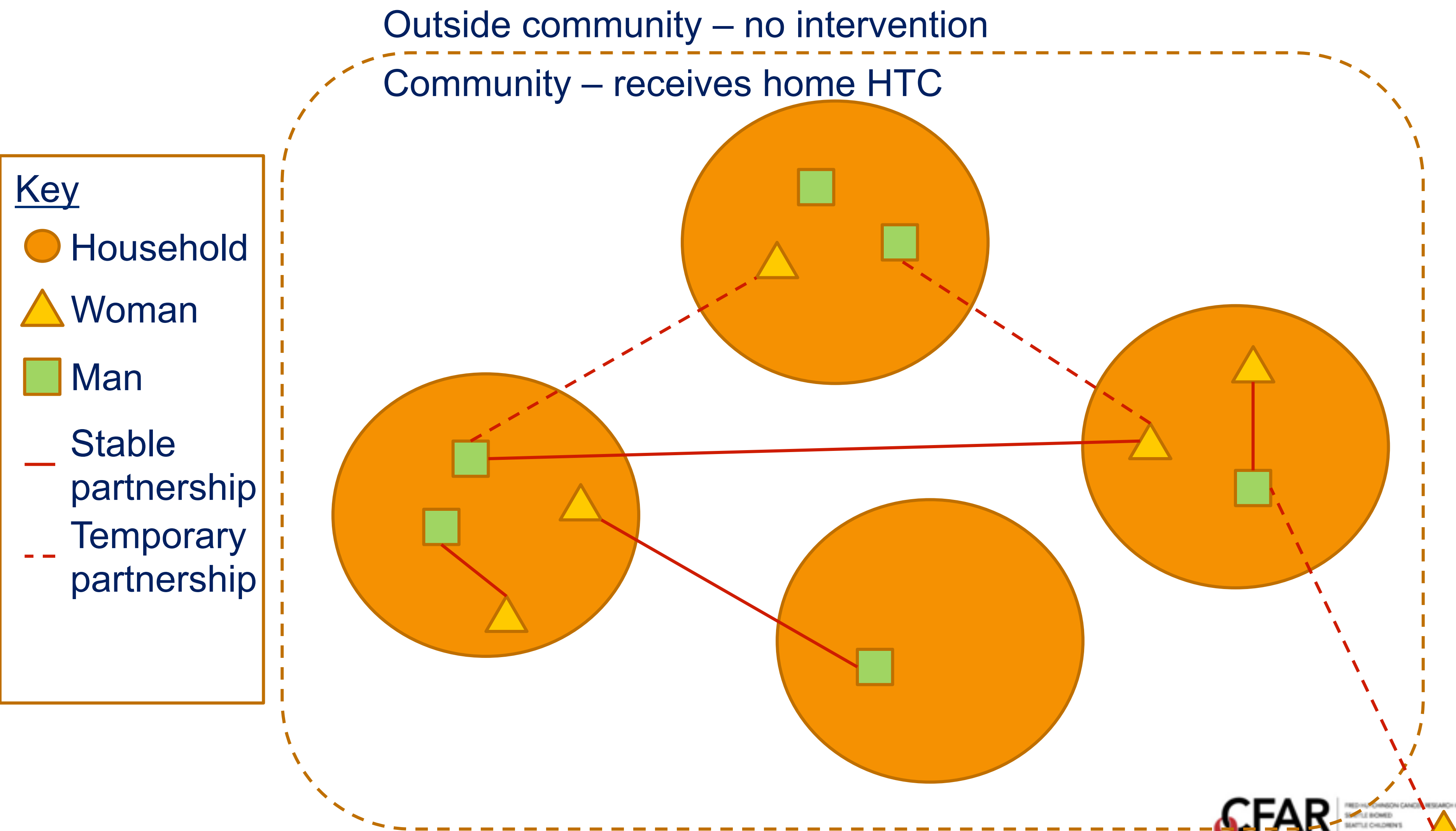
Ruanne V Barnabas, Heidi van Rooyen, Elioda Tumwesigye, Pamela M Murnane, Jared M Baeten, Hilton Humphries, Bosco Turyamureeba, Philip Joseph, Meighan Krows, James P Hughes, Connie Celum

- Ankole region, southwest Uganda, and KwaZulu-Natal, South Africa
- Sept. 2011 – May 2013

Findings	N (%)
Adults tested	3,393 (96%)
HIV+ identified	635 (19%)
Visited a clinic by month 12	96%
Started ART by month 12 (among those eligible for ART)	74%
Virally suppressed by month 12 (among those on ART)	77%

