Which human behaviours are the most important determinants of commonly used population-level sexual network measures

September 2011, Edinburgh

Boris V. Schmid, Mirjam Kretzschmar Dutch Sexual Contact Network

The Chlamydia Screening Implementation (CSI)

Goals:

1. Evaluate the effect of 4 years of CSI in the Netherlands
2. Predict the long-term effectiveness of CSI

Tasks:

1. Improve the existing sexual contact network model (SCN) of the Netherlands
2. Simulate endemic Chlamydia and healthcare measures on top of it (SIS disease, exp. durations of $\pm$15 or 433 days (Althaus2010), if you ignore incubation time)

BUILDING AN SCN

SCN is the result of many individuals behaving (badly)

but..

- Many SCN models are created from a population perspective.
  (There is ample population-level emperical data available)
- Sociological research on partner preference and acquisition is not focused on network modelling.
  (but on correlations with Status, Beauty, Education, Age, Proximity)

Much "freedom" in constructing the underlying mechanisms of the model

BUILDING AN SCN

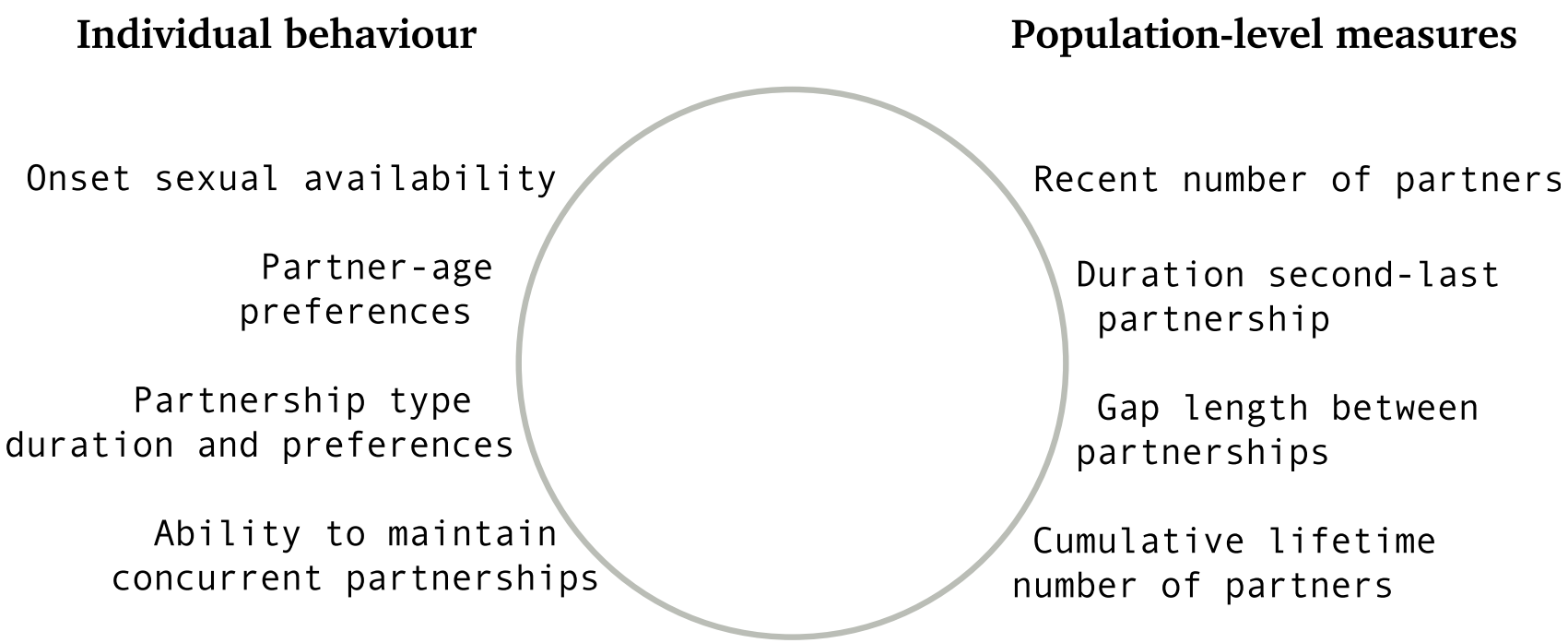
SCN is the result of many individuals behaving (badly)

but..

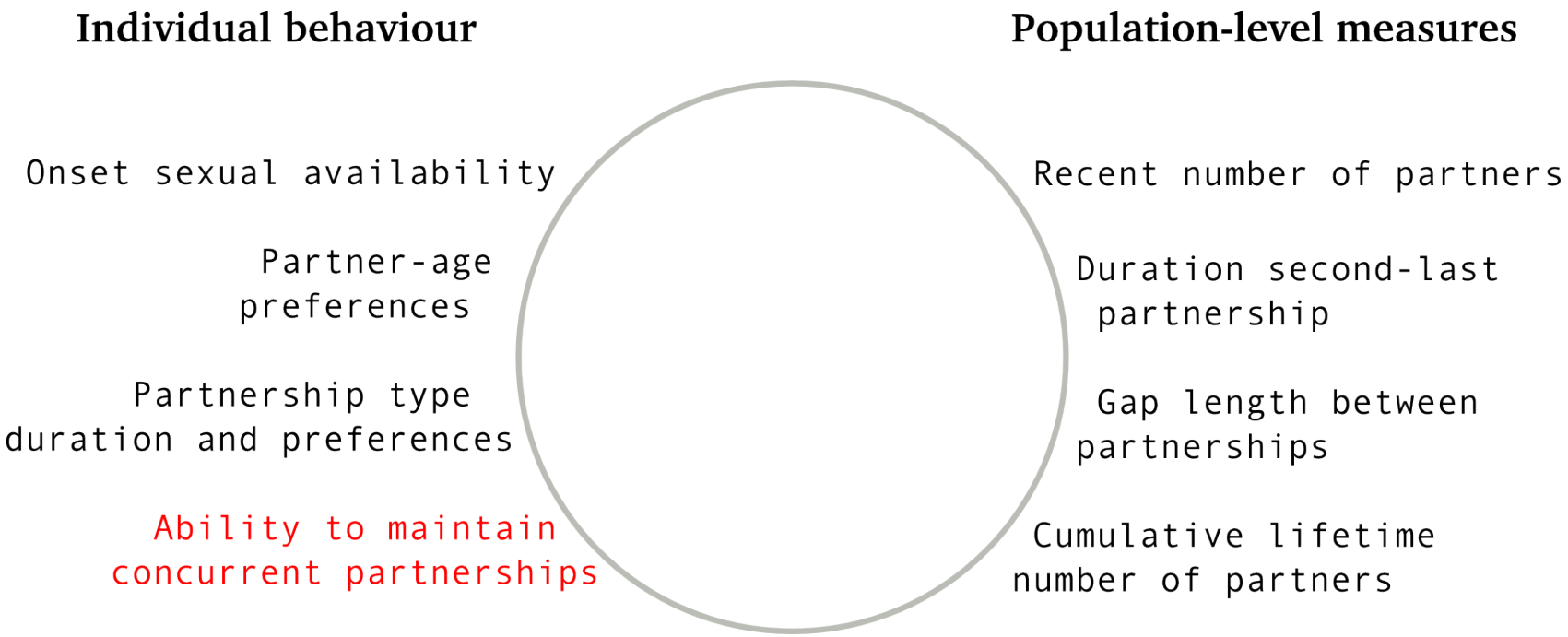
- Many SCN models are created from a population perspective.
  (There is ample population-level emperical data available)
- Sociological research on partner preference and acquisition is not focused on network modelling.
  (but on correlations with Status, Beauty, Education, Age, Proximity)

