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Partner-concurrency associated with herpes simplex virus 2 infection in young South Africans

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Summary

Whilst much is known about the individual-level risk factors for herpes simplex virus 2 (HSV-2) infection, little is known about why only some populations develop generalized HSV-2 epidemics. This study aims to assess the extent to which partner-concurrency (a factor which operates at both the partnership- and network-level) may be responsible. We utilized multivariate logistic regression to analyse the relationship between HSV-2 seropositivity and potential risk factors in data from a representative cross-sectional survey of 14–24 year olds from a township in South Africa conducted in 1999. The overall prevalence of HSV-2 was 53.3% amongst women and 17% amongst men. For men, four factors remained significantly associated with HSV-2 infection in the multivariate regression analysis: total number of sex acts, being a migrant labourer, Zulu ethnicity and being human immunodeficiency virus (HIV) positive. For women, eight factors were associated with HSV-2 infection: increasing age, partner-concurrency (having a partner who had other partners), an older partner, total number of sex acts, using hormonal contraception, Xhosa ethnicity, syphilis seropositivity and being HIV positive. We conclude that partner-concurrency is associated with increased HSV-2 seropositivity in women.

Keywords

HIV, AIDS, sexually transmitted infection, herpes simplex virus, HSV-2, risk factors, epidemiology, partner-concurrency, sexual network, South Africa

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Introduction

Lifetime number of sexual partners has been found to be a strong individual-level risk factor for HSV-2 infection in a wide array of studies from around the world.[1–3] In the USA, for example, HSV-2 prevalence increases monotonically from 3% in those with no lifetime partner to 10.2%, 20.7% and 46.1% in those with 1, 2–4 and more than 50 lifetime partners, respectively.[2] The number of sex partners does not, however, explain much of the large differences in HSV-2 prevalence between populations. Thus although HSV-2 prevalence increases steeply with number of partners for both blacks and whites in the USA, the rate of increase is considerably higher for blacks.[2] Similarly, there are wide variations in HSV-2 prevalence between different populations around the world.[4,5] Of the 43 countries with available data, female HSV-2 seroprevalence in the 20- to 24-year old age group is below 20% in 32 countries. In seven countries, all in sub-Saharan Africa, it exceeds 50%.[6] In this paper, a female HSV-2 seroprevalence of 50% or higher in the 20- to 24-year old

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age group is defined as a generalized HSV-2 epidemic (GHE). As HSV-2 is an important risk factor for human immunodeficiency virus (HIV) transmission, understanding what is responsible for these high HSV-2 prevalence rates is clearly an important question. So far little attention has been paid to population level risk factors for HSV-2 prevalence.[1,6] Much of the literature on HSV-2 epidemiology either disregards this issue or assumes that risk factors found to be significant at an individual level such as age, gender, ever being married and lifetime numbers of sex partners must be responsible for the differences in HSV-2 prevalence at a population level.[1,2,7] With the possible exception of Greenland,[8] there is, however, no evidence that we could find that populations with GHEs have higher rates of individual-level risk factors. For example, the countries in sub-Saharan Africa with GHEs do not have higher numbers of lifetime sexual partners than low HSV-2 countries.[9] Circumcision has recently been shown to be protective for the acquisition of HSV-2 and this may to some extent explain the lower HSV-2 prevalence rates in certain Western African countries compared to Eastern and Southern Africa.[10,11] Differential circumcision rates cannot, however, be the primary reason for differences in HSV-2 prevalence as most countries in Asia and Latin America have low circumcision and low HSV-2 prevalence rates.[5,11] Some have proposed that HIV infection interacts iteratively with HSV-2 and that both epidemics fuel each other.[1] Other authors speculate that network-level factors must be important, but they do not mention what these may be.[7]