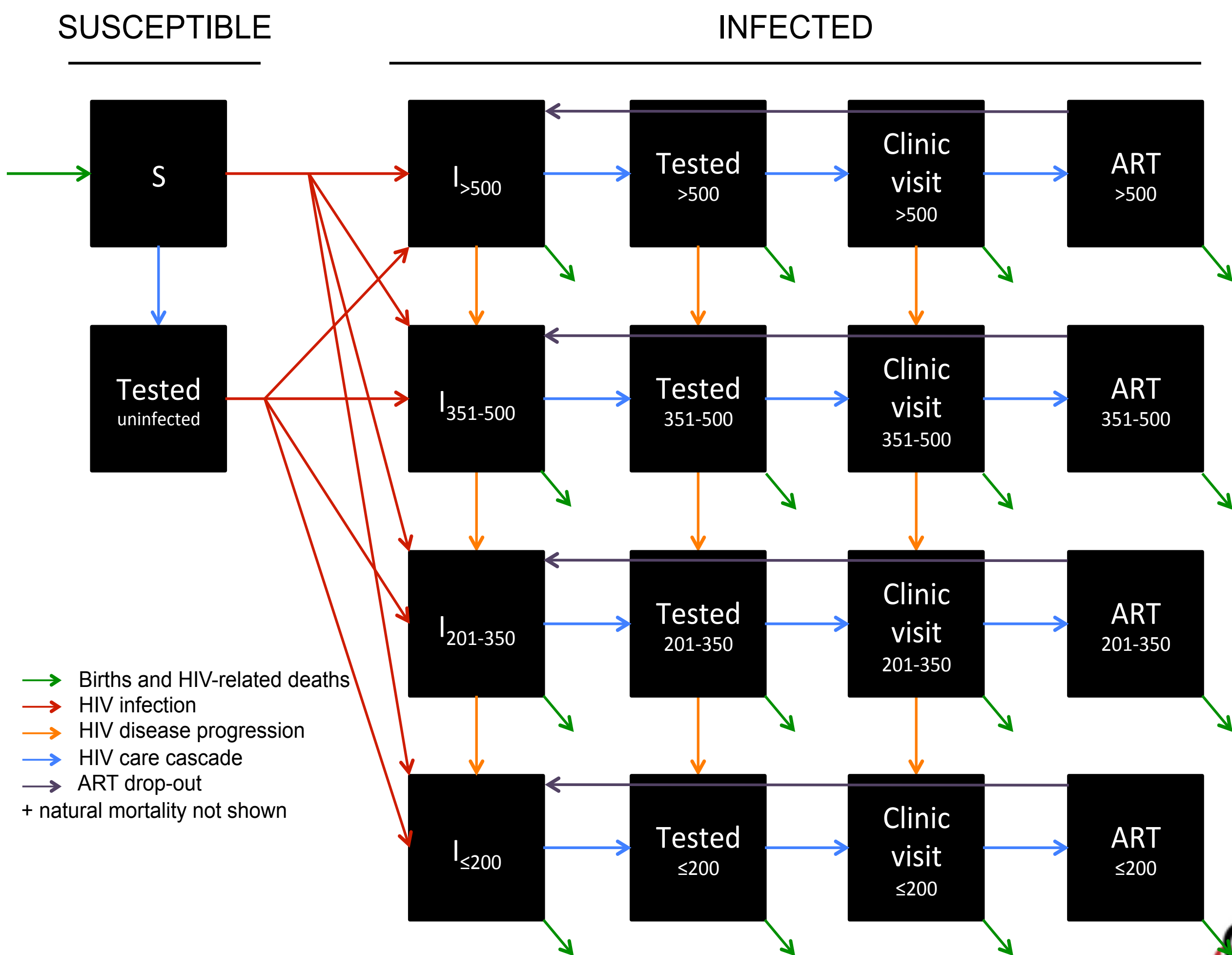
Barnabas, et. al., Lancet HIV, 2014

Model: community structure & partnerships

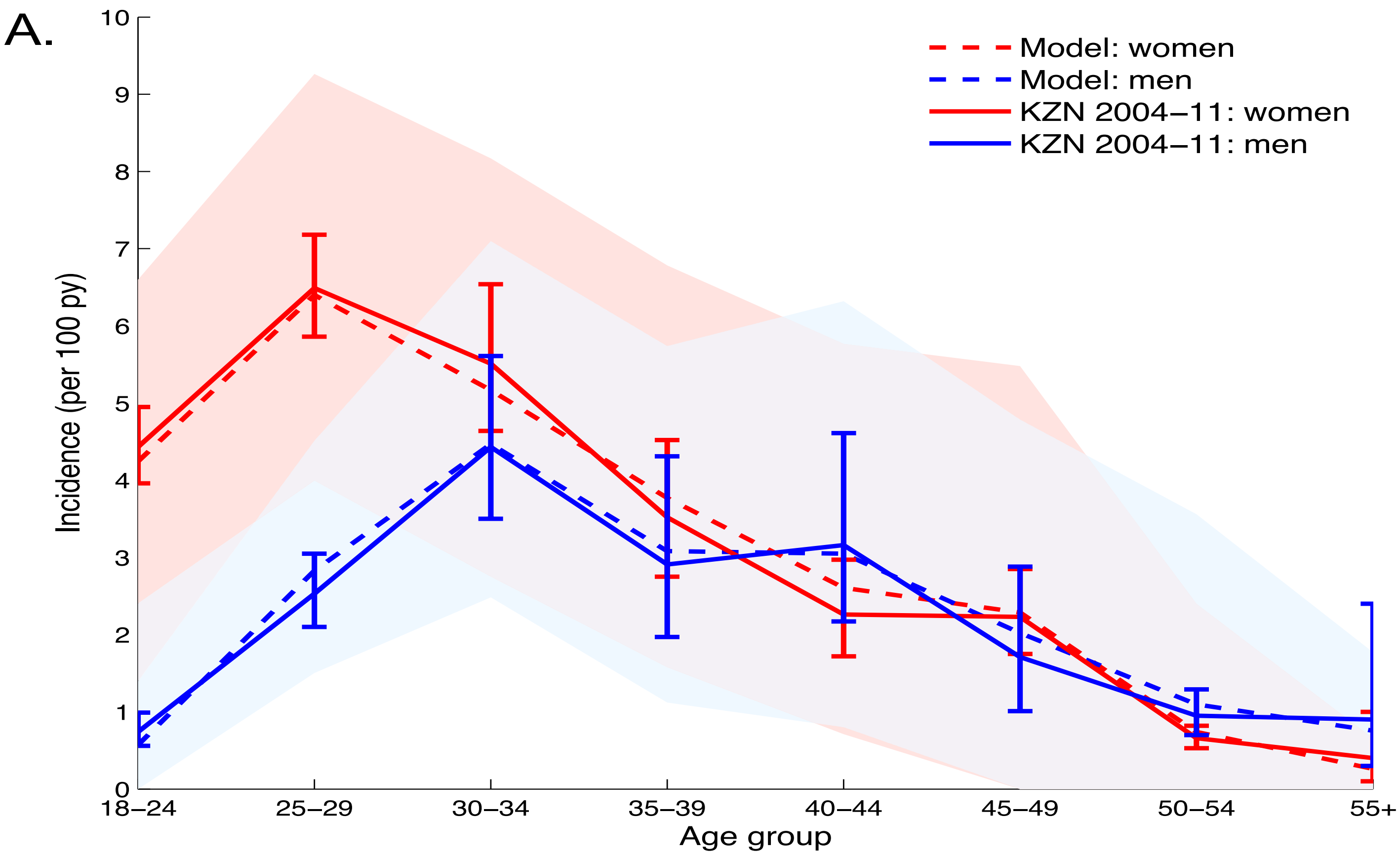


Smith, et. Al, Lancet HIV, 2015

Individual-based model structure



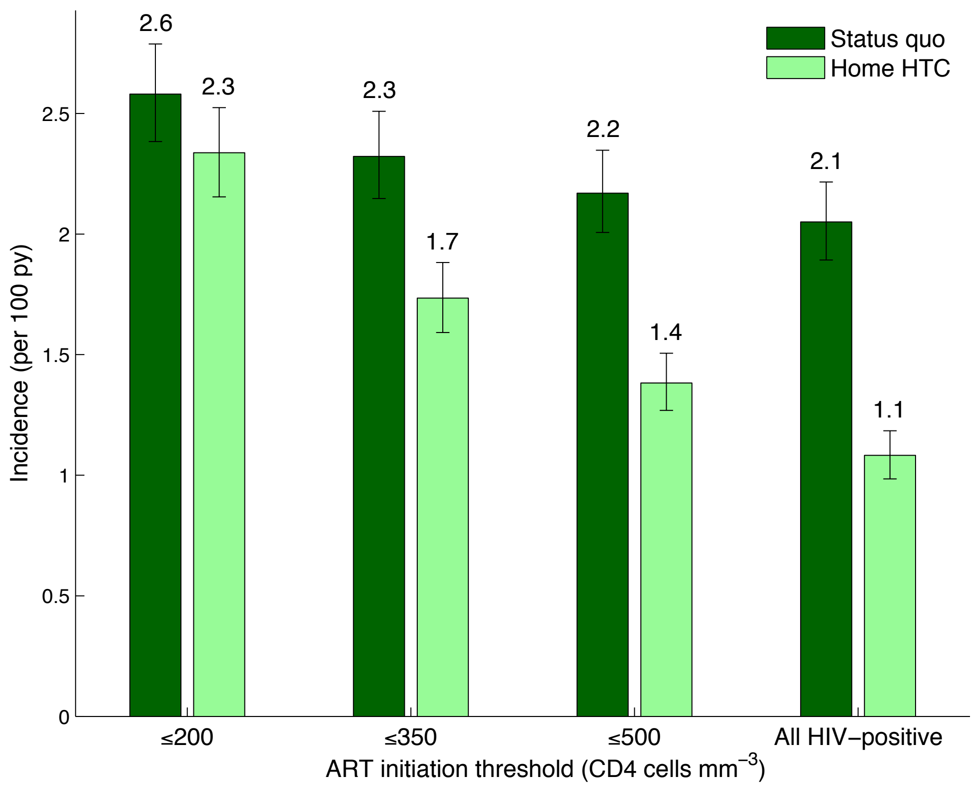
Model prediction compares well with observed data

