Demographic network models of circumcision interventions for HIV prevention among men who have sex with men in Peru

Steven M. Goodreau, *Univ. of Washington*; **Nicole B. Carnegie**, *Harvard Univ.*; **Eric Vittinghoff**, *Univ. of California, San Francisco*; **Javier R. Lama**, *Asociación Civil Impacta Salud y Educación*; **Jorge Sanchez**, *Asociación Civil Impacta Salud y Educación*; **Jonathan D. Fuchs**, *San Francisco Dept. of Public Health*; **Susan P. Buchbinder**, *Univ. of California, San Francisco*.

1. Motivation

- Three trials [Auvert et al. 2005, Bailey et al. 2007, Gray et al. 2007] have demonstrated the prophylactic effect of male circumcision (MC) for HIV acquisition among heterosexuals, and MC interventions are underway throughout sub-Saharan Africa.

- In most of the rest of the world, men who have sex with men (MSM) remain the largest group at high risk for HIV.

- MC efforts among MSM are stymied by the existence of role versatility among MSM; i.e. the possibility for a man to be both insertive and receptive during different acts of anal sex. Thus, circumcised MSM might still acquire HIV easily through receptive sex and then subsequently transmit easily through insertive sex.

- Given this, MC for MSM (MSM-MC) should reach its maximum potential in settings where:

  1. sexual role segregation (individual preference for always being insertive or always being receptive) is historically high and perhaps relatively stable across the life course;
  2. HIV incidence among MSM is high;
  3. reported willingness for prophylactic circumcision is high;
  4. pre-existing circumcision rates are low.

- Existing models to assess the potential impact of MSM-MC [Anderson et al. 2009; Londish et al. 2010] have been in high-income settings that do not necessarily fulfill all of these criteria.

- One settings that does fulfill them all is Peru.

2. Key Question

- We aim to identify the likely public health impact that male circumcision interventions for HIV prevention among MSM would have in Peru, as a theoretical upper bound for their effectiveness among MSM generally.

3. Modeling methods

We use dynamic, stochastic network models that build upon those previously published in [Goodreau et al 2013]. The core network modeling is based in separable-temporal exponential-random graph models (*STERGM*s) [Krivitsky and Handcock 2013], as implemented in the *statnet* suite of packages [Handcock et al 2008], with additional code written for this project.

3. Modeling methods (cont.)

STERGMs:
- Allow one to simulate dynamic networks whose:
  - cross-sectional network structure retains (stochastically) an arbitrary set of structural features defined by the user
  - relational durations also follow a model set by the user
- Can be parameterized from existing egocentric network data
- Can do so in the context of vital dynamics and changing attributes

We include 2 partnership types (main, casual), each modeled with:
- Age mixing, sexual role mixing, serosorting
- Degree distributions (i.e. partnership counts):
  - main: momentary degree – i.e. the propensity to be in 0, 1, or 2 ongoing main partnerships at any time point
  - casual: cumulative degree – the tendency to have different numbers of casual contacts per time period
- Late-stage reductions in activity

Other phenomena we model:
- Testing
- Treatment (with two adherence levels)
- Viral load (influenced by time since infection, treatment status, and adherence)
- Transmission - a function of
  - viral load
  - stage of infection (acute infection is hyper-infectious beyond high viremia; see model 2 in [Goodreau et al 2013])
  - Sexual role
  - Circumcision (if the insertive partner is HIV-)

More information in [Goodreau et al. 2013].

4. Key data sources

for sexual network structure, frequency of UAI within relationships, testing frequency, etc.:

- HPTN 036
- HPTN 039 (baseline)
- Peru 2008 Sentinel Surveillance

- We conducted additional lit reviews for treatment parameters.

5. Scenarios considered

Three different enrollment criteria (E):

- men who are insertive during 100% of anal sex acts (E100)
- men who are insertive during >80% of anal sex acts (E80)
- men who are insertive during >60% of anal sex acts (E60)

Two levels of uptake (U):

- 25% of eligible men (U25)
- 50% of eligible men (U50)

Yields six base scenarios:

- E100-U25
- E100-U50
- E80-U25
- E80-U50
- E60-U25
- E60-U50

Sensitivity analyses:

- Main model uses role freqs. from Sentinel Surveillance (SS-2008); we repeat analyses with role freqs. from HPTN-039

- We consider different frequencies of switching among role categories (a metric absent from all data sources): never, on average every 3 years, on average every 5 years