The prevalence of concurrency has been shown to facilitate the spread of a number of sexually transmitted infections (STIs).[12,13] If concurrent partnering were to enhance HSV-2 transmission, then various theoretical considerations would imply that this should be detectable in two predominant ways.[14] Firstly, there should be a network or ecological level correlation between concurrency and HSV-2 prevalence. Secondly, at an individual level, persons whose sex partners engage in concurrency (partner-concurrency) should have a higher HSV-2 seroprevalence than persons whose partners do not.[14] For a detailed explanation as to why it is partner-concurrency (having a partner who had additional partners at the time of their relationship) rather than respondent-concurrency (the survey respondent has more than one partner at a time) that acts as a risk factor for the acquisition of STIs (see Morris et al.[15] and Mah and Halperin[16]). We note that the terminology in the field is confusing; we use the terms partner and respondent-concurrency as defined above and as used by others such as Aral.[17] A recent publication has confirmed the existence of a strong association between the point prevalence of concurrency and HSV-2 prevalence at a cross-country level.[6] The second prediction has, to the best of our knowledge, not been tested before. In this study, we evaluate whether the partner-concurrency is associated with HSV-2 seropositivity in a population of young South Africans.

Methods

The Carltonville district is situated in the gold mining region of South Africa and has a population of 70,000, many of whom are migrant workers who live in single-sex hostel complexes. The Carltonville Youth Survey consisted of a random sample of 723 men and 784 women between the ages of 14 and 24 who were recruited in 2000. Households were selected via a two-stage random sampling technique. The sampling scheme was arranged so as to be self-weighting. The occupants of 89% of the selected houses were located and 11.3% of potential participants declined to participate. Study participants were interviewed about background characteristics and sexual behaviour, including characteristics of their sexual partners. These interviews were all conducted by trained interviewers and in private – outside the respondents' houses. Following the interview, urine and blood specimens were collected and tested for HIV and other STIs including HSV-2, syphilis, gonorrhoea and chlamydial infection. HSV-2 type specific immunoglobulin G antibodies were detected via a quantitative focus enzyme-linked immunoassay (MRL Diagnostics, Los Angeles, CA). The sensitivity and specificity of this test claimed by the manufacturer are 96.1% and 97.0%, respectively. For a more detailed description of the survey methodology see Auvert et al.[18] Respondents provided informed written consent to participate in the survey. Ethical approval for the study, including the consent process, was obtained from the Research on Human Subjects committee of the University of the Witswatersrand (Protocol number M 970235).

Statistical methods

The analysis was restricted to the 1182 individuals who reported ever having had penetrative vaginal intercourse. The risk factors investigated for HSV-2 infection are detailed in Table 1. Partner-concurrency was defined as having had at least one partner who had an additional sexual partner whilst in a sexual relationship with the respondent. The Joint United Nations Programme on HIV/AIDS consensus statement on the measurement of concurrency advised that both the point- and cumulative-prevalence rates of concurrency could be used to

monitor concurrency in populations.[19] We chose the cumulative prevalence of partner-concurrency as our measure of concurrency as HSV-2 seropositivity represents the cumulative probability of infection during each of the respondents' previous relationships. Using point prevalence of concurrency would miss the effect of any previous partner-concurrency on prevalent HSV-2 serostatus. Means and proportions were calculated with 95% confidence intervals (CIs). Medians and interquartile range (IQR) were calculated for non-normally distributed variables.

The statistical significance of the association between HSV-2 infection and potential risk factors was assessed via 95% CI of the odds ratio (OR) and chi-squared tests. Continuous variables were categorized. Risk factors that were associated with HSV-2 infection in univariate analysis at a significance level of p value of 0.1 or less were entered into a backward stepwise selection multiple logistic regression model using Wald statistics. Robust standard errors were utilized to account for the clustering of participants. The analysis was performed using STATA 10 software (Stata, East College Station, TX).

Results

Background characteristics

The median age for women was 19 years (IQR, 16–21) and for men 18 years (IQR, 16–21). There were slightly more women than men (784 and 723, respectively). Most of the respondents were either students (59.6%) or unemployed (31.4%). Other background characteristics are shown in Table 1.

Sexual behaviour

Of all, 79.4% of the women and 77.6% of the men reported having had sex (Table 1). The median age at first sexual intercourse was 17.2 years for women (IQR, 16.0–18.5 years) and 16.6 years for men (IQR, 15.2–18.2 years). The median number of lifetime sexual partners for women and men was 2 and 3, respectively. Of all, 34.4% of women and 55.4% of men had had three or more sexual partners in their lifetimes. Of those with at least one current sexual partnership, 13.7% of women and 28.3% of men had more than one current sexual partner. Of all, 63% of both women and men claimed that at least one of their previous partners had had an additional sexual partner at the same time as their relationship. Of all, 12% of women and 16% of men stated that they always used condoms with each of their previous five casual partners. Of all, 11% of men were circumcised and 54% of the women were using hormonal contraception.

