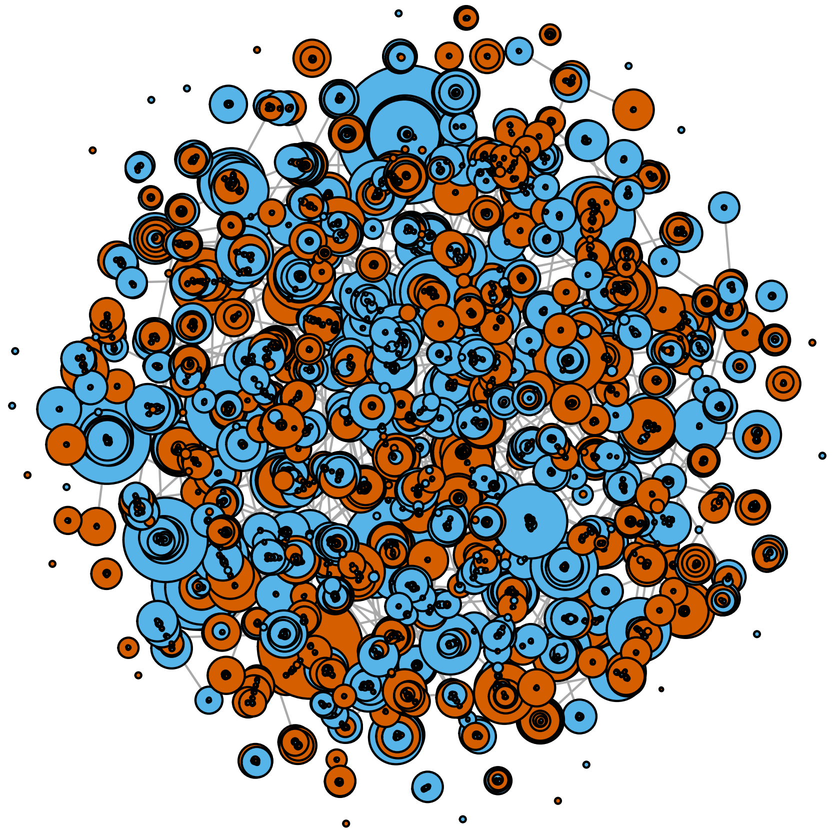
Can social networks explain patterns of male-bias in TB cases?

CEID Symposium 2019

Paige Miller



Tuberculosis: A deadly human pathogen

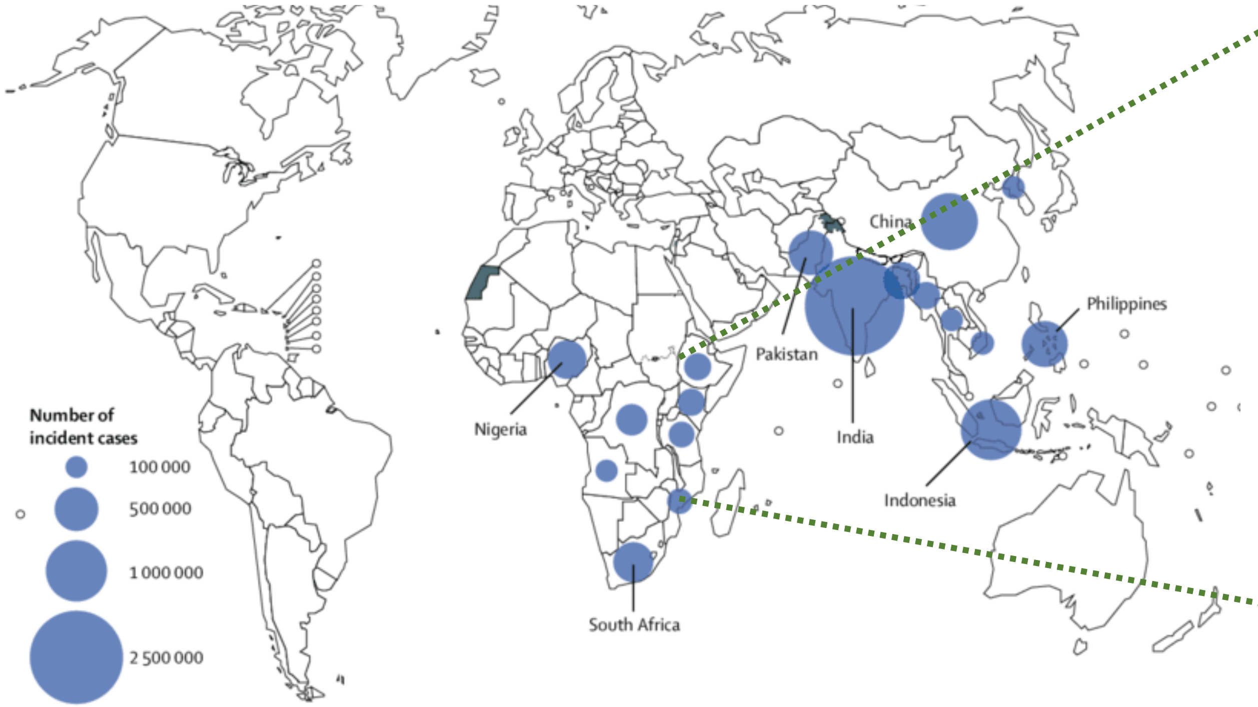
Mycobacterium tuberculosis:

- Respiratory transmission
- ~ 90% of infections result in latent TB (LTBI)

