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Concurrent sexual partnerships and sexually transmitted diseases among African men in Cape Town, South Africa

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Abstract

Background: Most studies that assess the relationship between concurrent sexual partnerships and sexually transmitted diseases (STDs) use dichotomous measures of whether concurrency was reported or not. However, different forms of concurrency have different degrees of associated risk for disease transmission, and this should be considered. This paper examines variation in both partner concurrency and individual concurrency among African men in Cape Town, South Africa, and assesses the relationship between different types of concurrent partnerships and STDs.

Methods: Longitudinal data from sexual partner history tables were used to form measures of concurrency, and the type of partner (main vs. non-main) and degree of condom use (consistent vs. inconsistent) associated with these concurrent relationships. Cross-sectional data from a self-administered module were also employed to assess the number of partners men had had concurrently and duration of individual concurrency. The association between the concurrency measures and self-reported STD status was assessed using probit regression models.

Results: Substantial differences between concurrent sexual partnerships were observed and these variations were associated with different disease risk. Men had a significantly greater chance of having an STD when partner concurrency was associated with main partners and inconsistent condom-use, and when individual concurrency involved a greater number of partners concurrently and long-term partnerships.

Conclusion: Partnership dynamics must be taken into account in studies assessing the role of concurrency in STD transmission and in STD prevention programs. Reducing concurrency (either in terms of number of partners or duration) and/or encouraging consistent condom use in concurrent partnerships would help reduce STD infections.

Key words: concurrency, concurrent sexual partnerships, sexually transmitted diseases, STD, South Africa

Introduction

Concurrent sexual partnerships are widely believed to play a significant role in the transmission of sexually transmitted diseases (STDs), including Human Immunodeficiency Virus (HIV), and there is growing advocacy for concurrency reduction as a key prevention tool (Halperin & Epstein, 2007; Mah & Halperin, 2010; Shelton, 2009). These views are not, however, unanimously held and opponents argue that the empirical evidence is not strong enough to support this hypothesis and justify such advocacy (Lurie & Rosenthal, 2010; Sawers & Stillwaggon, 2010).

Mathematical models have demonstrated that STDs can spread more rapidly in sexual networks that include concurrent sexual partnerships by increasing the likelihood of exposure to infected persons and reducing the time between sexual contacts among infected and susceptible persons (Doherty et al., 2006; Eaton, Hallet, & Garnett, 2011; Morris & Kretzschmar, 1997, 2000). Empirical studies have found that concurrent sexual partnerships are associated with a higher STD risk (Koumans et al., 2001; Potterat et al., 1999; Rothenberg et al., 1999). In studies in the United States concurrency was found to be a significant predictor of the transmission of Chlamydia (Potterat et al., 1999) and syphilis (Koumans et al., 2001). In another study in the United States adolescents with concurrent sexual partners were associated with a greater risk of having an STD (Rothenberg et al., 1999). More recently, a study among South African women found a significant relationship between individual concurrency and HIV status (Jewkes et al., 2010).

Other empirical studies, on the other hand have found no statistically significant relationship in multivariate regression analysis between concurrent sexual partnerships and individual STD risk (Kelley et al., 2003), and individual HIV status (Jewkes et al., 2006; Mattson et al., 2007; Zuma et al., 2003). Furthermore, in an ecological study using data from 34 sub-Saharan African countries, empirical evidence indicates that concurrency in the traditional form of polygyny (i.e. where a man has more than one wife) is associated with lower HIV prevalence (Reniers & Watkins, 2010).

One explanation for the inconsistent findings in analyses of individual STD risk and concurrency is the theory that concurrency increases the risk of transmitting an STD, not of acquiring it (Morris, 2001, Morris, 2010). In other words, it's whether your partner has other partners that should influence risk of acquiring an STD. Findings from a recent study in Russia is consistent with this theory: partner concurrency (partners with other partners), but not individual concurrency, was independently associated with increased odds of having an STD (Zhan et al., 2011). A study in Tanzania also found a statistically significant, albeit weak, relationship between partner concurrency and HIV status among monogamous women (Landman et al., 2008). However, in the same study this relationship was not significant among men and among the full sample of sexually active women. Furthermore, the study by Jewkes et al. (2010) among South African women that found a significant relationship between individual concurrency did not find a significant relationship between perceived male partner concurrency and HIV status (Jewkes & Dunkle, 2010).