Much "freedom" in constructing the underlying mechanisms of the model

IND. BEHAVIOR and POPULATION-LEVEL MEASURES



AVAILABLE EMPIRICAL DATA



Absent: behaviour information of partner(s), i.e. Mixing

Bakker2009, Johnson.Lancet2001, Fenton.Lancet2001, Foxman.STD2006, Althaus.Interface2011

Dynamic network

- $\pm$ 100,000 nodes (50 years of a population of 50,000)
- changing number of maximum edges $0 \leq D_{max} \leq 11$ per node
- nodes with $D_{max} > 0$ classified in two groups

```
regular:
10y            15y            20y            25y            65y
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1 ... 1, 1, 0, 0]

core:
[0, 0, 0, 0, 0, 0, 1, 1, 1, 5, 5, 5, 5, 5, 5, 2, 2 ... 2, 2, 0, 0]
```

- total number of edges within and between these 2 groups is pre-defined
- three types (exp. durations) of edges

MODEL IMPLEMENTATION

Population parameters (still)

- population size 50,000
- degree density within and between groups is pre-defined

Host parameters

- date of birth
- gender (m/f)
- sexual capacity (onset and level of sexual interest)
- partner age preferene (gender-based fixed distribution)
- transitional concurrency (gender-based constant)
- partnership-type preference (fixed relative freq. of 3 exp. distribution)

PARAMETERS: HOST CAPACITY

Capacity: maximum number of simultaneous partnerships that can be maintained

- Willingness of individuals to invest time, resources into acquisition and maintenance of partnerships.
- "Cost" of each partnership is 1.

```
regular:
10y              15y              20y              25y              65y
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1 ... 1, 1, 0, 0]

core:
[0, 0, 0, 0, 0, 0, 1, 1, 1, 5, 5, 5, 5, 5, 5, 2, 2 ... 2, 2, 0, 0]
```

Transitional Concurrency:

- the stage of a partnership where its cost becomes effectively 0.

PARAMETERS: HOST CAPACITY

Capacity: maximum number of simultaneous partnerships that can be maintained

- Willingness of individuals to invest time, resources into acquisition and maintenance of partnerships.
- "Cost" of each partnership is 1.

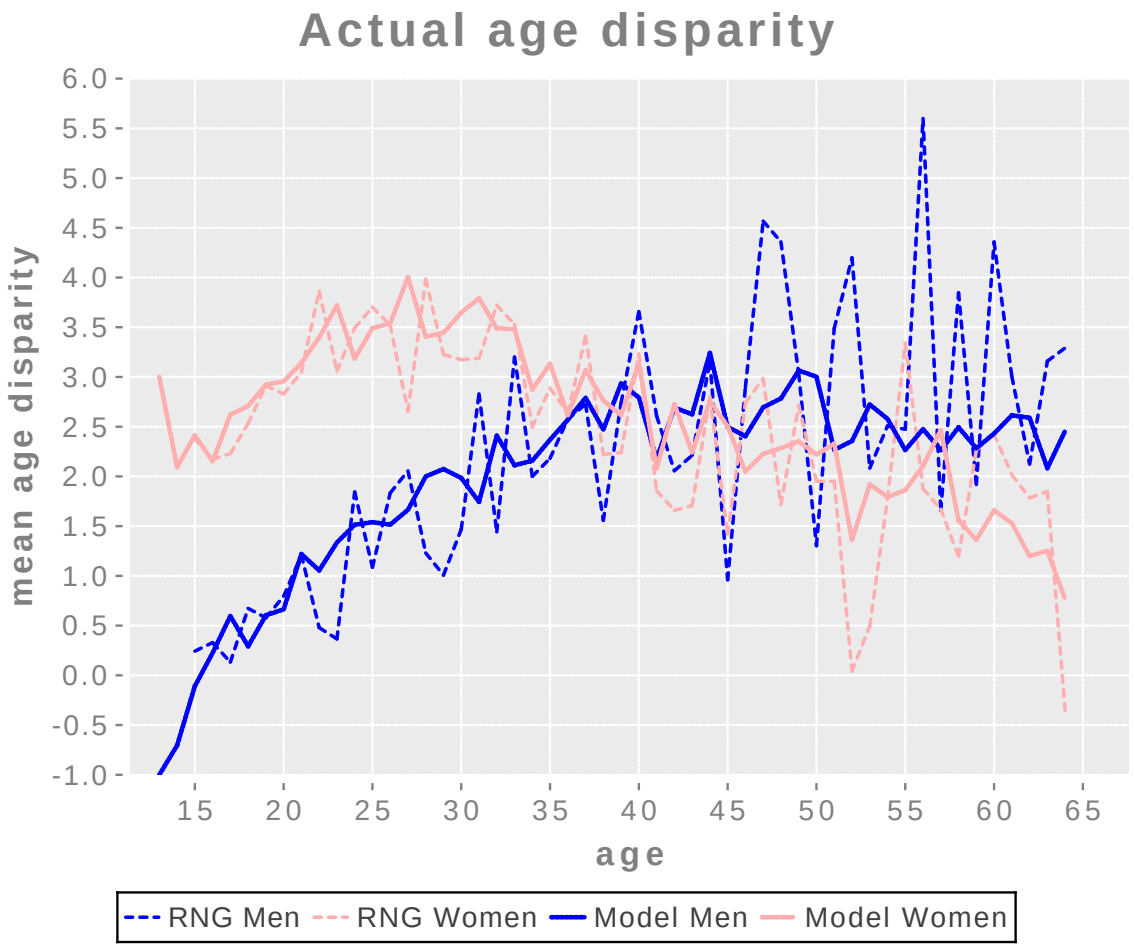
```
regular:
10y              15y              20y              25y              65y
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1 ... 1, 1, 0, 0]

core:
[0, 0, 0, 0, 0, 0, 1, 1, 1, 5, 5, 5, 5, 5, 5, 2, 2 ... 2, 2, 0, 0]
```