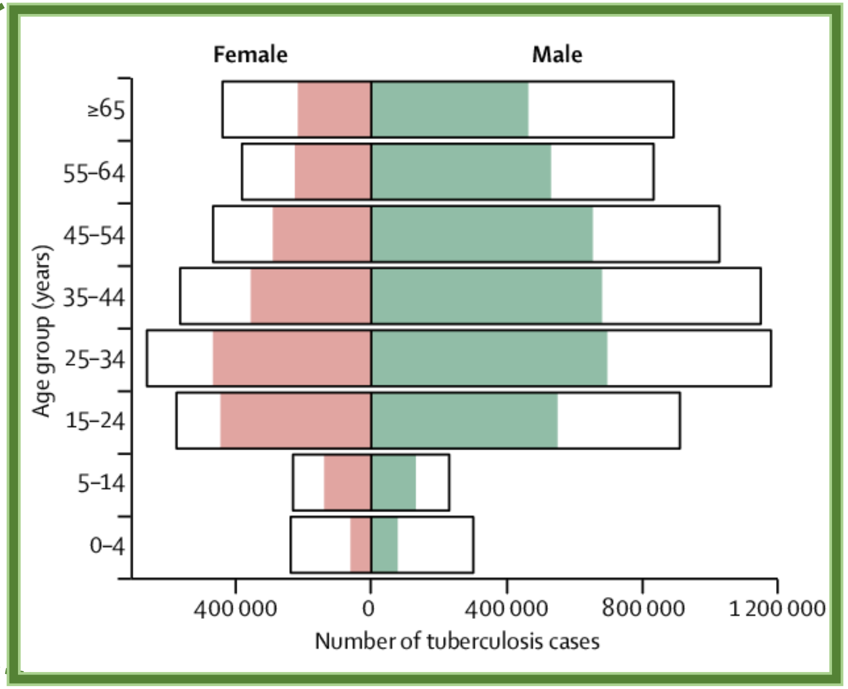
"One seventh of all human beings die of tuberculosis and … if one considers only the **productive middle-age groups**, tuberculosis carries away one-third and often more of these…" – Robert Koch 1882

Human tuberculosis is spread unevenly

Across populations



Within populations



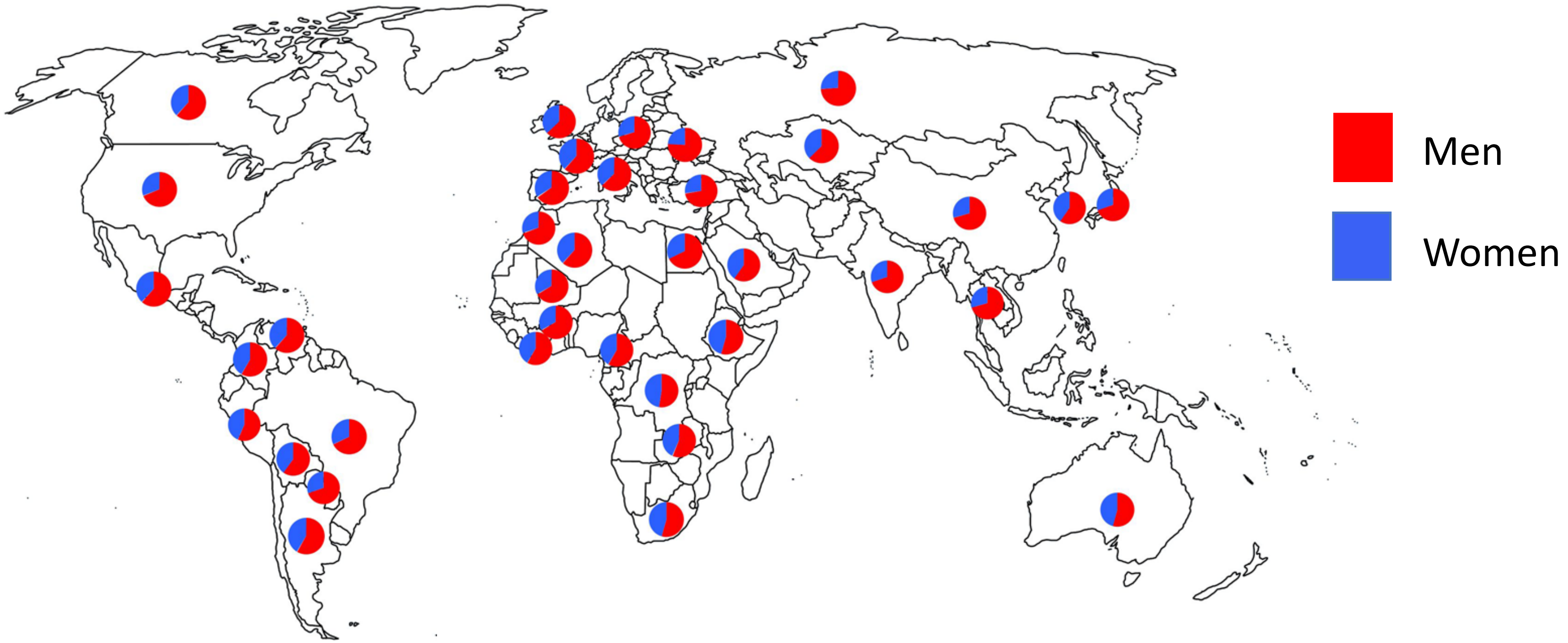
Global TB Report, *WHO* (2017)

A strikingly consistent trend in male-bias of TB

Global male:female case ratio in 2016:

1.8

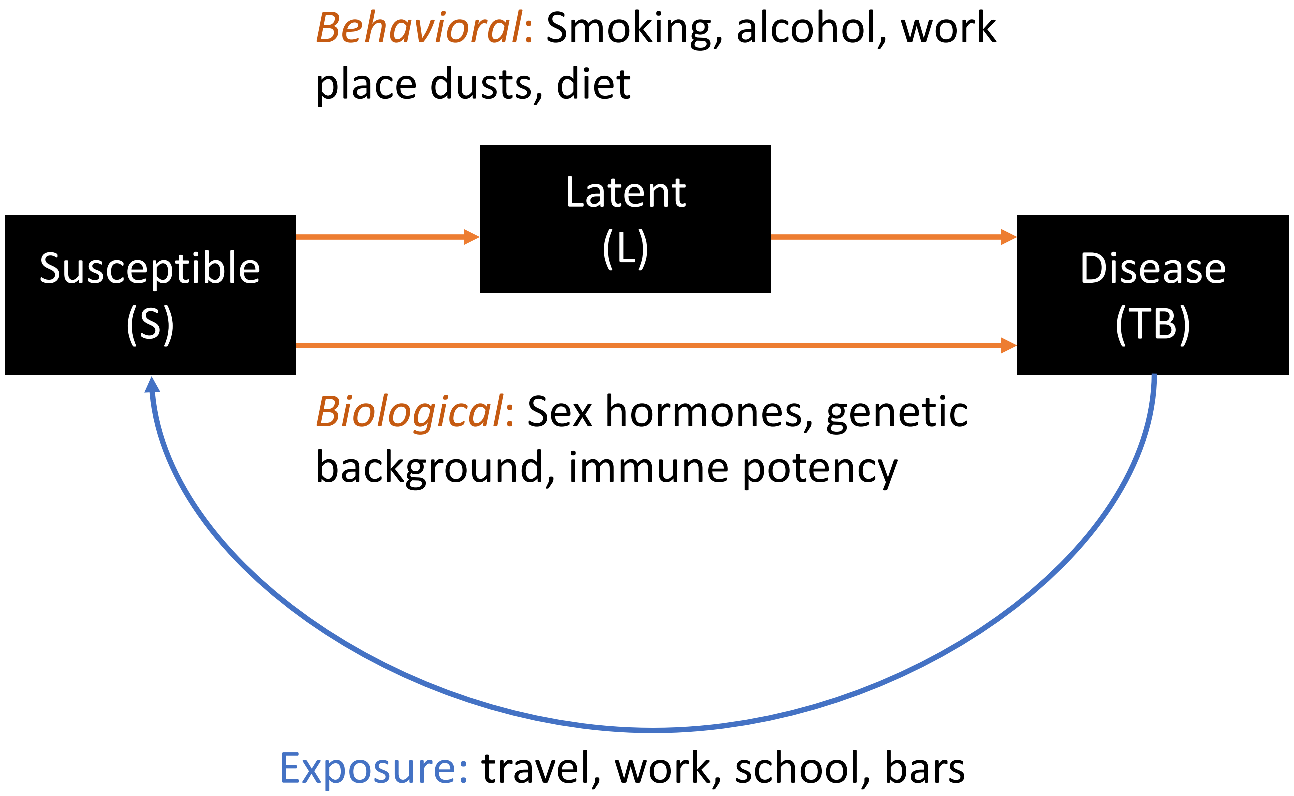
Ratio of *prevalent* : *notified* cases was 1.5 times higher in men, suggesting that men are less likely than women to achieve diagnosis



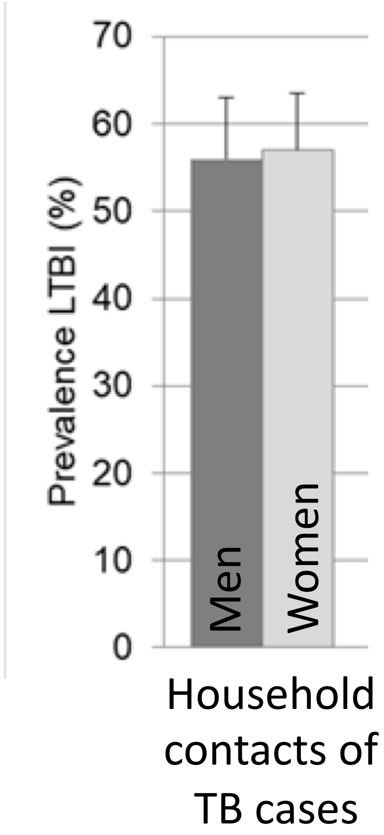
Horton et al. *Plos Med* (2016)

Neyrolles & Quintana-Murci, *Plos Med* (2009)

SUSCEPTIBILITY or EXPOSURE could differ between males and females



Lack of support for sex-specific susceptibility



Bates et al., *JAMA* (2007)
Neyrolles & Quintana-Murci, *Plos Med* (2009)

Kakaire (2018)

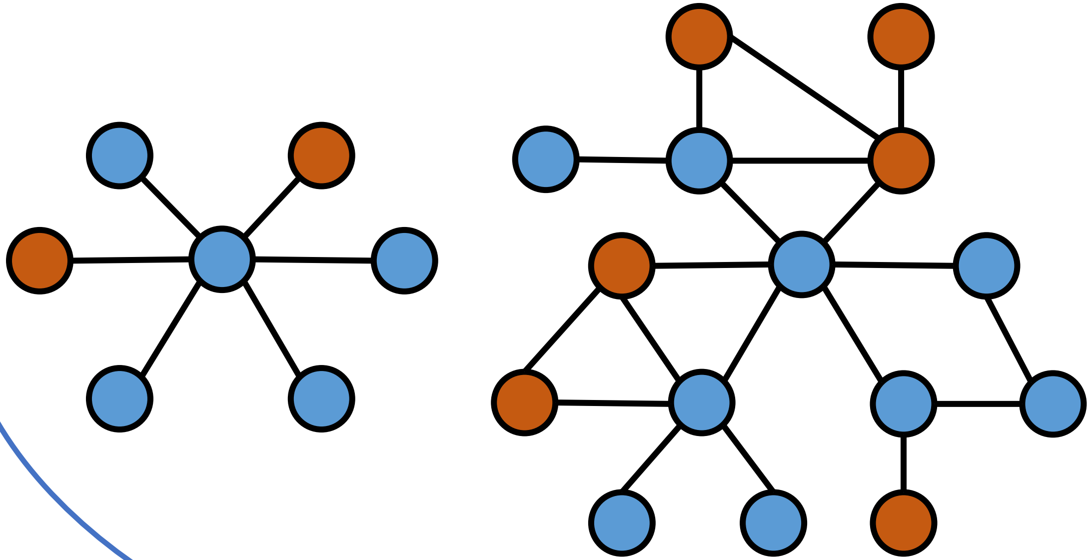
How might social networks facilitate higher exposure to Mtb?