Another potential explanation for these inconsistent findings is that concurrency studies generally use binary indictors of concurrency (yes/no) that combine all concurrent sexual

partnerships into one category. Concurrent sexual partnerships are defined by UNAIDS as overlapping sexual partnerships in which sexual intercourse with one partner occurs between two acts of intercourse with another partner (UNAIDS, 2009). However, different forms of concurrency should represent different degrees of risk for disease transmission. The duration of overlap and coital frequency may contribute as much or more to transmission dynamics than the mere presence of such partnerships (Aral, 2010; Lurie & Rosenthal, 2010; Mah & Halperin, 2010; Mattson et al., 2007). The number of concurrent partnerships a person has may also be important (Aral, 2010); and concurrency involving consistent condom use should represent no/low risk of STD infection.

In short, some concurrent partnerships may increase the odds of having an STD, while others present no/little risk of STD transmission. Dichotomous measures of concurrent partnerships may therefore conflate high and low risk partnerships and obscure the statistical relationships between STDs and concurrency. It is therefore necessary to expand the concept of risk from a focus on the individual to one on partnerships in order to better understand sexual behaviour and disease transmission (Gorbach & Holmes, 2003). Recent papers highlight this by noting that not all concurrency is alike and calling for further empirical studies to measure the prevalence of different manifestations of concurrency and how these are associated with STD/HIV risk (Aral, 2010, Kretzschmar et al., 2010, Reniers et al., 2010).

This paper examines variation in both partner concurrency and individual concurrency among Xhosa speaking men in Cape Town, South Africa, and how different forms of concurrency are associated with self-reported STDs. More specifically, this paper employs longitudinal data from sexual partner history tables to assess the type of relationships (main vs. non-main) and condom use associated with concurrency. A unique set of self-administered questions is then used to examine the maximum number of partners men have had concurrently and the longest duration a concurrent partnership has lasted. Finally, the relationship between STD status and variations in these aspects of concurrency is explored.

Materials and Methods

Data

The data for this paper comes from the Cape Area Panel Study (CAPS). The first wave of CAPS (in 2002), surveyed a representative sample of 4,752 young adults aged 14-22 living in Cape Town. For the first wave of the study, a two-stage sample was used, stratified by the three main population groups (African, coloured and white). In the first stage, clusters were selected, categorised by predominant population group, and in the second stage households were randomly selected from clusters to achieve a representative sample. Respondents were re-interviewed up to four more times, most recently in 2009 (wave 5), with the cohort then aged 20-30. The African male sample initially comprised 930 men and 582 were re-interviewed in 2009. The final estimation sample for this paper (n=439) consists of African men interviewed in waves 3 and 5 with complete data on all dependent and independent variables.

In all waves, study participants were asked detailed questions during face-to-face interviews on a variety of demographic, socioeconomic and behavioural topics. In wave 5, respondents were also asked to complete a self-administered module that included questions about concurrent sexual partnerships and STDs. Ethical approval was granted by the University of Cape Town and University of Michigan. Information regarding CAPS, including the initial sampling strategy, consent, ethical approval, and access to data and questionnaires can be found at http://www.caps.uct.ac.za.

Concurrency measures

Concurrency is generally measured either by asking individuals directly if they have had additional sexual partners during a specific sexual relationship, or by assessing overlap in the start and end dates of sexual relationships. The measures used in this paper are created from the direct method, as data required for the overlap method were not collected. In wave 3 (2005), respondents were asked questions to complete a table of their sexual partners history. Participants were asked to provide information on each of their last ten sexual partners, starting with the first person they had sex with. In wave 5 (2009), respondents were asked about their last two sexual partners, starting with the most recent person with whom they had sex.