Transitional Concurrency:

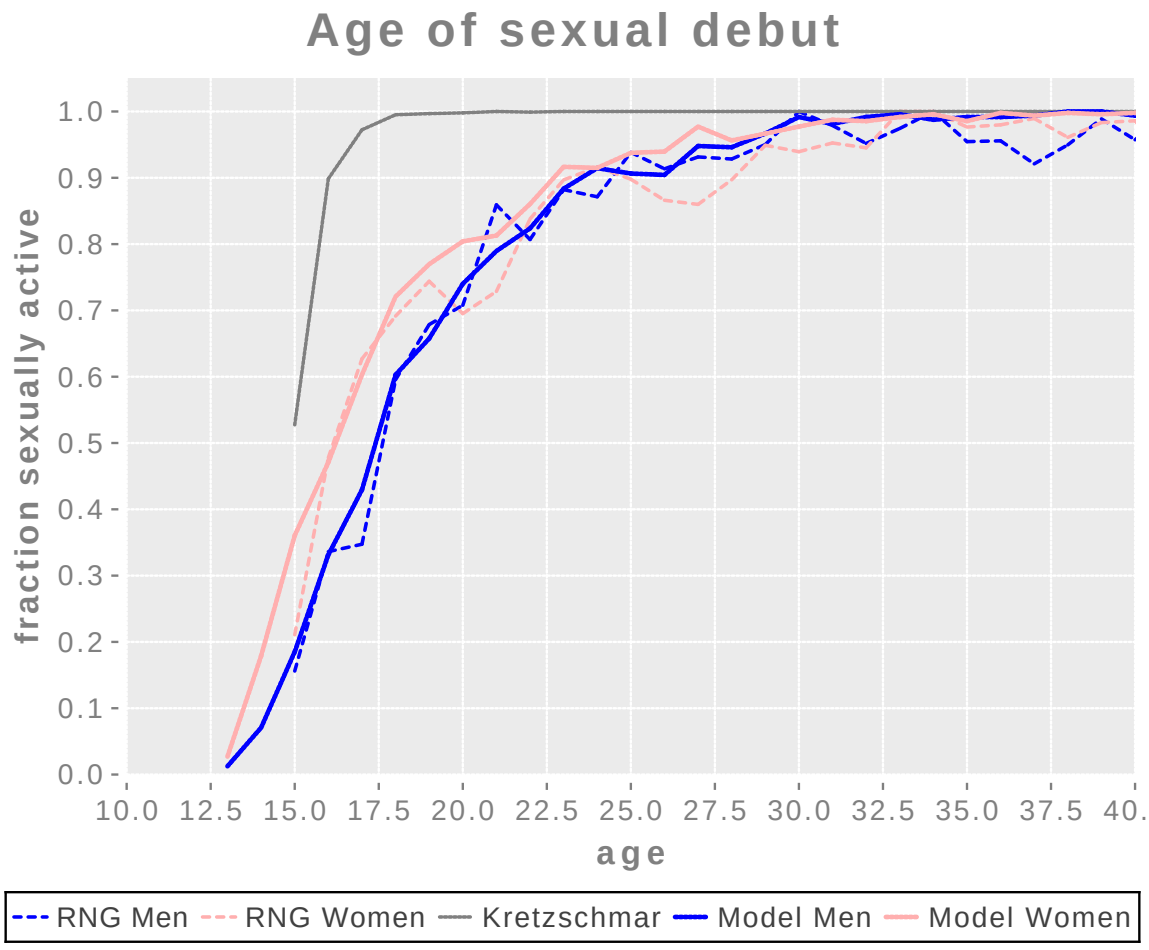
- the stage of a partnership where its cost becomes effectively 0.

PARAMETERS: PARTNER AGE PREFERENCE



- What you prefer influences the chance of accepting a partnership (e.g. is not necessarily what you end up with)

PARAMETERS: AGE SEXUAL DEBUT



- Start of sexual availability != start of sexual debut
- Start of sexual availability == for men/women

DATING ALGORITHM

Prerequisites:

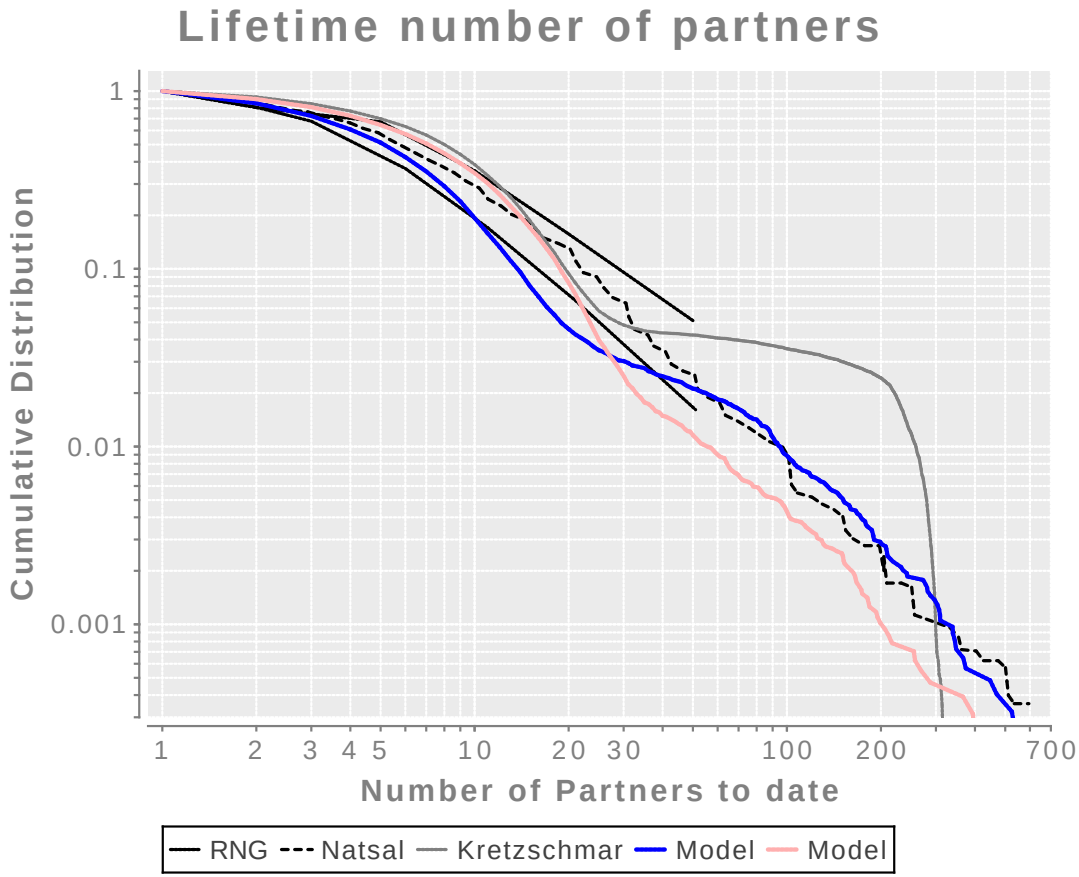
- Opposite gender
- Not already in a partnership with each other
- Free capacity