6. Results

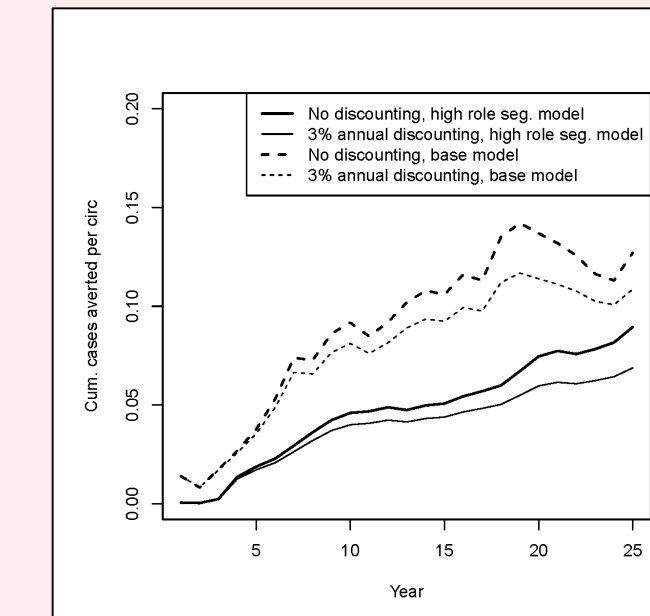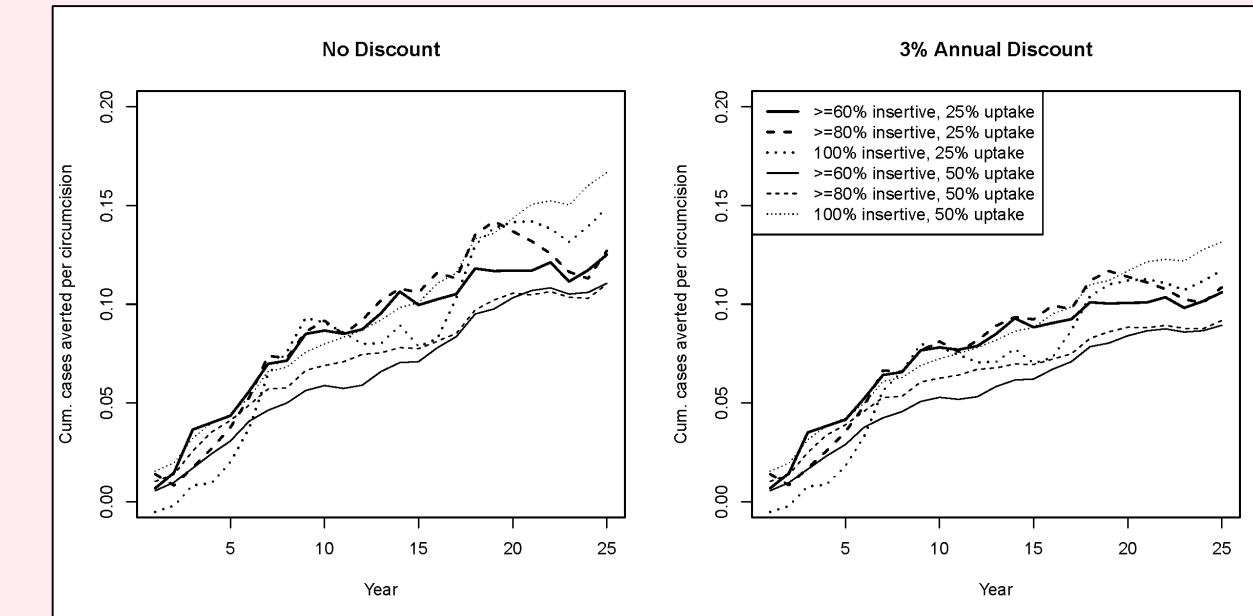% of respondents by sexual role during anal sex, last 5 years

	SS-2008	HPTN-039
Exclusively insertive	22.7%	54.0%
Versatile	50.1%	34.9%
Exclusively receptive	27.2%	11.1%

Main model (SS-2008):

Reductions in cum. incidence / Reductions in prevalence
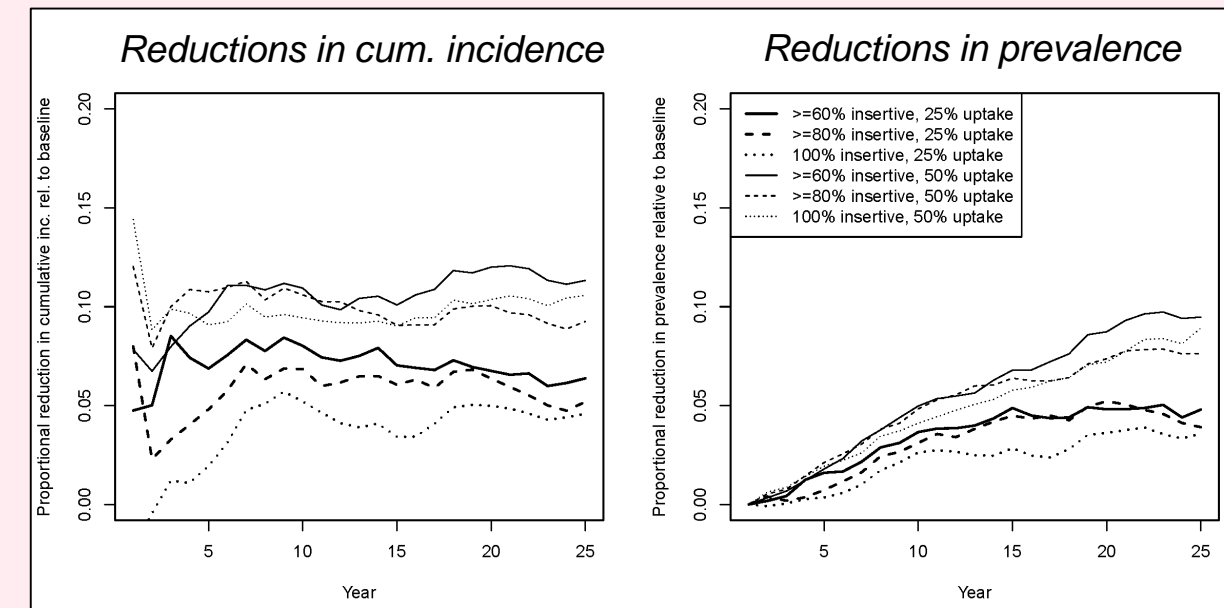
6. Results (cont.)