Individual level: Male position

Population level: Male assortativity

We investigated whether individual-level (**position**) or population-level (**assortativity**) factors were associated with TB using network data from Kampala, Uganda (2013-2015)

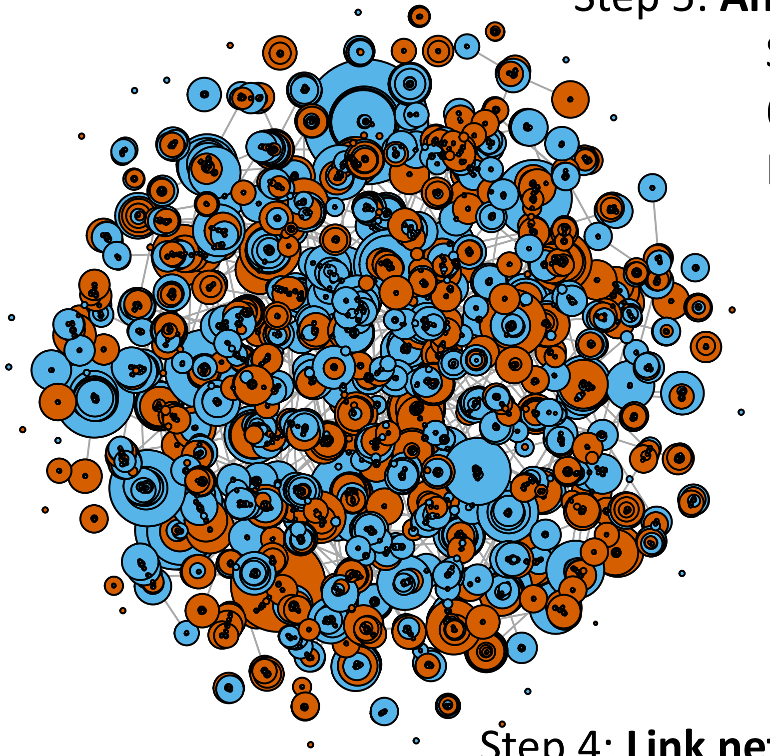
Step 1: Enroll **index cases** or **index controls** and solicit **first-level contacts**