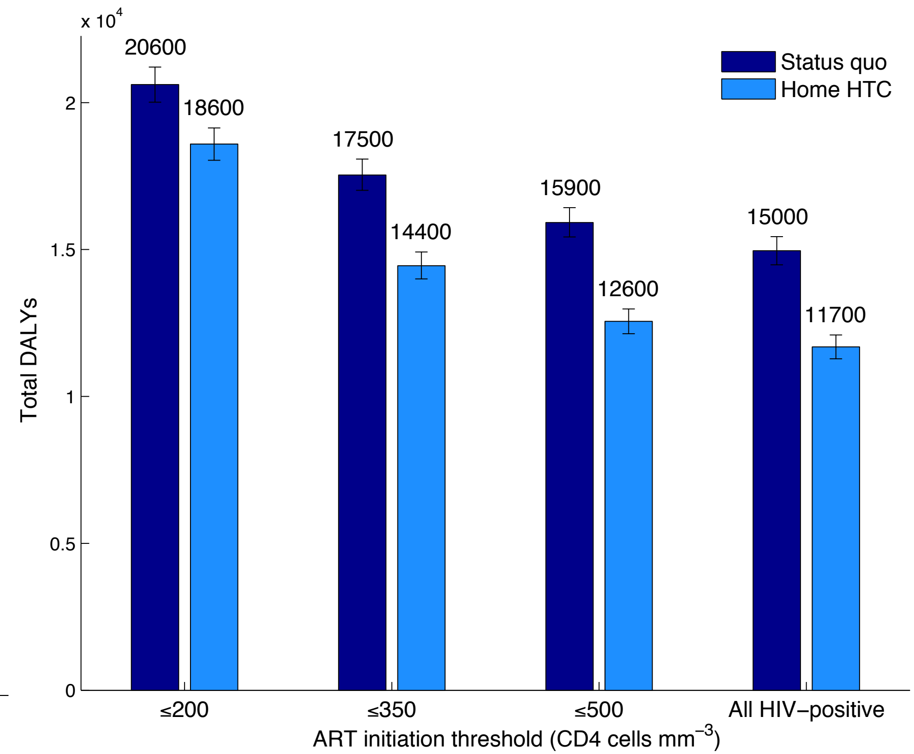


Cost-effectiveness of community-based strategies to strengthen the continuum of HIV care in rural South Africa: a health economic modelling analysis

Jennifer A Smith, Monisha Sharma, Carol Levin, Jared M Baeten, Heidi van Rooyen, Connie Celum, Timothy B Hallett, Ruanne V Barnabas

Home HTC and linkage has the potential to decrease HIV incidence





- **Under new South African ART initiation criteria (CD4 ≤500 cells per μL), home HTC and linkage has the potential to reduce HIV incidence by 36% and total DALYs by 21% over 10 years.**

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What data do we need for models?