Partner concurrency data was collected with the question: "As far as you know, did [**partner**] have any other sexual partners during the time that you and he/she were having a sexual relationship?" [Definitely yes, not sure, definitely no]. This question involves perceptions of another person's sexual behaviour and therefore must be regarded with a healthy degree of scepticism. This is emphasized by the fact that self-reported sexual behaviour itself likely involves a degree of measurement error (Minnis et al., 2009). Data on individual concurrency was collected using the question "Did **you** have any other sexual partners during the time that you and [**partner]** were having a sexual relationship? [Definitely yes, not sure, definitely no].

In addition to the concurrency questions, Wave 3 participants were asked the month and year they first had sex with each partner, about how long the sexual relationship with each partner lasted and coital frequency with each partner. In wave 5, these questions were replaced with a single question to describe the type of partnership [main partner, side-partner or roll-on, casual or once-off]. "Roll-on" was included as qualitative research conducted in Cape Town found this to be a common term for a concurrent partner (Mah & Maughan-Brown, 2009). In both waves 3 and 5, condom use was measured by asking how often, if ever, respondents used a condom with each partner [always, usually, sometimes, never]. The CAPS wave 3 and wave 5 sexual partner questions can be downloaded at http://www.saldru.uct.ac.za/home/index.php?/component/option,com_docman/Itemid,32/gid,391/task,doc_download/.

Three measures of partner concurrency were created from the partnership tables. *Partner concurrency* indicated respondents who perceived any of their partners in wave 3 or wave 5 to be involved with other partners (0 = no; 1 = unsure; 2 = yes). *Partner concurrency type* was created to differentiate between main and non-main partners who were perceived ("definitely yes") to have had other partners. For wave 3, *partner concurrency type* was designated as non-main if the relationship with the partner perceived to have other

partners was shorter than five months. Five months was selected as the cut off as the response options for relationship duration were less than a month, one to four months, five to 12 months and more than a year. About 25% of relationships that lasted longer than five months involved low coital frequency (10 times or fewer in total), and these partners were also coded as 'non-main'.

For wave 5, data on relationship length and coital frequency were not available. The assumption was therefore made that partners described as casual, once-off or side-partner would all represent non-main partners. The designation of "side-partners" as 'non-main' partners may be incorrect as men may have 'side-partners' that were long-term partnerships involving high coital frequency. However, this is unlikely to be a major source of bias as few men who reported their partner as a 'side-partner' were coded as having 'non-main' partner concurrency and individual concurrency. The *partner concurrency type* variable comprised three categories: 0 = no partner concurrency; 1 = partner concurrency: non-main partner; 2 = partner concurrency: main partner. Finally, p*artner concurrency condom use* separated individuals who reported partner concurrency and always used condoms with this partner (=1) and partner concurrency when condoms were used inconsistently (=2), with no partner concurrency as the reference group (=0).

Three measures of individual concurrency were created along the lines of the partner concurrency measures. *Individual concurrency* indicated respondents who reported having other partners while in a relationship recorded in the wave 3 or wave 5 sexual history tables (0 = no; 1 = yes). The few "unsure" responses were coded as no individual concurrency. Following the same methodology for the *partner concurrency type* variable, *individual concurrency type* was created to differentiate between main and non-main partnerships during which the respondent reported another partner. The *individual concurrency type* variable comprised three categories: 0 = no respondent concurrency; 1 = respondent concurrency: non-main partner; 2 = respondent concurrency: main partner. *Individual concurrency condom use* separated individuals who reported individual concurrency and always used condoms with the partner recorded in the partnership table (=1) and individual concurrency when condoms were used inconsistently (=2), with no individual concurrency as the reference group (=0).

There are several issues with using partnership tables to measure concurrent sexual partnerships, whether using the direct or overlap method. First, incomplete partner history tables may bias results as full disclosure of partners is required for accurate measurement (Helleringer et al., 2011, Maughan-Brown & Venkataramani, 2011). In CAPS there is the additional problem that if respondents had more than two different partners between wave 3 (2005) and wave 5 (2009) these partners are not captured in the partnership tables. Furthermore, measurement may be affected by social desirability bias – where respondents provide answers they perceive will portray a better image of themselves, rather than recording their actual behaviours. Finally, although the direct concurrency measure appears to elicit more complete data than the overlap method (Nelson, et al., 2007), perhaps the biggest shortfall of this method is that the duration of partnerships and size of partnership network is unknown (Lurie & Rosenthal, 2010).