Probability based on age-disparity:

- for women: probability based on disparity of man from "ideal" age.
- (binary prerequisite for men below age 20: women $<$ 2 years older)

RESULTS: LIFETIME NUMBER OF PARTNERS

(capacity and group degree density)

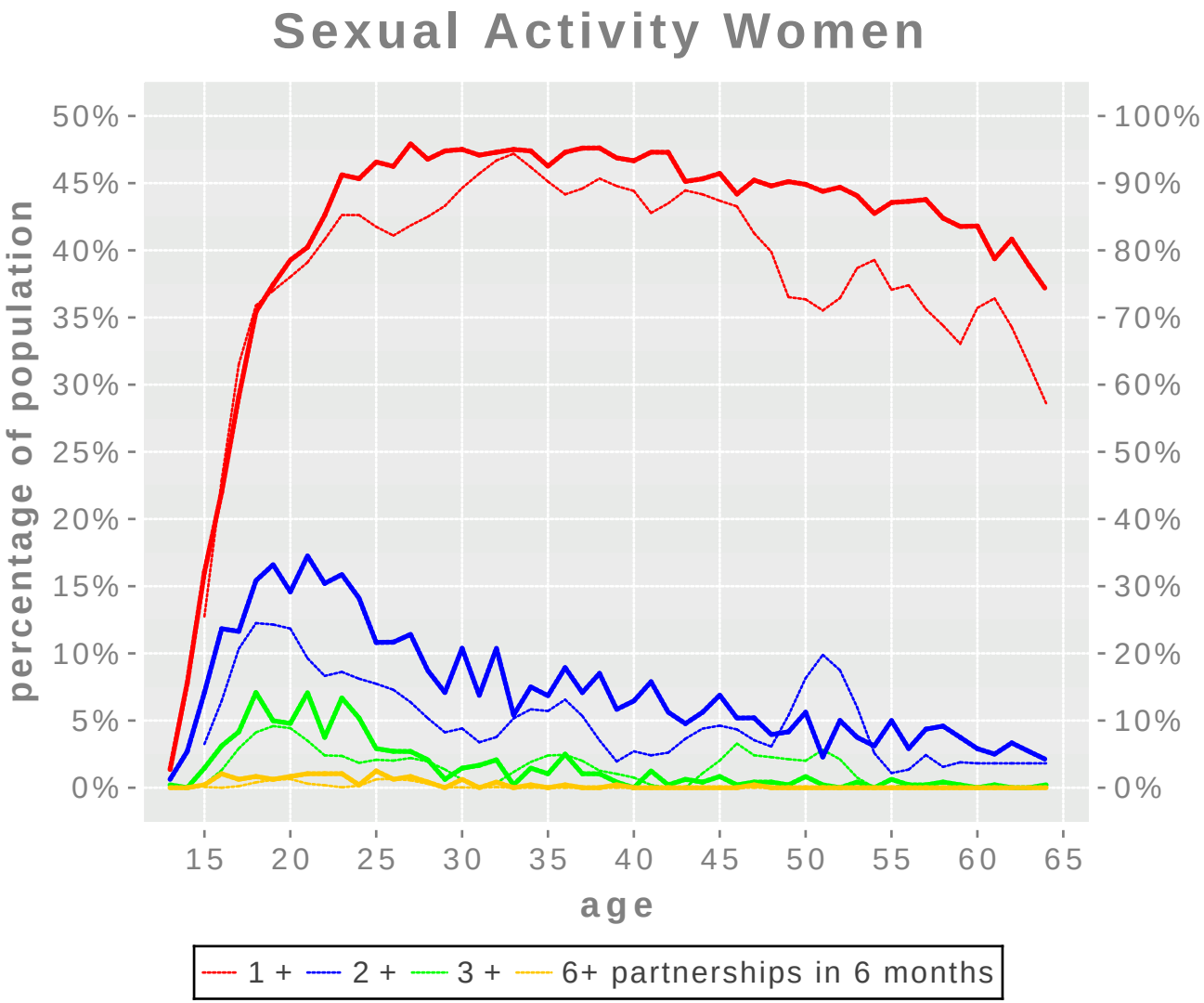


- Two bulges effect of two groups.
- Power-law because D_{max} is a f of pre-determined age of sexual availability and duration of high-sexual active period

RESULTS: RECENT NUMBER OF PARTNERS

for regulars: age-preference, partnership duration, sexual debut.

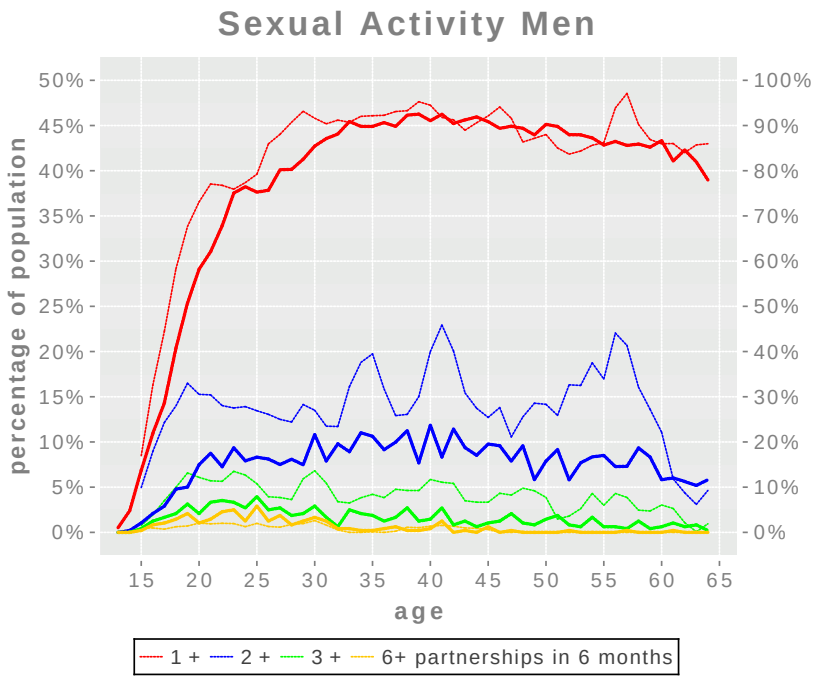
for core-group: shape of capacity vector