- Demographics
- Mixing patterns
- Natural history
- Transmission probability
- Factors that change susceptibility
- Factors that change infectiousness
- Effectiveness of interventions
- Engagement in health care

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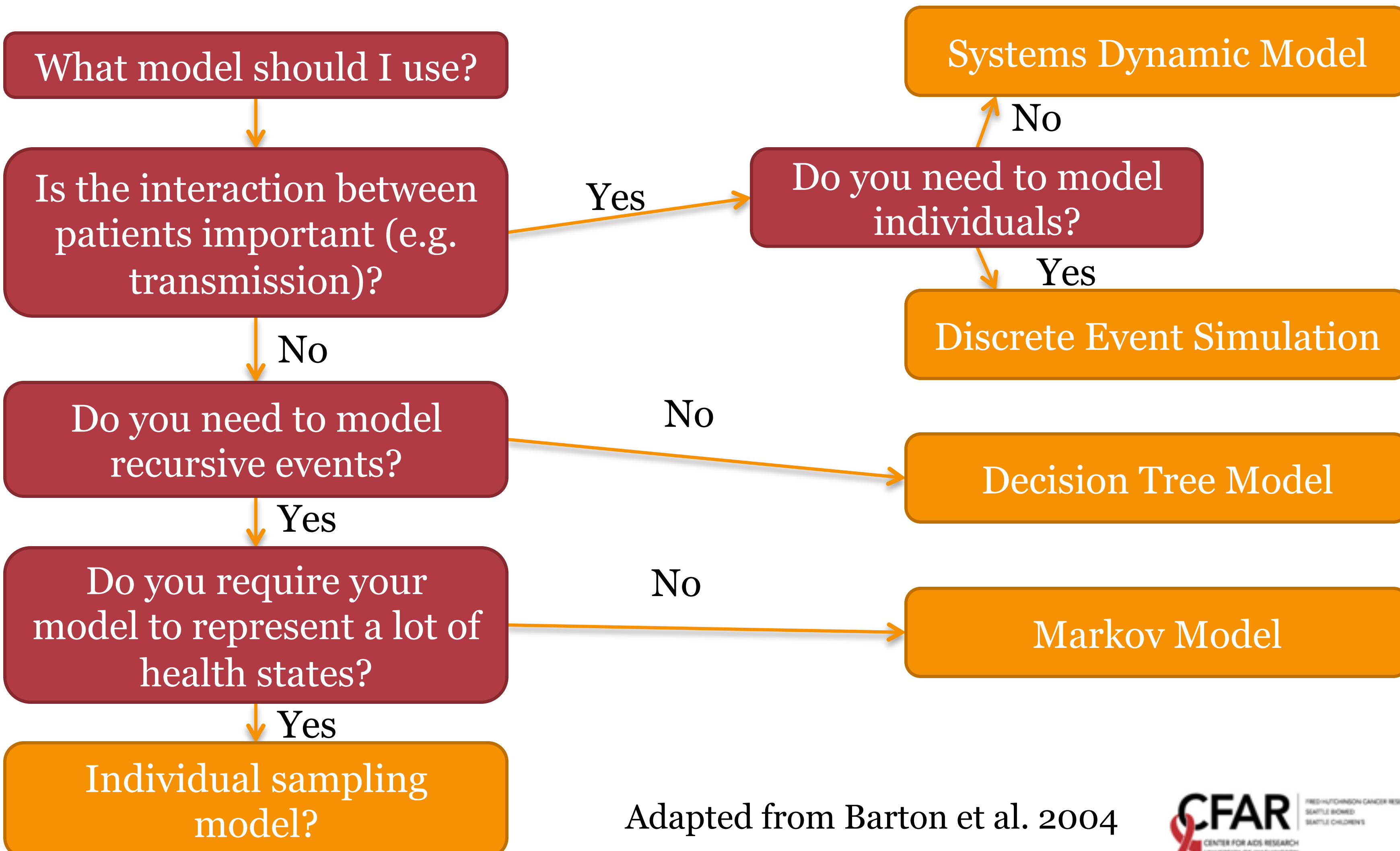
How to choose the appropriate model for health outcomes



Adapted from Barton et al. 2004

Summary

- Infectious disease modeling is a useful tool – assumptions are explicit, characterize uncertainty
- Study data can be used to parameterize models
- Models can be used to estimate health outcomes
- Consult with a health economist and/or modeler to choose an appropriate model to answer your question

- Contact: rbarnaba@uw.edu

Thank you

Study Participants
ICOBI and HSRC Staff

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PreventionRX Study