In wave 5 a self-administered module included three unique questions in an attempt to address these measurement issues. The self-administered module was designed to reduce social desirability bias. Respondents were told that on completion of this module the relevant pages would be sealed with stickers and not opened by the fieldworkers. To assist respondents with this module a translation in the respondent's preferred language was provided for the questions and response options. The first individual concurrency question asked "Have you ever been in a sexual relationship with someone and had sex with somebody else? This includes main partners, side-partners, roll-ons and one night stands." This question attempted to measure any concurrency with any sexual partner and avoid measurement bias introduced by incomplete partnership histories. However, the obvious caveat for this, and subsequent questions, is that such questions are likely to introduce some degree of recall bias.

The second question, "What is the largest number of sexual partners you have had at the same time for a week or more?" was used to separate respondents who had had two partners concurrently from those who reported three or more partners concurrently (with 'no concurrent partnership' as the reference group). Finally, the longest duration of any concurrent partnership was assessed using the question "What is the longest period of time during which you have had more than one sexual partner?" The variable *longest concurrent partnership* comprised three categories: base = no concurrent partner; 1 = concurrent partnership for shorter than 6 months; 2 = concurrent partnership for longer than 6 months.

STD measure

The wave 5 (2009) self-administered module asked two STD-related questions: "Have you ever had problems with your penis or vagina such as pain when you pee, sores or unusual fluids?" and "Have you ever had a sexually transmitted disease (STD) that is not HIV?" In addition, wave 4 (2006) asked respondents whether, in the last 30 days, they had experienced (1) painful urination, (2) Abnormal genital discharge, and (3) Ulcer or sore on your private parts. The STD measure used in this paper was a binary indicator created for respondents who reported ever having an STD or a history of dysuria, genital discharge, ulcers or sores.

Covariates of STDs

The Cape Area Panel Study collected a range of socio-economic and behavioural information that are used as controls in the models. Measures of educational attainment (0-12 years of schooling, with any tertiary education recorded as 13) and socioeconomic status (logged monthly per capita household income from Wave 1) were included, given their importance in predicting HIV/STD status in other studies (Bärnighausen et al., 2007, Corno & de Walque, 2007, Krieger et al., 2003). Studies have shown that male circumcision reduces the risk of contracting HIV (Siegfried et al., 2009), syphilis and gonorrhea (Cook et al., 1994), and herpes simplex virus type 2 and human papillomavirus (Tobian, et al., 2009). A binary indicator was therefore created for whether the individual reported being circumcised, equal to 1 for those who answered "yes" to the question "Are you circumcised? (That is, some or all of your foreskin has been removed)" and zero for those who answered "no".

In addition, the models included a set of sexual behaviour indicators obtained across all waves. First, a binary measure reflecting the number of lifetime sexual partners (1 if the

individual reported 5 or more lifetime partners, and zero otherwise) was created to control for individuals who have had multiple partners, whether serially or concurrently. A continuous measure of years sexually active was also constructed to control for increases in STD risk that accrue from additional years of sexual exposure. Third, age at first penetrative vaginal intercourse was included as a baseline for years sexually active and because younger initiation of sex has been associated with greater STD risk (Kaestle et al., 2005). Finally, a binary measure of whether respondents used contraception the first time they had sex was added as a control for attitudes/preferences towards unprotected sex and/or access to protective contraceptives respectively.

Analysis

The sample for this study comprises African men and is restricted to individuals successfully interviewed in CAPS wave 3 (2005) *and* wave 5 (2009) and only includes participants who completed both sexual partner history tables. Descriptive statistics for the study sample were first computed. Then simple tabulations of the prevalence and variations in partner and individual concurrency are provided. Comparison of means tests of condom use between partnerships with and without concurrency and between partnership types are presented. The aim of this comparison was to assess whether knowledge of partner concurrency or self-reported individual concurrency was associated with greater condom use. An assessment of condom use between partnerships of different duration provides an indication of which partnerships involving concurrency represented a greater risk for disease transmission.