Cumulative cases averted per circumcision, without (L) and with (R) 3% annual discounting

Cases averted directly (in adult-circumcised men during insertive sex) vs. indirectly (through averted onward transmission); main model (SS-2008); E80-U25 scenario

Sensitivity analysis: cum. cases averted per circumcision, base model (SS-2008) vs. high role segregation model (HPTN-039), with and without discounting, E80-U25 scenario

Sensitivity analysis: cum. cases averted per circumcision under different mean rates of switching among role categories; main model (SS-2008); E80-U25 scenario
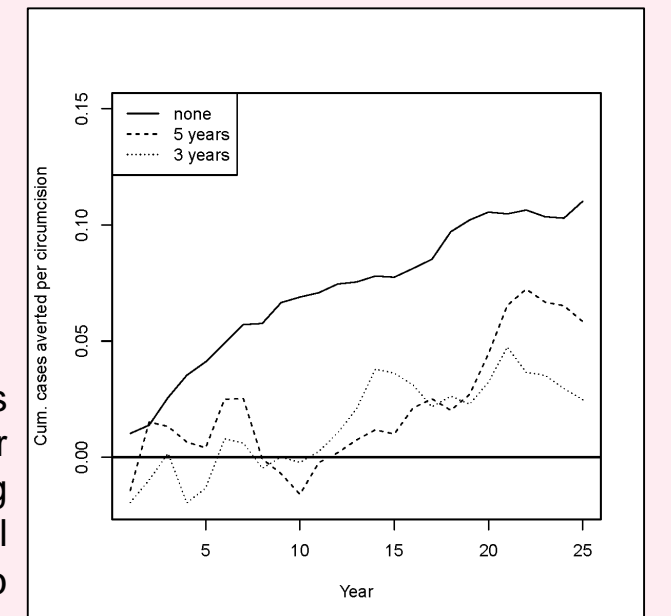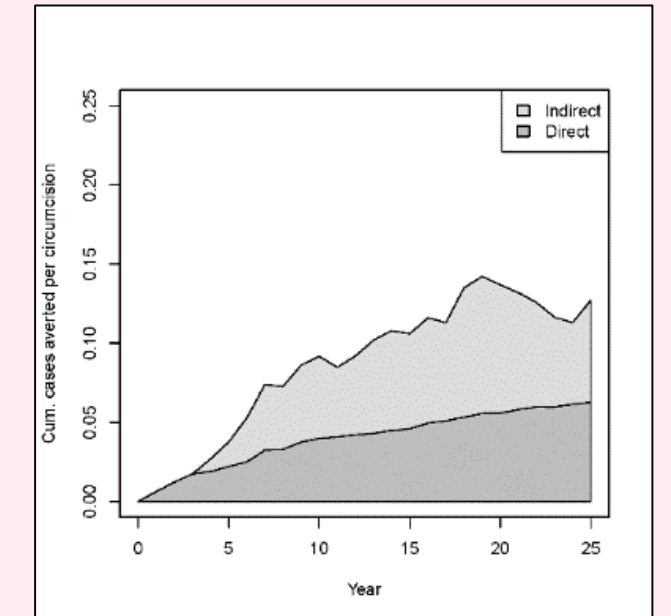
7. Conclusions

- Our models suggest a rather modest public health impact of MSM-MC, even in a setting like Peru; with coverage up to 50%, MSM-MC is unlikely to avert more than 5-10% of cases over the coming decades

- However, this *is* more efficient than in other settings previously explored; we achieved similar incidence reductions with 25-50% uptake instead of 100%

- MSM-MC's effectiveness attenuates rapidly if men switch role classes frequently (mean ~ every 3 years)

- Circumcision may, however, be a useful consideration for individual men who are exclusively insertive and who anticipate remaining so for long periods of time.

- To the extent that Peru represents an upper bound on the likely effectiveness of MSM-MC, we can surmise that such an intervention is unlikely to reduce HIV incidence among MSM by more than 10% anywhere.

8. Acknowledgments