P3.227

A comparison of microsimulation and deterministic approaches to modelling of sexually transmitted infection dynamics

Leigh Johnson[1] and Nathan Geffen[2]

1 Centre for Infectious Disease Epidemiology and Research, University of Cape Town
2 Centre for Social Science Research, University of Cape Town

Email: Leigh.Johnson@uct.ac.za

Background

- Deterministic models are widely used in simulating the potential effect of programmes for the control of HIV and other sexually transmitted infections (STIs).
- Most deterministic models are 'frequency-dependent' and do not model pair formation explicitly.
- The distinction between frequency-dependent and pair formation models is illustrated in Figure 1: frequency-dependent models allow a more rapid progression from acquiring an infection from one partner to transmitting the infection to another partner.
- The frequency-dependent approach may be inaccurate as it does not account for the low risk of onward transmission that exists while the newly-infected individual remains in contact with the partner who infected them.
- We aim to quantify this inaccuracy by comparing a frequency-dependent deterministic model to a 'gold standard' microsimulation model of pair formation.

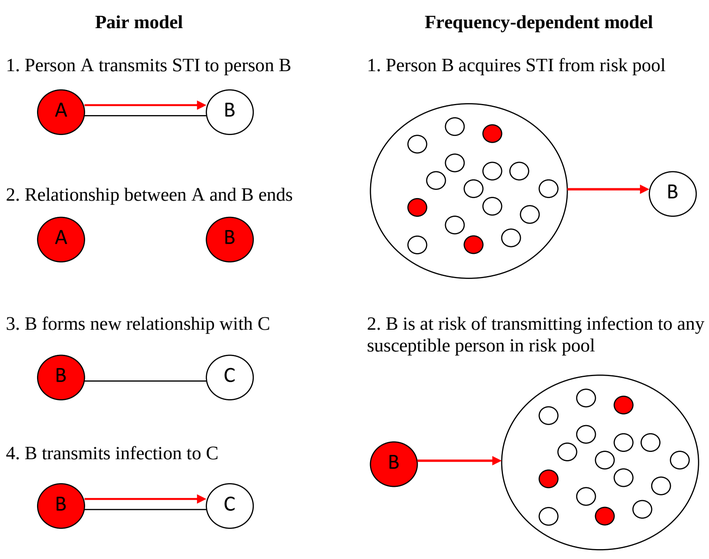

Figure 1: Approaches to modelling STI transmission

Methods

- We used a previously-developed deterministic, frequency-dependent model of the transmission of seven different STIs (HIV, genital herpes, syphilis, chancroid, gonorrhoea, chlamydia and trichomoniasis) as well as bacterial vaginosis and vaginal candidiasis, in the South African population [1].
- We created an individual-based microsimulation model to represent as closely as possible the assumptions of the deterministic model, but using a pair-formation approach instead of a frequency-dependent approach in modelling STI transmission.
- For both models, STI parameters and sexual behaviour parameters were fixed at those values that had previously been estimated for the South African setting, based on the deterministic model.
- For each STI, steady-state endemic prevalence levels were estimated using both models.
- We hypothesize that the extent of the difference between the frequency-dependent deterministic model and the microsimulation pair formation model is related to the 'early transmission fraction'.
- This early transmission fraction is defined as the fraction of transmission that occurs within the first 26 weeks of infection if it is assumed (as in the frequency-dependent model) that individuals engage in sex with uninfected partners at a constant rate that is independent of their time since infection.
- We chose 26 weeks in the definition of the early transmission fraction to correspond to the assumed average duration of non-spousal relationships.
- We test the hypothesis in two ways:
  a) By examining the correlation between the ratio of microsimulation prevalence to deterministic model prevalence and the early transmission fraction, across the seven STIs
  b) By examining the correlation between the same two quantities when randomly varying the STI transmission and natural history parameters, for each of four STIs (genital herpes, chlamydia, trichomoniasis and gonorrhoea).

[1] Johnson LF, Dorrington RE, Bradshaw D and Coetzee DJ (2011) The effect of syndromic management interventions on the prevalence of sexually transmitted infections in South Africa. *Sexual and Reproductive Healthcare.* 2:13-20.

Table: Endemic STI prevalence levels and early transmission fractions

		Endemic prevalence		Prevalence ratio, microsimulation: deterministic	Fraction of transmission in 1st 26 weeks
		Micro-simulation	Deter-ministic		
HIV	Males	18.3%	20.4%	0.897	0.138
	Females	26.9%	31.5%	0.854	0.145
	Average			0.876	0.142
Genital herpes	Males	26.8%	32.8%	0.817	0.032
	Females	45.9%	56.8%	0.808	0.035
	Average			0.813	0.033
Chlamydia	Males	4.9%	9.0%	0.544	0.282
	Females	6.0%	11.6%	0.517	0.282
	Average			0.531	0.282
Trichomoniasis	Males	3.0%	6.5%	0.462	0.726
	Females	12.4%	32.7%	0.379	0.191
	Average			0.420	0.456
Gonorrhoea	Males	0.63%	5.0%	0.126	0.898
	Females	0.83%	7.9%	0.105	0.858
	Average			0.116	0.878
Syphilis	Males	0.0%	7.6%	0.000	0.992
	Females	0.0%	8.4%	0.000	0.937
	Average			0.000	0.964
Chancroid	Males	0.0%	0.96%	0.000	0.998
	Females	0.0%	1.17%	0.000	0.976
	Average			0.000	0.982
Bacterial vaginosis	Female	35.4%	34.8%	1.017	-
Vaginal candidiasis	Female	41.0%	41.1%	0.998	-