Nine probit regression models for STD status were then estimated. The first three models assessed the relationship between partner concurrency and STD status: starting with the general measure of partner concurrency and then replacing this measure with indicators for type of partnership (non-main vs. main) and condom use (always vs. inconsistent). The next three models assessed the relationship between STDs and individual concurrency (general, partnership type and condom use), as measured from the wave 3 and wave 5 sexual partner history tables. The last three models used the individual concurrency variables created from the wave 5 self-administered module to assesses whether (i) individual concurrency ever, (ii) number of partners men have had concurrently, and (iii) duration of concurrent partnerships were associated with STDs. All models included controls for education, household income, circumcision status and the sexual behaviour variables. The goal of this first specification was to assess the robustness of the relationship between the concurrency variables and STD status to the inclusion of factors that may have been jointly correlated with the concurrency variables and STDs.

A second set of models is then presented that included both partner concurrency *and* individual concurrency variables. These models identified aspects of concurrency that were independent risk factors of STDs. A common problem in all models is that the precise timing of STDs and concurrent partnerships was unknown. Causal inference is thus complicated by the fact that some men may have had an STD prior to engaging in concurrency (leading to an upward bias) or may not have engaged in concurrency *because* they had an STD (leading to a downward bias). This potential source of bias should be considered when interpreting the results.

Marginal effects are presented for all models instead of probit coefficients as marginal effects are more easily interpretable (for a continuous variable the coefficient reflects the percentage point increase in the probability of observing the dependent variable for a 1 unit change in the independent variable; for binary variables, it reflects a similar change in the dependent variable from moving from 0 to 1 on the independent variable of interest). All standard errors were corrected for heteroskedasticity. All analysis was conducted using Stata version 11.1 (Stata Corp, College Station, Texas).

Results

Descriptive statistics for the estimation sample of African men are presented in Table 1. Twenty-nine percent reported an STD. The average respondent was just under 25 years old, had completed 10.5 of schooling and was from a household with an average monthly per capita income of R404 ($39 based on 1 July 2002 exchange rate). The average respondent was therefore from fairly poor households and had not completed secondary school. Almost all men (99%) reported Xhosa as their preferred language and, as expected due to traditional circumcision practices among this ethnic group, the vast majority (92%) was circumcised. Regarding sexual behaviour, everyone in the estimation sample had reported having sex, with an average age of first sex of 15.5 and 9.2 years sexually active. Significant variation in sexual behaviours was reported: 55% reported five or more sexual partners and 43% reported the use of contraceptives at first sex.

Table 1 – Descriptive Statistics for Estimation Sample (African men)

	Mean	SD	N
STD Status (=1)	0.29	0.45	439
Demographic and SES			
Age (years)	24.72	2.69	439
Education (years)	10.48	1.93	439
Per capita Wave 1 (2002) Household Income (Rand)	404.11	413.91	439
Preferred language: Xhosa	0.99	0.08	439
Circumcised (=1)	0.92	0.26	439
Sexual Behavior			
Ever had sex (=1)	1	0	439
Years Sexually Active	9.23	2.76	439
Age at first sex	15.49	1.85	439
Contraceptive used at First Sex (=1)	0.43	0.49	439
5 or More Sexual Partners (=1)	0.55	0.49	439

The prevalence and variation in partner and individual concurrency are displayed in Table 2. Forty-six per cent of African men reported partner concurrency and the majority reported individual concurrency (66%) in the 2005 and/or 2009 sexual history tables. Significant variation in partnership type and condom use between concurrent partnerships was

evident. In terms of partner concurrency, 61% of the men who reported partner concurrency (28% of all men) indicated that these were non-main partners perceived to have additional partners rather than main partners; and a similar percentage (59%) reported always using condoms with these partners. In contrast, in terms of individual concurrency, men were almost three times more likely (74%) to report having sex with someone else while with partners classified as main rather than non-main partners and only 44% reported consistent condom use with the concurrent partner listed in the partnership tables.