Prevalence of HSV-2 and HIV

The overall prevalence of HSV-2 was 53.3% amongst women and 17% amongst men. For HIV, the prevalence was 34.4% and 9.4%, amongst women and men, respectively. Positive syphilis serology suggestive of active syphilis was found in 1.8% of men and 4.5% of women. In men, the prevalence of gonorrhoea and chlamydial infection was 2.8% and 4.8%; the corresponding figures in women were 10.9% and 14.6%, respectively.

Risk factors for HSV-2 in sexually active individuals: univariate analysis

The prevalence of HSV-2 increased rapidly with age, and especially so in women. HSV-2 seropositivity rose from 18.6% (95% CI, 11.4–25.8) amongst women aged 14–15 years to 94.3% (95% CI, 87.6–100) amongst women aged 24 years. As shown in Table 1, HSV-2 was more common in both genders amongst those who were married, had children, drank alcohol in the last month, were not in secondary school and were migrant workers. In addition, women but not men who lived in squatter settlements had a higher prevalence of HSV-2.

HSV-2 prevalence increased with both the number of sexual partners and the number of sex acts. This relationship was more pronounced in women. Compared to women who had one lifetime partner, the ORs for women who had two partners was 3.7 (95% CI, 2.4–5.8) and 8.9 (95% CI, 5.7–14.0) for those who had three or more partners. The OR of women and men who had more than 50 sex acts in their lives compared to those who had 10 or less was 13.4 (95% CI, 7.1–25.0) and 6.5 (95% CI, 3.7–11.5), respectively. Women, but not men with more than one current partner had a higher prevalence of HSV-2. If at least one partner had engaged in a concurrent relationship, then the OR for HSV-2 seropositivity was 1.7 (95% CI, 1.1–2.6) for men and 2.9 (2.0–4.0) for women. Having had a partner five or more years older was associated with an increased risk of HSV-2 infection for women only. Consistent condom use was associated with a decreased risk of HSV-2 in women only.

HSV-2 infection was strongly associated with HIV infection with ORs of 11.6 (95% CI 6.5–20.5) and 14.8 (95% CI 9.0–24.5) for men and women, respectively. Syphilis was also significantly associated with HSV-2 in both men and women, but the association with gonorrhoea and with chlamydial infection was statistically significant in women only.

Multivariate analysis

For men, four factors remained significantly associated with HSV-2 infection in the multivariate analysis: total number of sex acts in life more than 50, being a migrant

Table 1. HSV-2 serological status, characteristics of men and women and odds ratios.