Step 2: Enroll first-level contacts and solicit **second-level contacts**

Step 3: Repeat until **123 index cases** and **123 index controls**

Step 4: **Link networks together** that have common connections



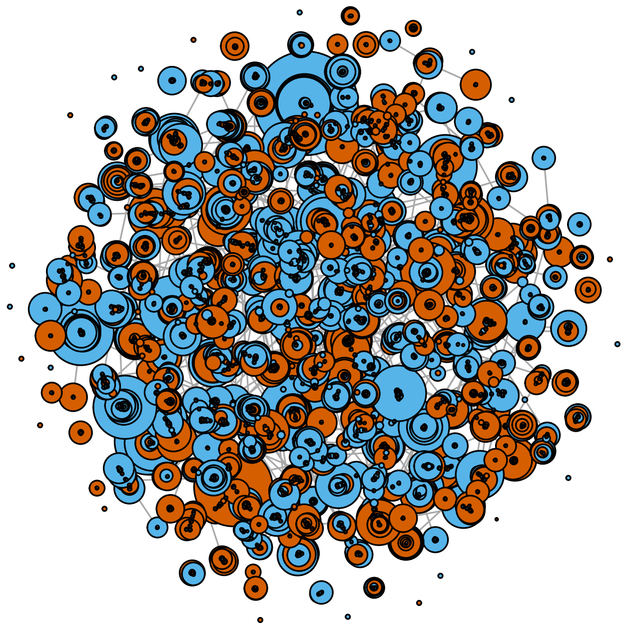
Step 5: **Analyze network**

Size: 11,214

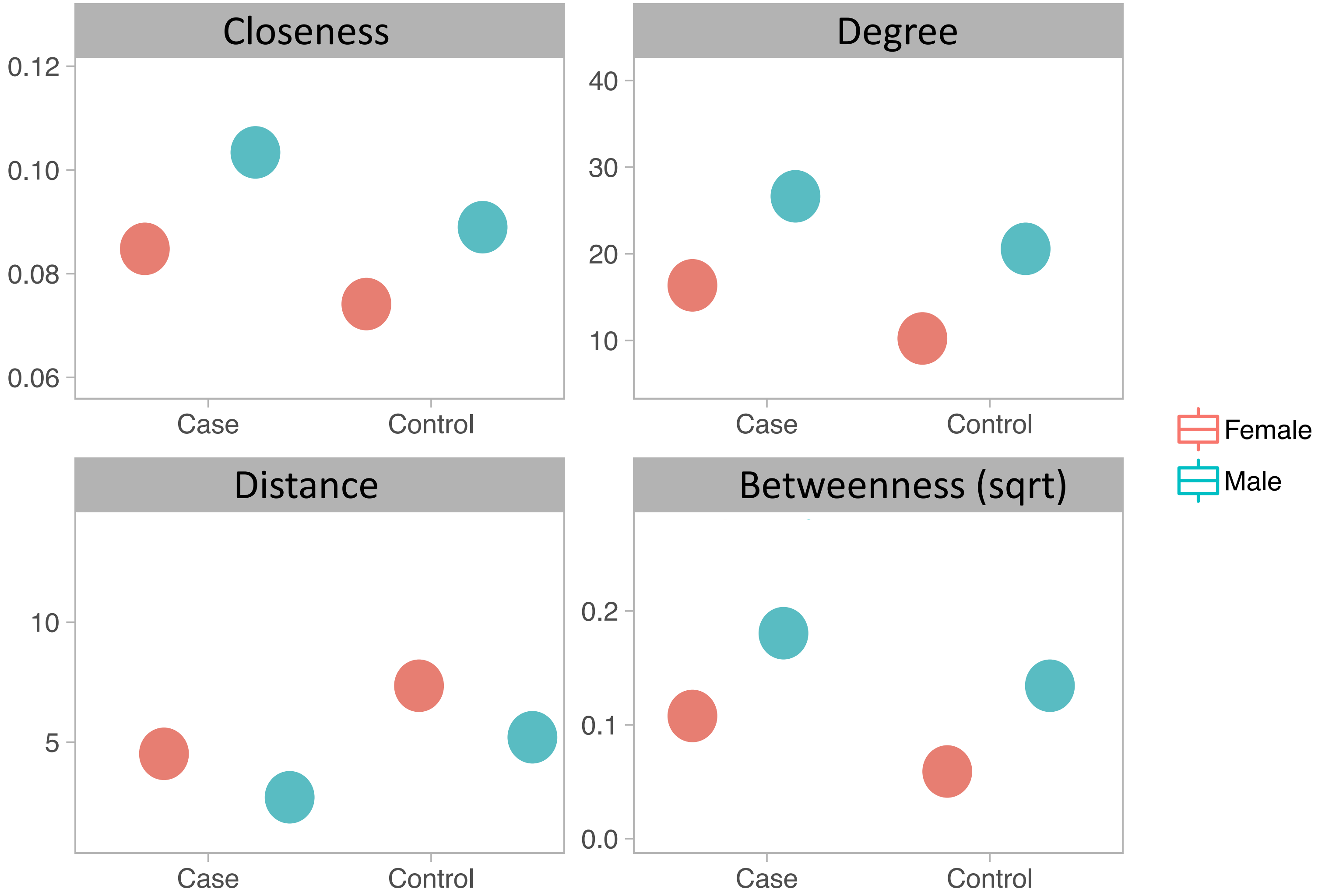
6,180 men; 5,034 women

Mean degree (index): 10.9

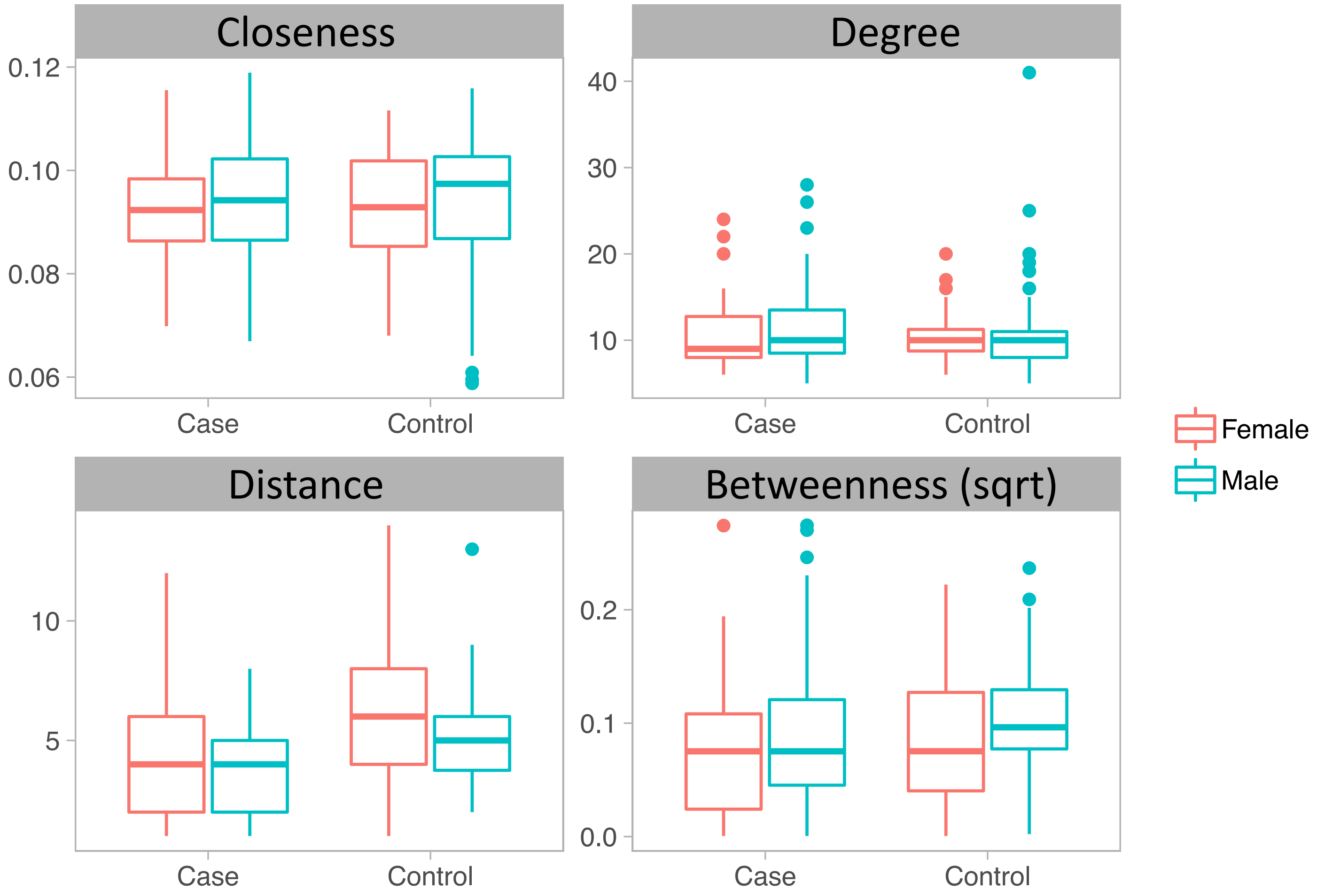
Expectations if node position increases exposure to TB