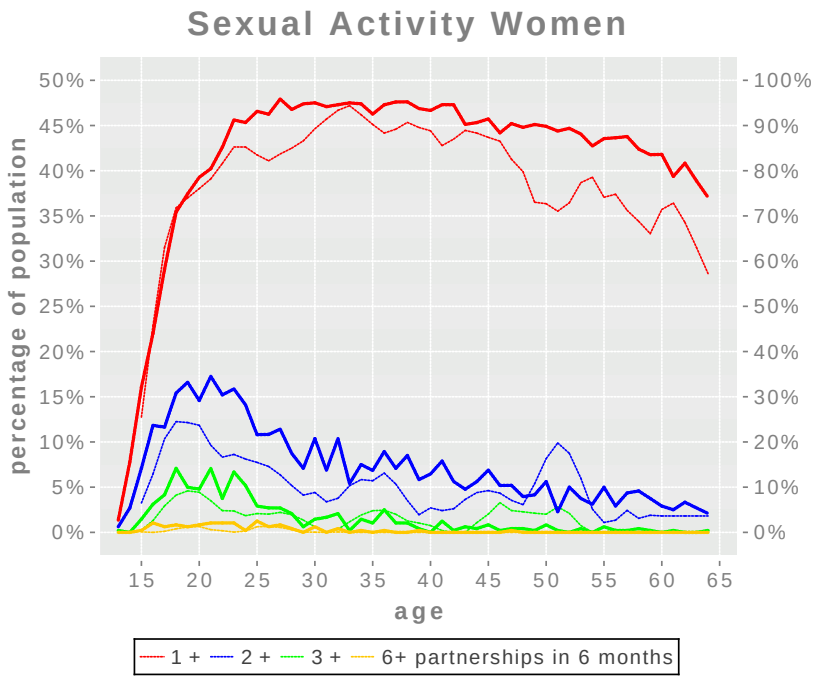


RESULTS: RECENT NUMBER OF PARTNERS

for regulars: age-preference, partnership duration, sexual debut.

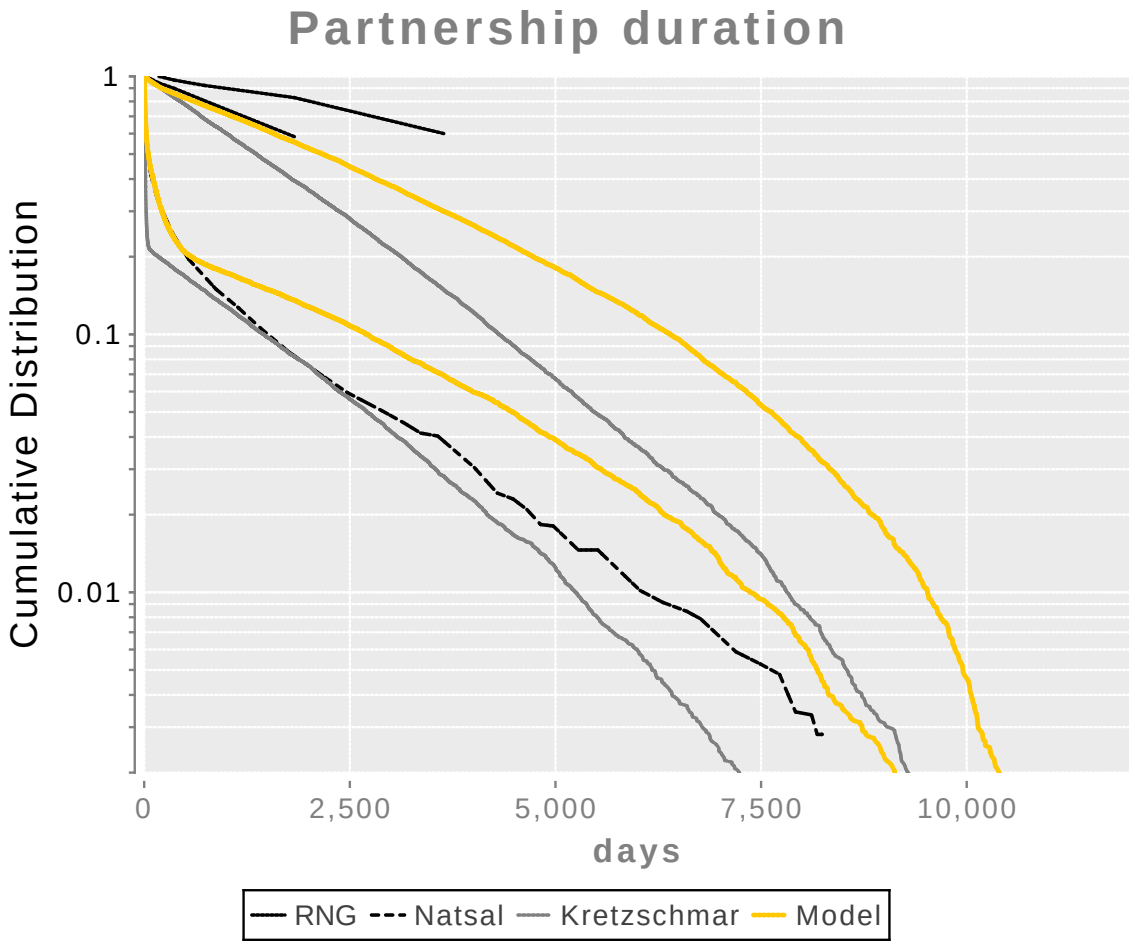
for core-group: shape of capacity vector