	Sexually active men					Sexually active women				
	n (%)	HSV-2 (%)	OR	95% CI	P	n (%)	HSV-2 (%)	OR	95% CI	p
Background characteristics										
Age					<0.0001					<0.0001
14–16 years	99 (17.7)	9.2	1	–		86 (13.8)	33.3	1		
17–18 years	143 (25.5)	8.4	0.9	0.3–2.2		123 (19.8)	45.1	1.6	0.9–2.9	
19–21 years	178 (31.8)	17.7	2.1	1–4.7		226 (36.3)	67.3	4.1	2.4–7	
22–24 years	140 (25)	42.5	7.2	3.4–15.5		187 (30.1)	88.6	15.5	8.2–29.5	
Marital status					0.001					<0.0001
Married or living as married	31 (5.5)	45.2	1			108 (17.4)	92.4	1		
Never married	529 (94.5)	18.5	0.2	0.1–0.6		513 (82.6)	58.8	0.1	0.05–0.2	
Children					<0.0001					<0.0001
Yes	64 (11.4)	56.2	7.1	4.1–12.4		248 (39.9)	82.3	4.1	22.8–6.1	
No	496 (88.6)	15.2	1			374 (60.1)	52.8	1		
Alcohol at least once per month										
Yes	235 (42.0)	26.5	2.0	1.3–3.0	0.001	100 (16.1)	80.4	2.5	1.5–4.3	0.001
No	324 (58.0)	15.2	1			521 (83.9)	61.7	1		
Currently in secondary school					0.0001					0.0001
Yes	289 (51.6)	9.0	1			241 (39.1)	49.1	1		
No	324 (58.0)	31.7	4.6	2.9–7.5		375 (60.9)	75.5	3.1	2.2–4.5	
Living in squatter settlement					0.314					<0.0001
Yes	156 (27.9)	22.7	1.26	0.8–2		251 (40.4)	77.8	2.8	1.9–4	
No	404 (72.1)	18.9	1			371 (59.7)	55.6	1		
Born in Carltonville										
Yes	322 (57.5)	16.9	0.6	0.4–1	0.04	273 (43.9)	57.6	0.6	0.4–0.8	0.002
No	238 (42.5)	24.0				348 (56)	70.0			
Migrant worker										
Yes	47 (8.4)	46.8	4.1	2.2–7.7	<0.001	45 (7.2)	82.2	2.7	1.2–5.9	0.013
No	509 (91.6)	17.5	1			568 (92.8)	63.2	1		
Education completed					0.06					0.3
None	23 (4)	30.4	1	–		25 (4)	80.0	1		
Primary	131 (23)	25.4	0.8	0.3–2		153 (25)	66.0	0.5	0.2–1.4	
Secondary	378 (68)	16.8	0.5	0.2–1.2		409 (66)	63.6	0.4	0.2–1.2	
Post secondary	28 (5)	28.6	0.9	0.3–3.1		35 (6)	58.8	0.4	0.1–1.2	
Ethnic group					0.001					0.012
Tswana	234 (42.0)	14.5	1			221 (35.9)	57.0	1		
Zulu	47 (8.4)	32.0	2.7	1.4–5.6	0.005	42 (6.8)	71.4	1.9	0.9–3.9	0.085
Xhosa	158 (28.6)	21.5	1.6	1.0–2.7	0.075	193 (31.7)	71.0	1.8	1.2–2.8	0.003
Sotho	87 (15.7)	17.2	1.2	0.6–2.4	0.549	118 (19.5)	61.9	1.2	0.8–1.9	0.388
Other	29 (5.2)	44.8	4.8	2.1–10.8	<0.001	39 (6.3)	76.9	2.5	1.1–5.5	0.022
Sexual behaviour										
Lifetime partners					<0.0001					<0.0001
One	129 (23.1)	13.4	1			211 (34.1)	38.0	1		
Two	120 (21.5)	13.3	1.0	0.5–2.1		164 (26.5)	69.5	3.7	2.4–5.8	
Three or more	309 (55.4)	25.4	2.9	1.2–3.9		244 (34.4)	84.5	8.9	5.7–14.0	
Number of current relationships					0.46					0.0003
None	148 (26.6)	17.1	1			149 (24.7)	56.1	1		
One	288 (51.9)	22.0	1.4	0.8–2.3		383 (63.7)	64.5	1.4	1.0–2.1	
Two or more	119 (21.4)	19.3	1.2	0.6–2.2		69 (11.5)	83.6	4.0	1.9–8.2	

(continued)

Table 1. Continued.