Analyzed statistics for index individuals (cases and controls)



Few differences in individual network position by sex or index type (case or control)



Two-way anovas
(sex + index type):

`closeness ~ sex, p > 0.05`

`degree ~ sex, p > 0.05`

`distance ~` **`sex + type, p < 0.05`**

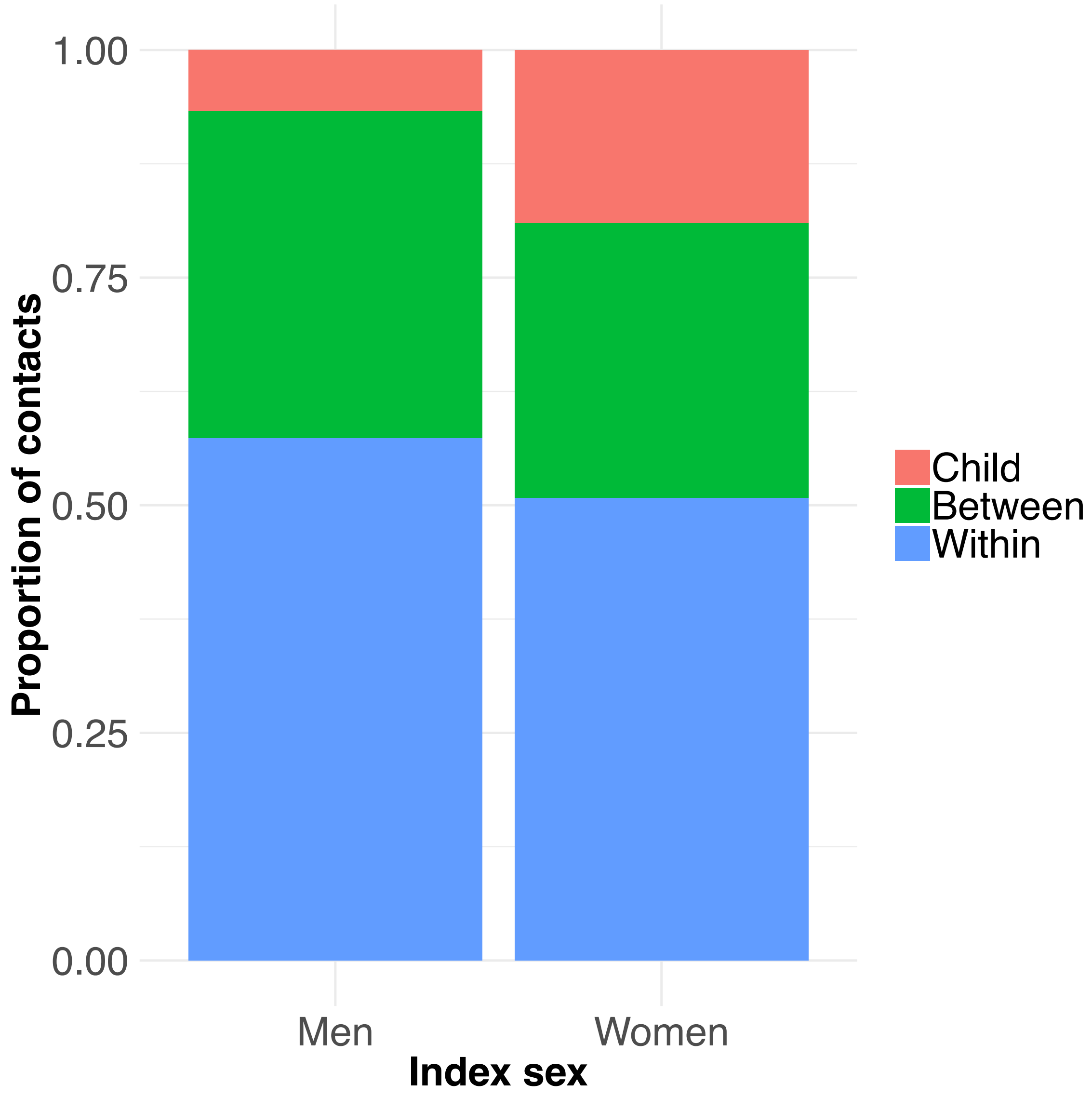
`between ~` **`sex + type, p < 0.05`**

Sex assortative mixing could increase exposure among men

Multivariate, log binomial analysis (age, HIV, contact type) of LTBI prevalence among contacts:
LTBI is more prevalent among men than among women –
PR: 1.4 (95% CI: 1.2 – 1.7)

Network assortativity coefficient:

$$\rho_{\text{sex}} = 0.25\ (\pm 0.01)$$



Kakaire (2018)