RESULTS: DURATION

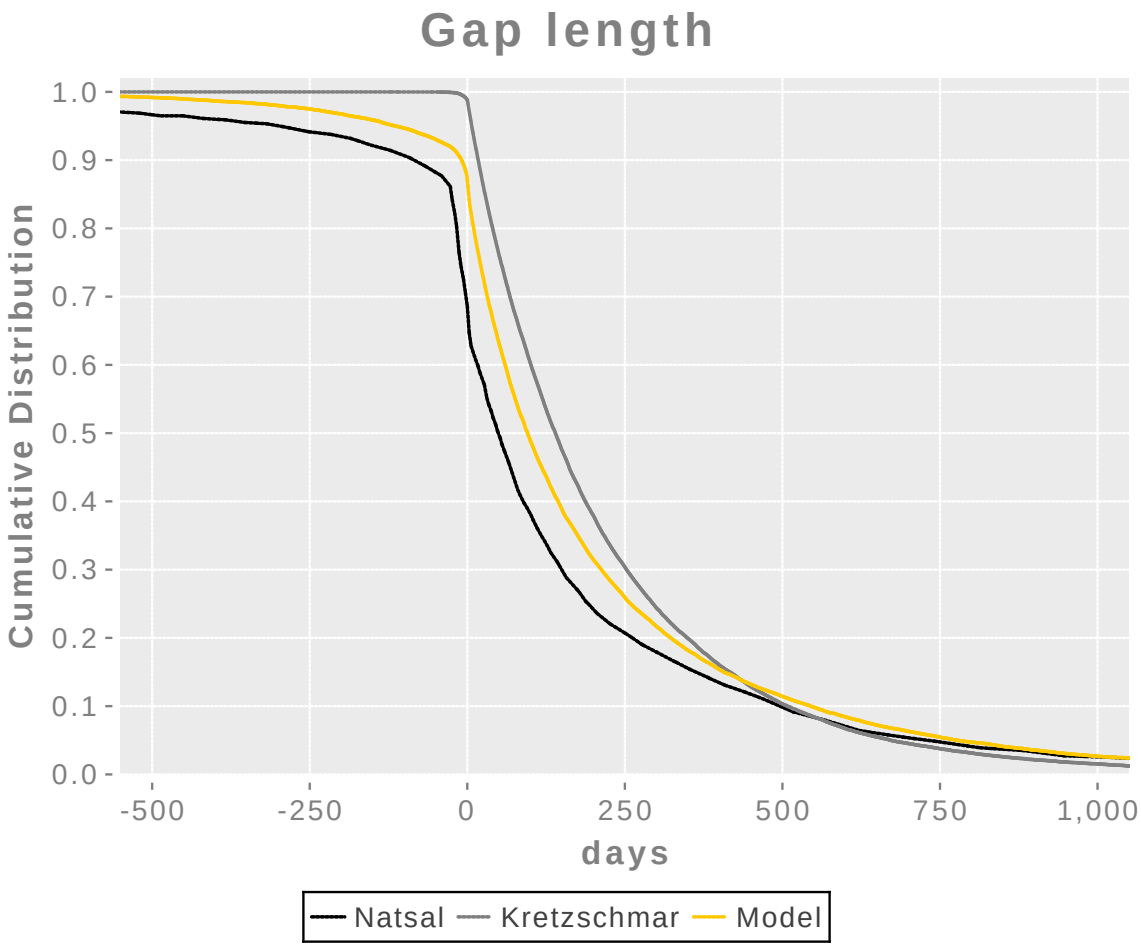
(partnership types relative freq. and duration)



- Limited data on Dutch duration of partnerships
- UK network has in general longer casual, shorter steady partnerships

RESULTS: CONCURRENCY

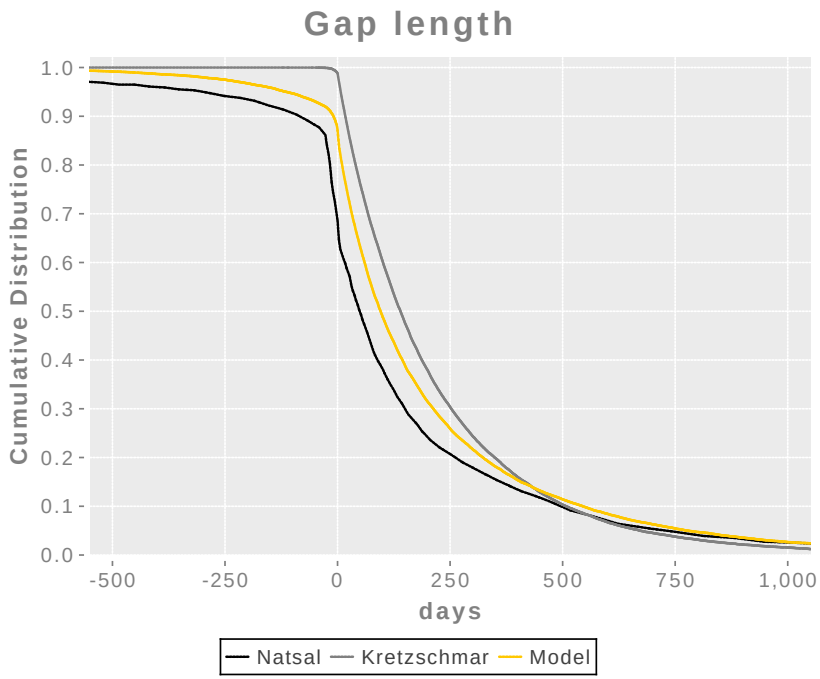
(transitional concurrency, pop. degree density)

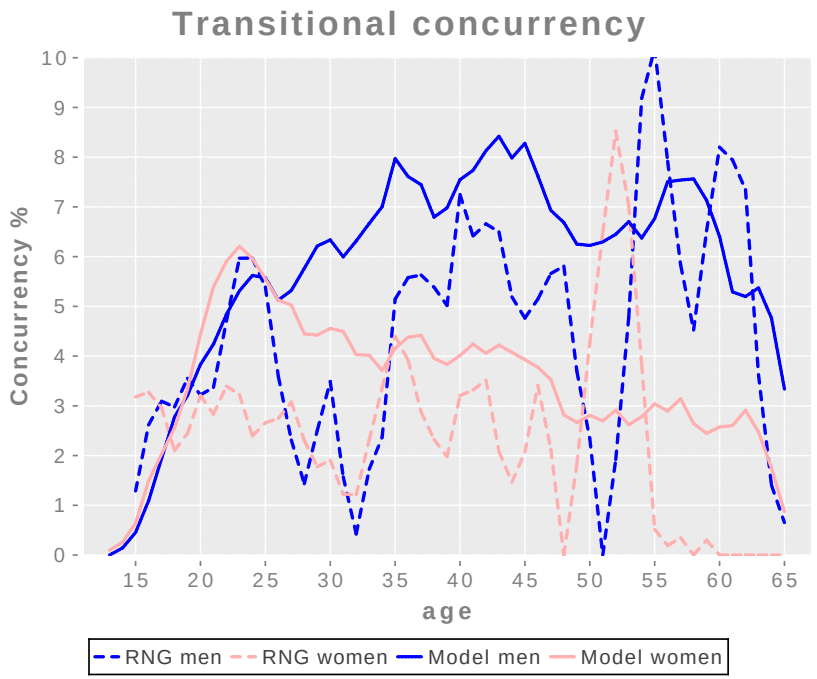


- For UK data: increase transitional concurrency to 20% of partnership duration (from 7.5-12.5%)

RESULTS: CONCURRENCY

(transitional concurrency, pop. degree density)





PARAMETERS: CHLAMYDIA

Chlamydia trachomatis

- Transmission rate is expressed as /day, /sexact, /unprotected sexact, and usually fitted to prevalence
- Symptomatic infections (15-50%): incubation time + exp. 2 weeks time until treatment
- Asymptomatics: Clear infection exp. with mean 433 days (Althaus2010)