The second panel in Table 2 presents data from the 2009 self-administered questions that asked about lifetime experience of individual concurrency. Fifty-eight percent of respondents reported ever having had a concurrent partner. This is similar to the figure derived from the sexual partnership history tables. There was 66% agreement between the self-administered and partnership history table measures. Thirteen percent of data inconsistency comprised men who reported ever having a concurrent partner in their lives (self-administered), but who had not indicated having other partners in the sexual history tables. This data inconsistency may be a product of the study design, as partners between 2005 and 2009 may not be recorded on the 2009 sexual history table. The remaining 21% of individuals reported individual concurrency in the sexual history tables but said they had never had a concurrent sexual partnership in the self-administered section. A study examining data consistency between the one-shot and overlap measures of concurrency found only 45% agreement between these measures (Nelson et al., 2007). The agreement between the two concurrency measures in this paper is therefore relatively high in the context of different measures of concurrency.

Significant variation was also evident in both the greatest number of partners respondents had ever had concurrently and the length of their longest concurrent partnership. Just over a half (55%) of respondents who had a concurrent partnership reported having had three or more partners concurrently. This indicates significant variation in the size of sexual networks, and thus potential STD risk, that different men are/have been connected to. With regard to the length of concurrent partnerships, more men reported a concurrent partnership of longer than six months (52%) than those who reported their longest concurrent partnership as having been shorter than six months (43%) – with five percent missing data.

Table 2 – Prevalence and variation in partner and individual concurrency for estimation sample

Partner and individual concurrency reported in 2005 & 2009 partnership tables (N = 439)					
Partner concurrency			*Individual concurrency*		
	%	*n*		*%*	*n*
No	16	68	No	34	151
Unsure	38	167	Yes	66	288
Yes	46	204			
Partnership type			*Partnership type*		
No concurrency	54	235	No concurrency	34	151
Non-main partner	28	124	Non-main partner	17	74
Main partner	18	80	Main partner	49	214
Condom use			*Condom use*		
No concurrency	54	236	No concurrency	34	151
Condoms always used	27	119	Condoms always used	29	126
Inconsistent condom use	19	84	Inconsistent condom use	37	162

Individual concurrency (ever) reported in 2009 self-administered module (N = 439)		
	%	*n*
No	42	184
Yes	58	255
Most partners concurrently		
None	42	184
2	32	142
3 or more	18	77
Data unavailable	8	36
Longest concurrent partnership		
None	42	184
< 6 months	25	109
> 6 months	30	130
Data unavailable	3	16

Table 2 shows that not all concurrent partnerships involved consistent condom use. This indicates the potential for concurrent partnerships to increase risk of disease transmission, as compared to a scenario where all/most concurrency involves consistent condom use. However, it is possible that concurrency involves significantly greater condom use than non-concurrent partnerships, because individuals in these partnerships perceive themselves to be at greater STD risk. If this were the case then concurrency could offer a degree of protection against STDs. On the other hand, the use of condoms may be dictated more by partnership type, with individuals using condoms more with non-main partners and less with main partners. If this were the case then main partners may represent greater STD risk from concurrency than non-main partners because main partners involve more sex *and* unprotected sex. Means tests of condom use by concurrency and then by partnership type (Table 3) were used to assess condom use in different partnerships. The condom-use

variable was coded so that '1', '2', '3' and '4' indicates respondents who never, sometimes, usually or always used condoms while with their partner respectively. A higher average score therefore indicates more consistent condom use.

Panel 1 in Table 3 shows that respondents who perceived their main partners to have other partners were slightly more likely to use condoms, but this association was not statistically significant. Those, on the other hand, who perceived their non-main partners to have other partners were associated with less consistent condom use than those who did not report partner concurrency. With regard to individual concurrency, there was no difference in condom use in main partners by concurrency status, while respondents who reported concurrent partnerships with non-main partners were, on average, significantly more likely to use condoms consistently than those who reported no partnership concurrency. In sum, perceived partnership concurrency was not associated with safer sex and neither was individual concurrency with main partners. Only individual concurrency with non-main partners was associated with safer sex. This suggests that individual concurrency with non-main partners may represent significantly lower STD risk than with main partners because coital frequency is lower *and* condom use is more consistent.