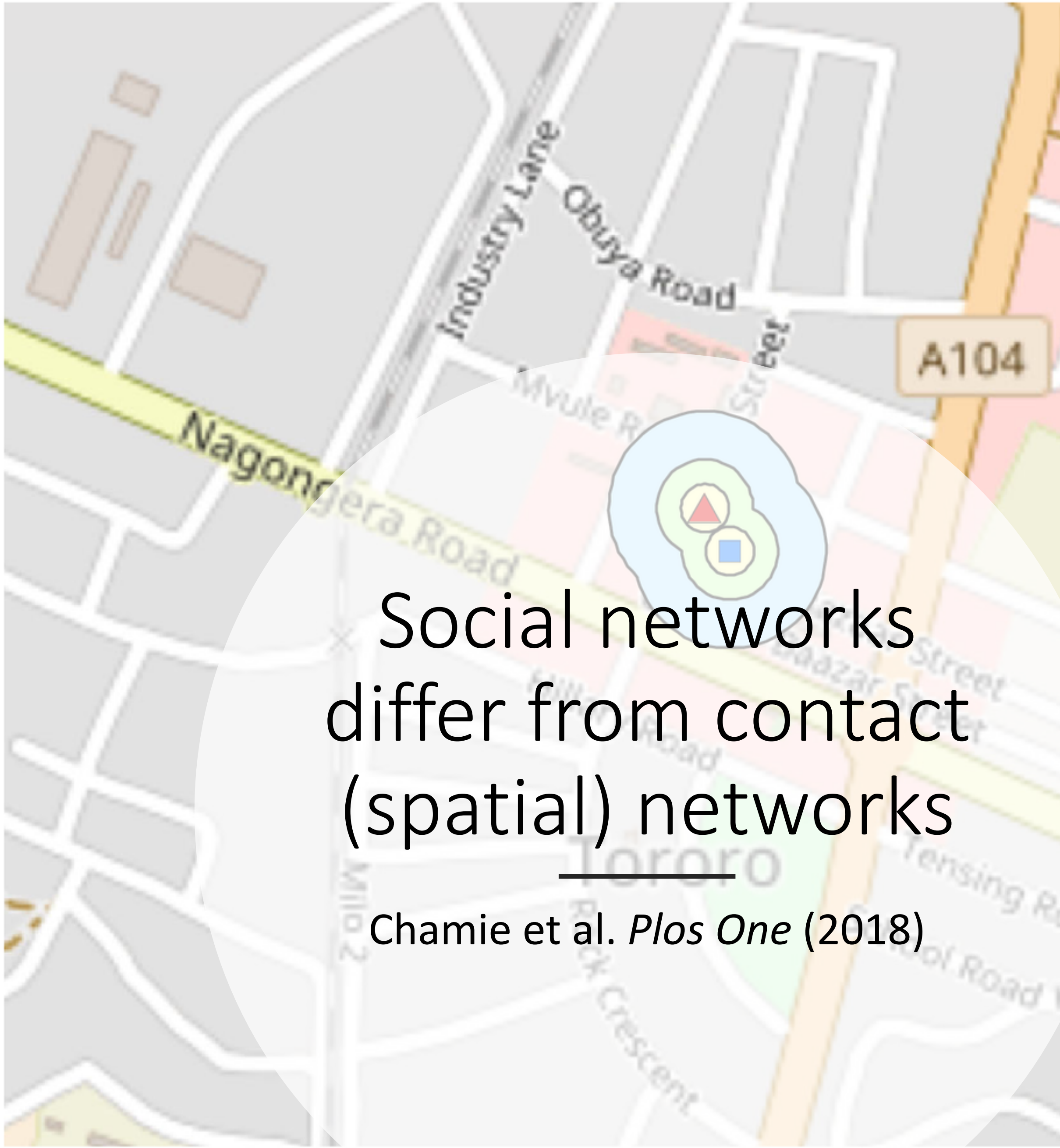
How might social networks explain male-bias in TB cases?

~~*Individual level*: Male position~~

Population level: Male assortativity

A – Cluster 1

B – Cluster 14

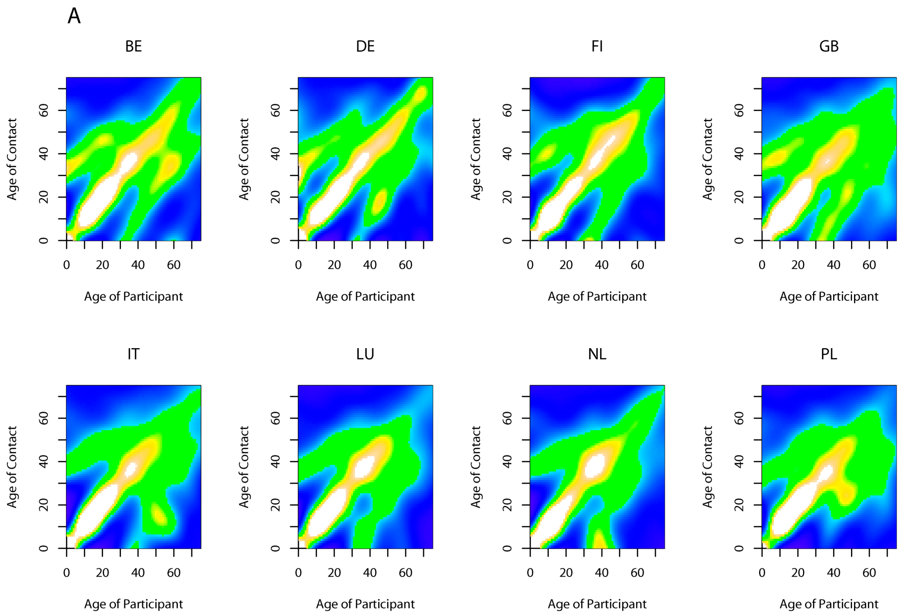


Social networks differ from contact (spatial) networks

Chamie et al. *Plos One* (2018)

What are the characteristics of epidemics on assorted networks?

- **Degree-assortative** networks are more resilient to node-removal
- **Age-assortative** contact patterns impact age-distribution of cases and optimal age-targeted interventions
- **Sex-assortative** networks … where one sex has higher susceptibility??



Newman, *Phys Rev E* (2003)
Mossong et al. *Plos Med* (2008)
de Celles et al., *Sci Transl Med* (2018)