Healthcare

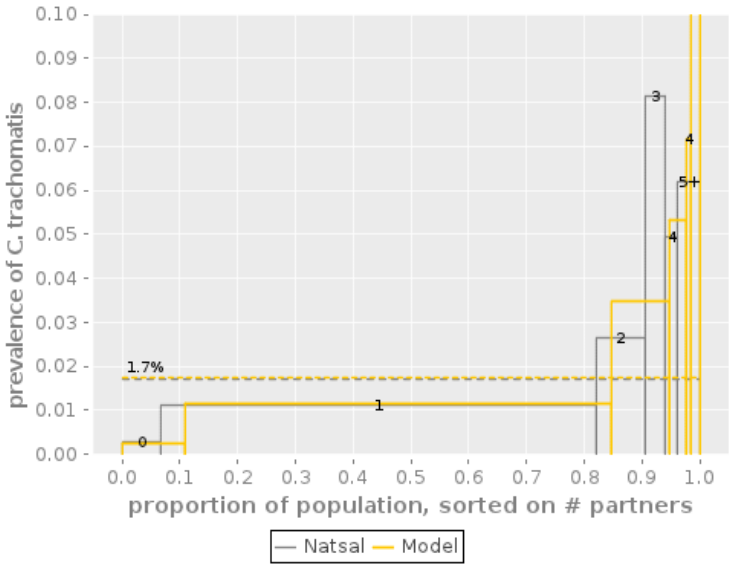
- Symptomatics are treated. Asymptomatics might be tested
- Current partners are frequently notified in NL

(solution: model a different country or perhaps use pair-wise modelling)

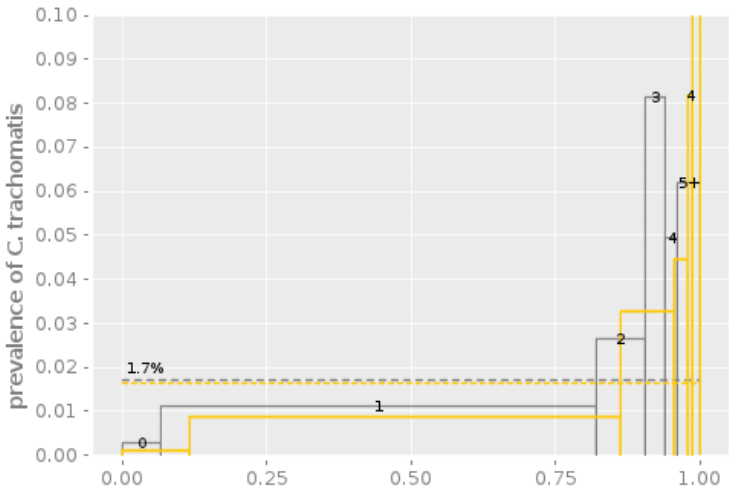
RESULTS: DISTRIBUTION CT (MIXING)

(group mixing)

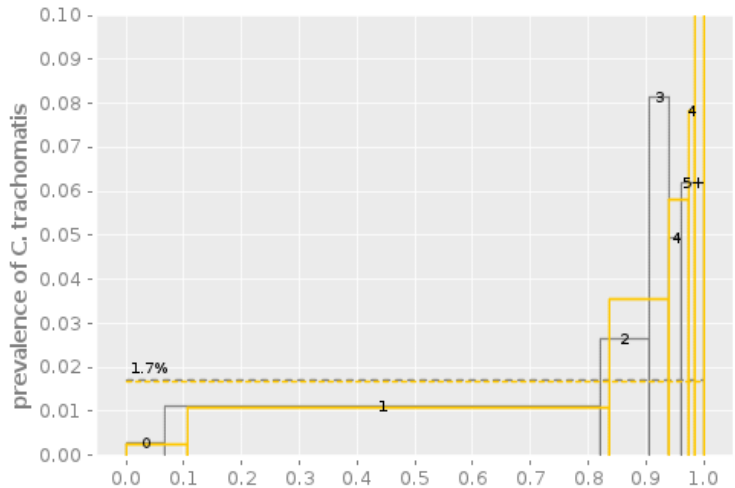
"Best fit"



Max. assortative



Max dis-assortative



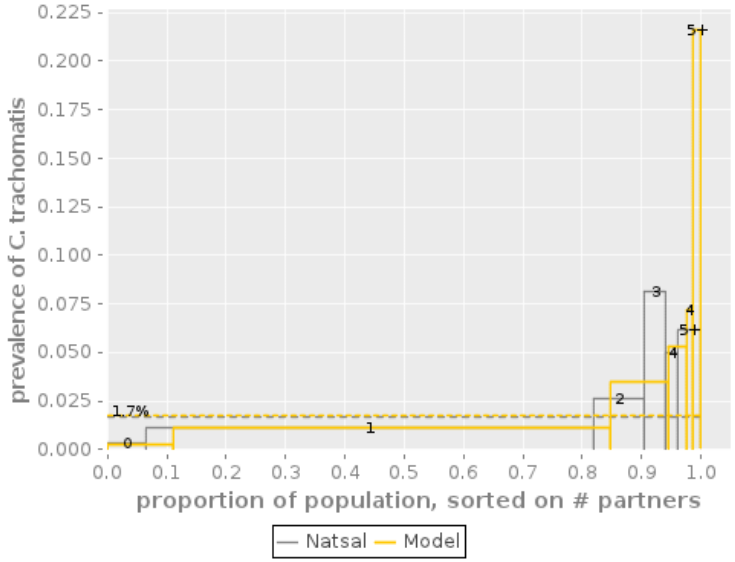
Boris V. Schmid, Mirjam Kretzschmar

Dutch Sexual Contact Network

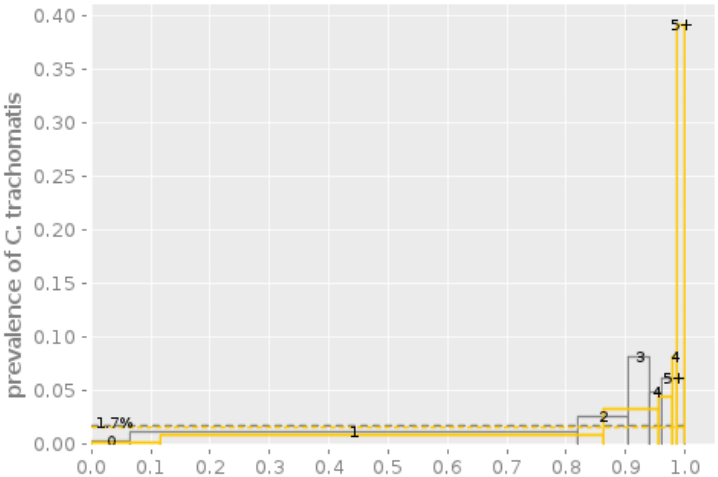
RESULTS: DISTRIBUTION CT (MIXING)

(group mixing)