	Sexually active men					Sexually active women				
	n (%)	HSV-2 (%)	OR	95% CI	P	n (%)	HSV-2 (%)	OR	95% CI	p
At least one partner had an additional sex partner whilst in sexual relationship with respondent					0.02					<0.0001
No	207 (37)	15.0	1			228 (36.7)	49.3	1		
Yes	353 (63)	22.8	1.7	1.1–2.6		394 (63.3)	73.6	2.9	2.0–4.0	
At least one partner was 5 or more years older					0.34					<0.0001
No	551 (98.4)	19.7	1			401 (64.5)	55.0	1		
Yes	9 (1.6)	33.3	2.0	0.5–8.3		221 (35.5)	82.0	3.7	2.5–5.6	
Total sex acts					<0.0001					<0.0001
<11	293 (52.3)	11.0	1			236 (37.9)	41.5	1		
11–50	185 (33.0)	23.4	2.5	1.5–4.1		250 (40.2)	72.4	3.7	2.5–5.4	
>50	82 (14.6)	44.4	6.5	3.7–11.5		136 (21.9)	90.4	13.4	7.1–25.0	
At least one casual partnership with 20 or more sex acts					<0.0001					<0.0001
No	398 (71.1)	13.2	1			317 (51.0)	48.4	1		
Yes	162 (28.9)	36.6	3.8	2.5–5.9		305 (49.0)	81.4	4.7	3.2–6.7	
Ever had sex against their will					0.11					0.34
Yes	20 (3.6)	19.4	1			98 (15.8)	63.8	1		
No	539 (96.4)	35.0	2.2	0.9–5.7		522 (84.2)	68.8	1.25	0.8–2.0	
Condom use at first sex					0.12					<0.0001
No	449 (80.6)	21.1				469 (75.4)	70.4			
Yes	108 (19.4)	14.8	0.6	0.4–1.2		152 (24.6)	46.7	0.4	0.3–0.5	
Condom used always with last 5 casual partners					0.16					<0.0001
No	467 (84.0)	21.1	1			536 (87.9)	67.9	1		
Yes	89 (16.0)	14.8	0.6	0.3–1.2		74 (12.1)	37.5	0.3	0.2–0.5	
Ever given money for sex					0.02	NA				
No	517 (97.6)	18.9	1							
Yes	13 (2.5)	46.1	3.7	1.2–11.2						
Sex with a mineworker	NA									0.017
No						581 (94.9)	63.2			
Yes						31 (5.0)	83.3	2.9	1.1–7.7	
Hormonal contraception	NA									0.049
No						285 (45.8)	60.4	1		
Yes						337 (54.2)	68.1	1.4	1–1.94	
Circumcised (Male)					0.001	NA				
Yes	61 (10.9)	36.0	1							
No	498 (89.1)	17.8	0.4	0.2–0.7						
Age at first sex					0.61					0.69
≤15 years	158 (28.2)	18.6	1			74 (11.9)	66.7	1		
>15 years	402 (71.8)	20.5	1.1	0.7–1.8		547 (88.0)	64.3	0.9	0.5–1.5	
STIs and symptoms thereof										
HIV					<0.0001					<0.0001
Negative	494 (88.2)	13.9				363 (58.4)	44.5			
Positive	66 (11.79)	65.2	11.6	6.5–20.5		259 (41.6)	92.3	14.8	9.0–24.5	
Syphilis (RPR and FTA)					0.005					0.0003
Negative	550 (98.2)	19.2	1			594 (95.5)	63.2	1		
Positive	10 (1.8)	60.0	6.3	1.7–22.7		28 (4.5)	92.9	7.6	1.7–32.1	
Chlamydia trachomatis					0.21					0.03
Negative	533 (95.2)	19.5	1			531 (85.4)	62.9	1		
Positive	27 (4.8)	29.6	1.7	0.7–4.0		91 (14.6)	74.4	1.7	1.0–2.8	

(continued)

Table 1. Continued.

	Sexually active men					Sexually active women				
	n (%)	HSV-2 (%)	OR	95% CI	P	n (%)	HSV-2 (%)	OR	95% CI	p
Neisseria gonorrhoeae					0.27					0.008
Negative	544 (97.1)	19.6	1			554 (89.0)	62.9	1		
Positive	16 (2.8)	31.3	1.9	0.6–5.5		68 (10.9)	78.8	2.2	1.2–4.1	
Discharge (vaginal or urethral) in last year					<0.0001					<0.0001
No	457 (82.1)	15.9	1			421 (68.1)	59.2	1		
Yes	100 (17.9)	38.4	3.3	2.0–5.3		197 (31.9)	76.0	2.1	1.5–3.2	
Genital sores in last year					0.0003					0.002
No	489 (88.4)	17.3	1			550 (89.0)	62.8	1		
Yes	64 (11.6)	38.1	2.9	1.7–5.2		68 (11)	80.6	2.5	1.3–4.6	

NA: not applicable; HSV: herpes simplex virus; OR: odds ratio; CI: confidence interval; STI: sexually transmitted infection; RPR: rapid plasma reagin; FTA: fluorescent treponemal antibody.

labourer, Zulu ethnicity and being HIV positive. For women, eight factors were associated with HSV-2: age over 21 years, partner-concurrency, an older partner, total number of sex acts, using hormonal contraception, being married, syphilis infection and being HIV positive. HIV positivity was the risk factor that exhibited the strongest association with HSV-2 infection (Table 2).