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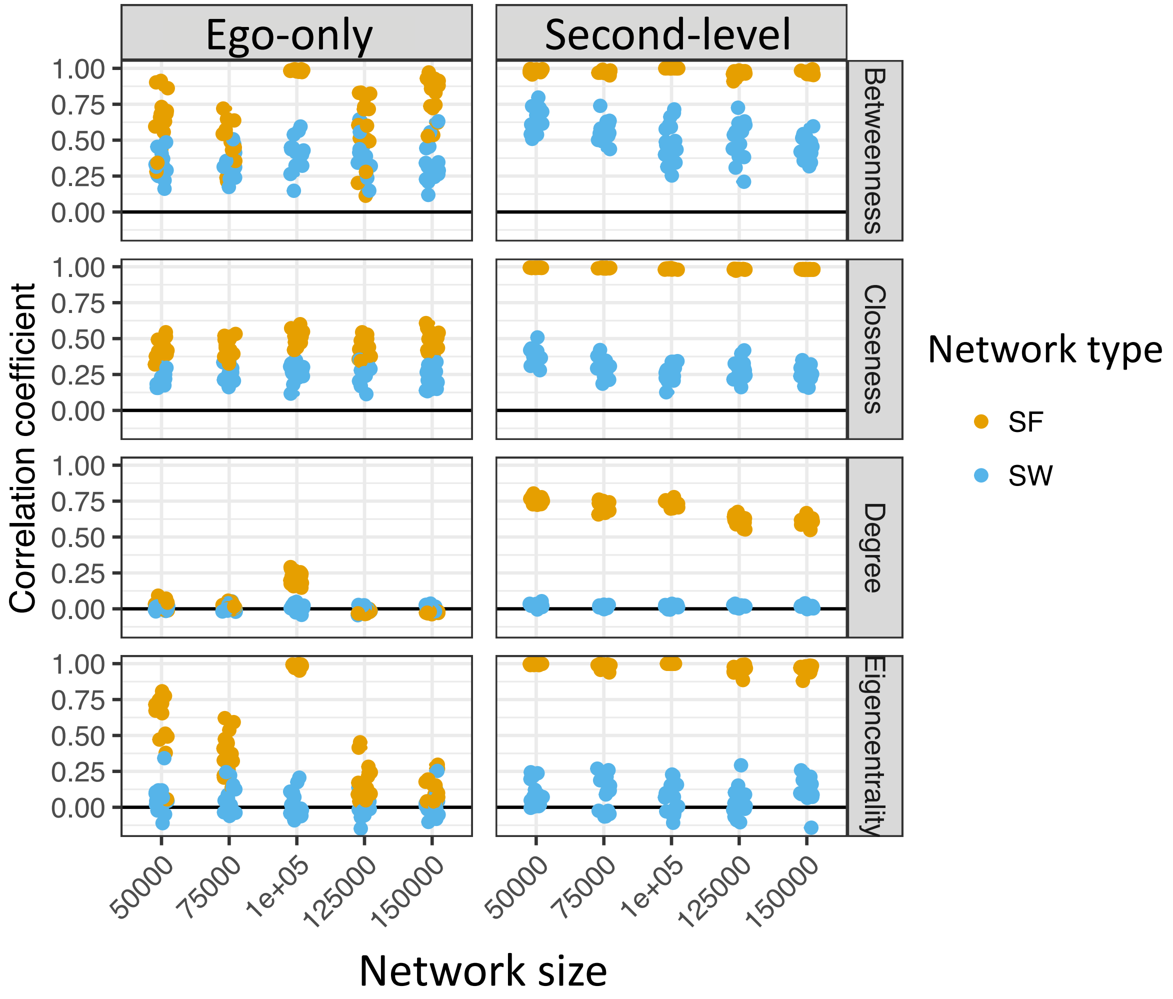
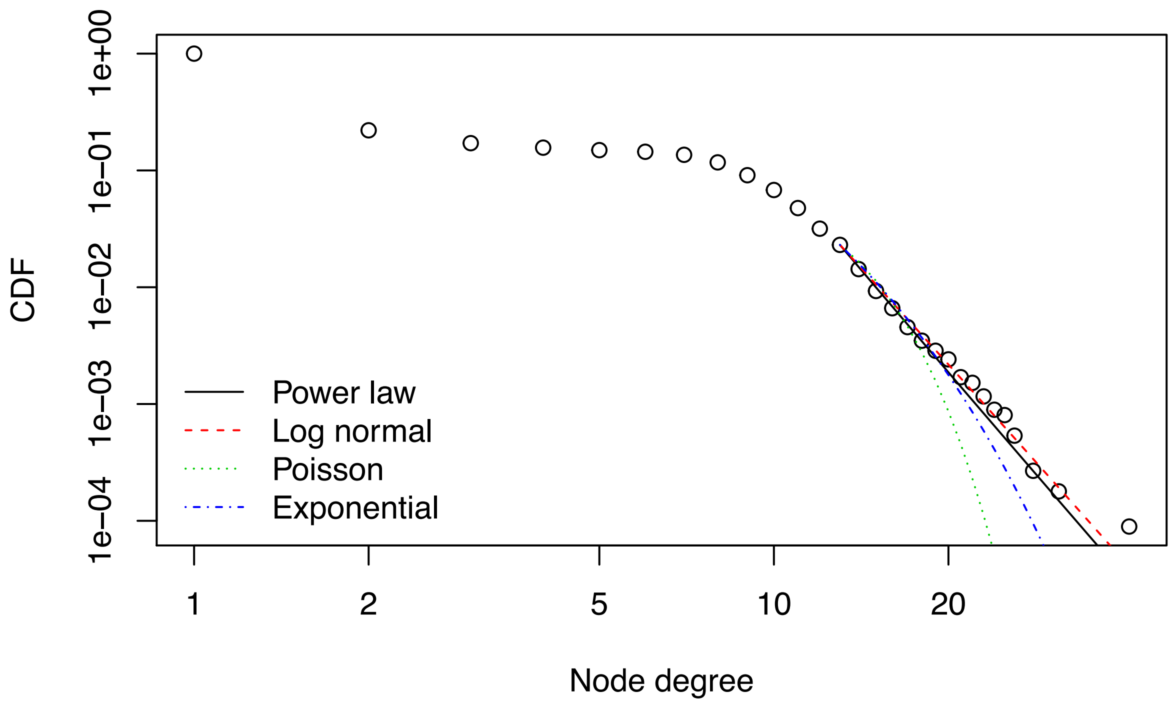
Sensitivity analyses indicate correlation of estimated statistics with underlying statistics



Kampala network's degree distribution resembles scale-free



Assortativity