Results

- Endemic STI prevalence levels were consistently lower in the microsimulation pair formation model than in the frequency-dependent deterministic model (Table).
- However, there was no material difference between the two models in the estimated prevalence of bacterial vaginosis and vaginal candidiasis, which suggests that the difference is entirely due to the modelling of sexual transmission.
- Using the STI parameters that had previously been estimated for the frequency-dependent model, the microsimulation model does not suggest sufficient transmission potential to sustain epidemics of syphilis or chancroid (endemic prevalence of zero).
- However, for HIV and genital herpes there was relatively little difference in the endemic prevalence levels estimated by the microsimulation and deterministic models.
- The ratio of microsimulation to deterministic model prevalence was strongly negatively associated with the fraction of transmission occurring in the first 6 months of infection (r = -0.98, Figure 2).
- Negative correlation was also seen when randomly varying the STI parameters for genital herpes (r = -0.44), chlamydia (r = -0.48), trichomoniasis (r = -0.37) and gonorrhoea (r = -0.36).

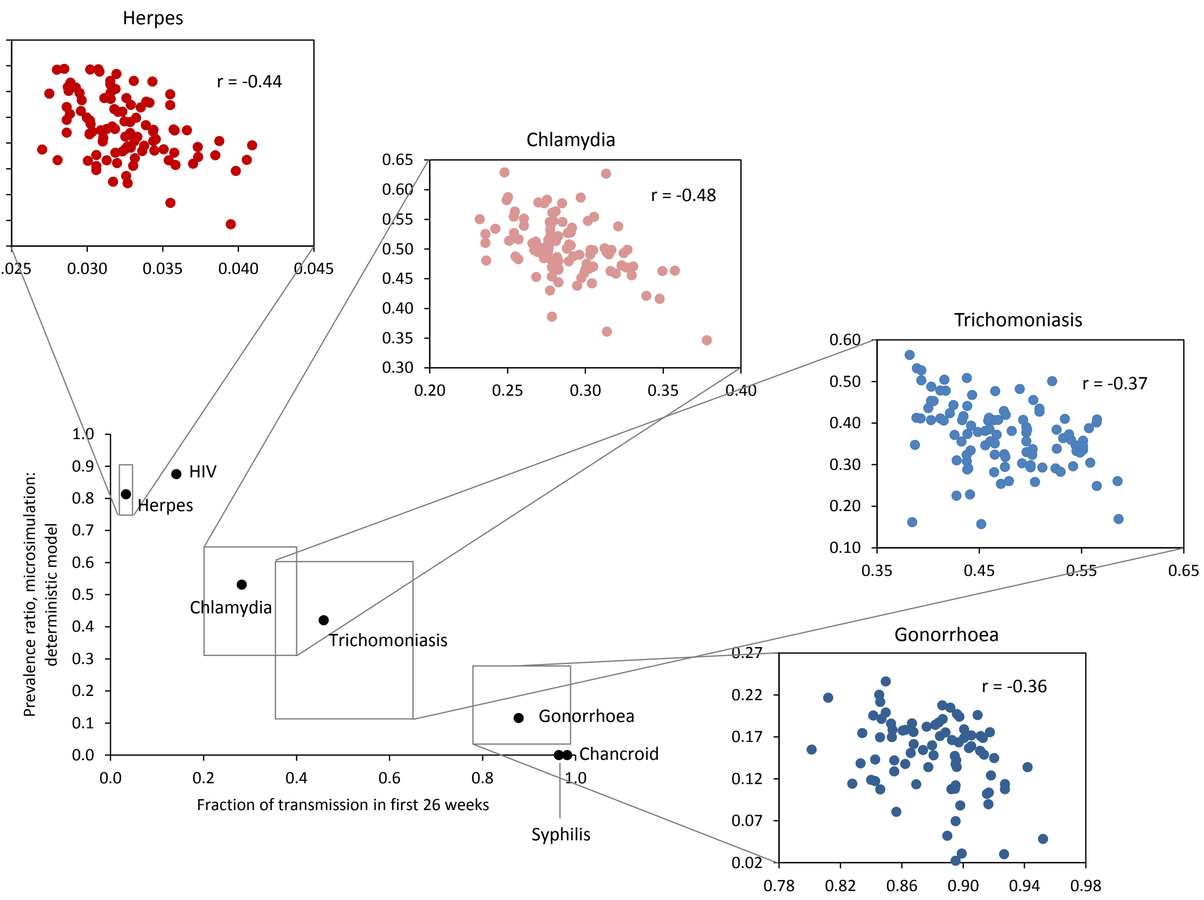

Figure 2: Correlation between ratio of microsimulation to deterministic prevalence and early transmission fraction

Conclusion

- Frequency-dependent deterministic models of STIs tend to exaggerate the levels of transmission in the early stages of infection, because they ignore the limited risk of onward transmission during the period in which individuals remain in contact with the partner who infected them.
- This bias is particularly significant for short-term, non-viral STIs.
- Further work is required to assess whether microsimulation models of pair formation predict more accurately the effects of STI prevention and treatment programmes.