In order to further investigate the high prevalence of HSV-2 infection in women who reported only one lifetime sex partner, we ran an additional logistic regression model limited to the group of women with only one lifetime sexual partner. The only variables which were positively associated with HSV-2 infection in multivariate analysis were partner-concurrency (OR 2.4, CI 1.1–5.2), consistent condom use (OR 0.3, CI 0.1–0.7) and HIV infection (OR 19.4, CI 6.3–59.5).

Discussion

There is strong evidence that HSV-2 infection results in an approximately two-fold increased risk of HIV acquisition in individuals[20,21] and that HSV-2 is a major driver of HIV in generalized HIV epidemics.[1,20] This begs the question what causes high prevalence rates of HSV-2 infection in certain populations. Some authors have argued that the high HSV-2 prevalence rates are due to the way the HIV and HSV-2 epidemics "fuelled each other."[1]

The evidence that HIV enhances HSV-2 spread is limited.[22] The historical evidence certainly does not support the idea that HIV leads to an increase in HSV-2 prevalence. This is clear if we consider the two cases where HSV-2 prevalence has been accurately tracked in populations that experience HIV epidemics. Firstly, a study in Northern Malawi tracked population HSV-2 prevalence from 1988 to 2005 – a time when adult HIV prevalence increased from 4 to 12%.[23] During this time the age adjusted HSV-2 prevalence did not increase. Secondly, HSV-2 prevalence has been closely followed in the USA since 1976 via the National Health and Nutrition Examination Surveys. Although HIV prevalence was extremely low at the time of the first survey, HSV-2 was high amongst the black population.[2] Although HIV has disproportionately affected the black population in the USA (adult HIV prevalence reaching 3% in Washington, DC),[24] this has not translated into any noticeable increase in HSV-2 (HSV-2 prevalence for black women 51% in 1976–1980 and 48% in 2005–2008).[2,25] These historical data provide a rebuttal to the argument that high HSV-2 prevalence rates are primarily due to HIV.

The Carltonville Youth Survey allowed us to explore, at an individual level, partner-concurrency as a risk factor for HSV-2 infection. We found partner-concurrency to be weakly associated with an increased risk of HSV-2 acquisition. Although the size of the ORs was similar in women (1.7) and men (1.5), the relationship was only statistically significant in the women. The risk factor analysis in women who reported only one lifetime sex partner provides further evidence that increased sexual network connectivity mediates at least a part of the high risk of HSV-2 transmission in this population.

A further factor that was associated with HSV-2 acquisition for women only was having had a partner who was five or more years older. If one considers the low HSV-2 prevalence of the young men in this cohort, and the low number of lifetime partners that these women have had, then it is not surprising that sexual partnerships with older men (who have higher HSV-2 prevalence rates) are an important risk factor for HSV-2 transmission. Since 35% of women had a partner five or more years older, this could constitute an important focus for STI prevention efforts.

This study supports the findings from other studies which found an association between hormonal contraception use and HSV-2 seropositivity.[26,27] Whilst this

Table 2. Multivariate logistic regression analysis of risk factors for HSV-2 seropositivity.

	Sexually active men			Sexually active women		
	OR	95% CI	*p* value	OR	95% CI	*p* value
Age						
14–16 years	1			1		
17–18 years	0.8	0.3–2.0	0.603	1.1	0.5–2.4	0.738
19–21 years	1.2	0.5–2.9	0.679	1.7	0.9–3.2	0.122
22–24 years	2.4	1.0–6.1	0.060	2.8	1.2–6.3	0.012
Highest level of schooling completed						
None	1			1		
Primary	1.4	0.5–4.4	0.551	1.0	0.3–3.4	0.982
Secondary	0.9	0.3–2.6	0.784	0.9	0.3–3.0	0.885
Post secondary	0.8	0.2–3.3	0.363	0.6	0.1–2.6	0.464
Living in squatter settlement						
No	NE			1		
Yes				1.5	0.9–2.5	0.139
Migrant worker						
No	1					
Yes	2.5	1.1–5.4	0.025	NE		
Lifetime partners						
One	1			1		
Two	0.7	0.3–1.5	0.363	1.4	0.8–2.4	0.270
Three or more	0.9	0.4–1.8	0.687	1.5	0.8–2.8	0.255
At least one partner had an additional sex partner whilst in sexual relationship with respondent						
No	1			1		
Yes	1.5	0.9–2.6	0.120	1.7	1.0–2.7	0.035
At least one partner was 5 or more years older						
No	NE			1		
Yes				2.0	1.2–3.3	0.011
Total sex acts						
<11	1			1		
11–50	1.2	0.6–2.3	0.530	2.1	1.3–3.4	0.004
>50	2.7	1.2–6.0	0.012	3.5	1.5–8.4	0.004
Condom used always with last 5 casual partners						
No	1			1		
Yes	1.1	0.5–2.4	0.731	0.8	0.4–1.4	0.392
Married						
No	NE			1		
Yes				3.0	1.1–7.9	0.026
Hormonal contraception	NA					
No				1		
Yes				1.7	1.1–2.6	0.028
Circumcised (male)						
No	1			NA		
Yes	1.7	0.8–3.4	0.177			
HIV						
Negative	1			1		
Positive	7.0	3.5–14.2	0.000	8.1	4.6–14.4	0.000