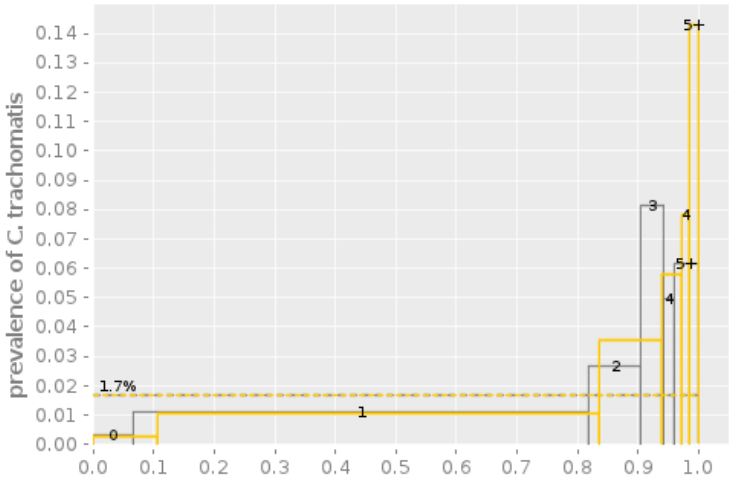
"Best fit"



Max. assortative



Max dis-assortative

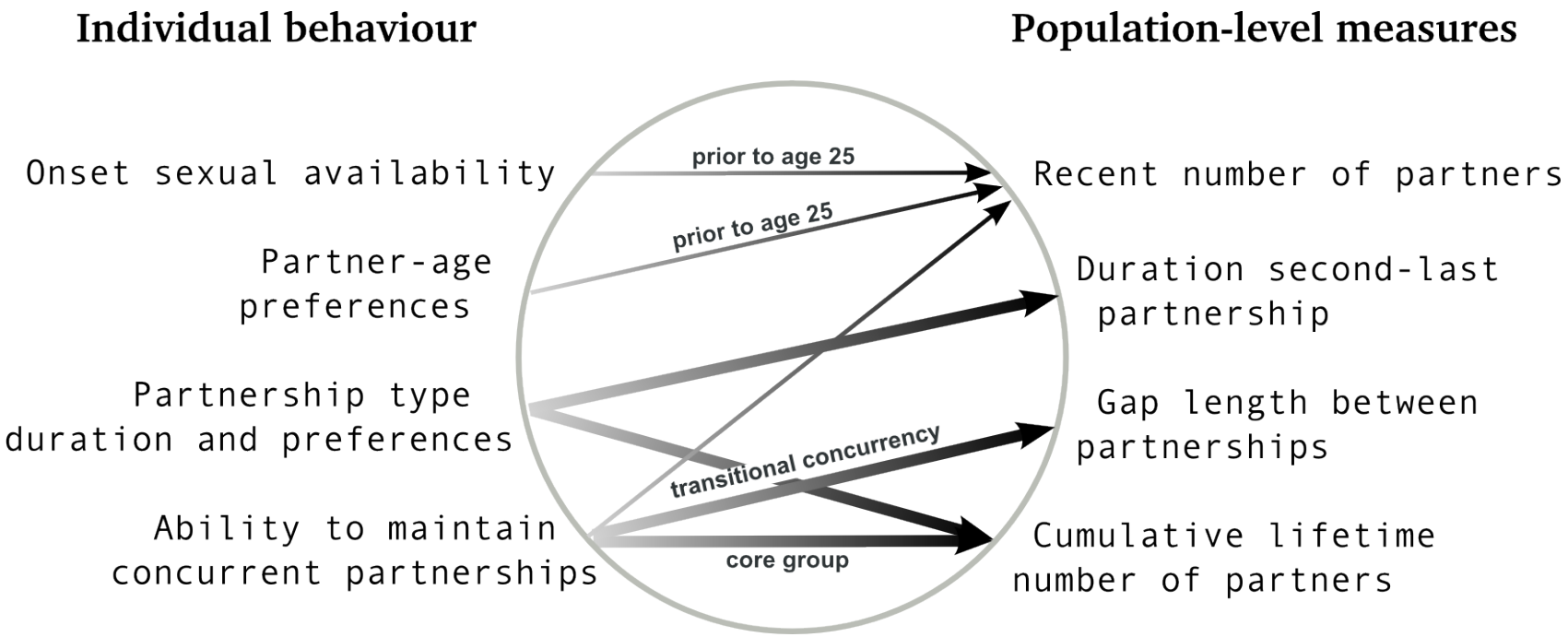


Boris V. Schmid, Mirjam Kretzschmar

Dutch Sexual Contact Network

CONCLUSION

How individual behaviour influences population measures



note:

- Fixed-range partner-age preference is important
- Mixing of regular and core is very important for disease (Doherty2006, and robustness of endemic), but not known.

HOW SIMPLE IS COMPLEX ENOUGH

speculative, for theoreticians

How simple a model still represents a sexual contact network?

You need:

- Capacity (D_{max}) per node goes up and down over time. How high up differs between nodes. (Either dependent or independent of local network)
- Low level of assortative mixing based on D or D_{max}.
- Assortative mixing based on age.
- at least 1 type of exponential partnership duration.
- (SIS disease with 2 exponential durations)

HOW SIMPLE IS COMPLEX ENOUGH

speculative, for theoreticians

How simple a model still represents a sexual contact network?

You probably can leave out (in order of certainty):

- variation in onset and stop of sexual availability (e.g. when in a lifetime a host reaches $D_{max} = 0$.
- effect of disease on network, e.g. breakups, partner notification (in case of Chlamydia)
- gender/gender-based differences
- transitional concurrency (under the condition that disease duration and partnership gaplength are of the same timescale)

ACKNOWLEDGEMENTS

- Mirjam Kretzschmar (RIVM, Julius Centre)
- Christian Althaus, Sereina Hertog, Janneke Heijne, Nichola Low (University of Bern, Swiss)
- CSI and KEA groups

Names and affiliations of the CSI projectgroup

J.E.A.M. van Bergen
I.V.F. van den Broek
E.E.H.G. Brouwers
J.S.A. Fennema
H.M. Götz
C.J.P.A. Hoebe
R.H. Koekenbier
E.L.M. Op de Coul
L.L. Pars
S.M. van Ravesteijn

GGD Amsterdam
Amsterdam Public Health Service

GGD Rotterdam-Rijnmond
Municipal Public Health Service Rotterdam-Rijnmond

GGD Zuid Limburg
South Limburg Public Health Service

Soa Aids Nederland
STI AIDS Netherlands

RIVM KEA group

Eelco A.M. Over
G. Ardine de Wit

Unit Epidemiologie & Surveillance,
Centrum voor Infectieziektebestrijding RIVM
Unit Epidemiology & Surveillance,
RIVM/Centre for Infectious Disease Control Netherlands