(continued)

Table 2. Continued.

	Sexually active men			Sexually active women		
	OR	95% CI	*p* value	OR	95% CI	*p* value
Syphilis (RPR and FTA)						
Negative				1		
Positive				4.4	1.1–18.7	0.042
Ethnic group						
Tswana	1			NE		
Zulu	2.8	1.1–7.0	0.033			
Xhosa	1.3	0.6–2.8	0.520			
Sotho	1.1	0.5–2.3	0.865			
Other	2.6	0.9–7.8	0.086			
N	548			599		

NA: not applicable; NE: not entered by the stepwise procedure; HSV: herpes simplex virus; OR: odds ratio; CI: confidence interval; RPR: rapid plasma reagin; FTA: fluorescent treponemal antibody.

association could be due to residual confounding by sexual behaviour, the emerging evidence of an association between HIV and hormonal contraception suggests that this issue merits further investigation.[28]

There are a number of strengths and limitations with our analysis. The Carletonville Youth Survey involved a large representative sample of young persons. It had a low refusal rate and the quality of reported sexual behaviour was reasonable as assessed by a follow-up validation study. This study revealed that 11 (20.4%) of 54 individuals who indicated in the survey that they had never had sex, had in fact had sex at the time of the survey. In a similar vein, of the 319 individuals who reported never having had sex, 26 (8.2%) and 13 (4.0%) were HSV-2 and HIV positive, respectively. It is important to recognize that respondents' reports of their partners having engaged in partner-concurrency may be inaccurate. In one study where this was assessed, individuals tended to underestimate the extent of partner-concurrency.[29] The prevalence of partner-concurrency found our study was, however, commensurate with that found from a survey of a similar age group from elsewhere in South Africa.[30] The data are cross-sectional and thus it is not possible to ascertain direction of causality in any of the associations found. This is especially the case for the association between HSV-2 infection and HIV infection. The STI variables (HIV and syphilis) could be mediating variables and we thus ran the models with and without these variables. Because removing the STI variables did not considerably alter the results we only show the inclusive models. There a number of other population-level determinants of STI spread which we have not assessed. These include the temporal ordering of sexual partnering, the rates of partnership formation and dissolution and other determinants of sexual network structure.[17]

As noted above, a previous study has shown an ecological correlation between concurrency and HSV-2 prevalence rates.[6] The study presented here reveals that partner-concurrency is associated with an increased prevalence of HSV-2. Taken together, these findings offer a plausible explanation that could explain a part of the wide variations in HSV-2 prevalence in different populations. These results do, however, need to be confirmed in longitudinal studies that serially measure sexual behaviour and HSV-2 serology (and biological risk factors for HSV-2 infection) of respondents and their partners. Ideally, these studies should start soon after sexual debut and include subpopulations with low and high HSV-2 prevalence rates to be able to adequately tease out the relative contributions that individual, partner-level and network-level factors make in generating high HSV-2 prevalence rates.

Authors' contribution

CK, RC, AB and NH contributed to the conceptualization of the study. CK and NH performed the data analyses. CK wrote the first draft and all authors read and contributed to the final draft of the paper.

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Conflict of interest

The authors declare no conflict of interest.

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