The second panel in Table 3 indicates that type of relationship, non-main or main, is associated with significantly different condom use. Condoms were used more consistently in non-main partnerships than main partnerships ($p<0.01$).

Table 3. Average condom use by concurrency and partnership type

	No concurrency			**Concurrency**			
	Mean	SD	N	Mean	SD	N	p-value
Partner concurrency							
Main partners	2.69	1.27	397	2.84	1.22	192	0.15
Non-main partners	3.47	0.99	258	3.18	1.19	204	0.01
Individual concurrency							
Main partners	2.79	1.23	419	2.76	1.24	274	0.69
Non-main partners	3.27	1.12	277	3.49	0.98	276	0.02

	Non-main partner			**Main partner**			
	Mean	SD	N	Mean	SD	N	p-value
Full Wave 3 & 5 samples	3.34	1.08	498	2.83	1.21	630	0.00
Partner concurrency	3.18	1.18	204	2.84	1.22	192	0.01
Individual concurrency	3.49	0.98	276	2.76	1.23	274	0.00

Table 4 presents the results of the multivariate regression analysis, controlling for demographic and sexual behaviour variables, but including only partner *or* individual concurrency indicators. Columns 1, 2 and 3 display probit marginal effects for the partner concurrency variables and 4, 5 and 6 for the individual concurrency variables as measured in the sexual partner history tables. The estimates for the model for perceived partner

concurrency (4.1) illustrate that partner concurrency ("yes") is associated with a 17% increase in the probability of reporting an STD compared to no partner concurrency, while individuals who were "unsure" about partner concurrency were associated with 6% point increase in the probability of reporting an STD, but this relationship was not statistically significant. Model 4.2 shows that men with 'main' partners perceived to have other partners are slightly more likely to report an STD than 'non-main' partners (16% versus 12%). In model 4.3 respondents who reported inconsistent condom use with partners perceived to have other partners are 18% ($p<0.001$) more likely to report an STD, and those who reported always using condoms 11% more likely. The latter finding was unexpected as consistent condom use should be protective regardless of ones partners' sexual behaviour. However, it is possible that these individuals are connected to other sexual networks that increase STD risk. This will be explored later in the paper when models include both partner and respondent concurrency indicators.

In terms of individual concurrency (models 4.4-4.6), having other partners was associated with a 6-9% increase in reporting an STD, but these variables are all on the margin of statistical significance. Similar to partner concurrency, individual concurrency while with 'main' partners or involving inconsistent condom use was associated with greater STD risk compared to their counterfactuals, but the differences are very small (1.2% and 2.5% respectively).

Table 5 displays probit marginal effects for models including the individual concurrency variables created from the CAPS wave 5 (2009) self-administered module. Model 5.1 indicates that individual concurrency is associated with a 19% greater chance of reporting an STD ($p<0.001$). This is a much stronger association than displayed by the variables in Table 4. Model 5.2 and 5.3 illustrate that variation in number of partners reported concurrently and maximum length of concurrent partnerships, respectively, mattered for STD risk. Individuals who reported three or more partners concurrently were more than twice as likely to report an STD than those who reported 2 partners concurrently (36% versus 16%). Furthermore, respondents who reported a concurrent partnership of longer than six months were 10% more likely to report an STD than respondents who reported concurrency for shorter than six months (25% versus 15%)

Table 4. Probit marginal effects for STD status for partner and individual concurrency as measured in sexual partner history tables

Dependent variable: Had an STD	**Partner Concurrency**			**Individual Concurrency**		
	4.1	4.2	4.3	4.4	4.5	4.6
Concurrency "Unsure" (0 = no concurrency)	0.058					
	(0.072)					
Concurrency "Yes" (0 = no concurrency)	0.17**			0.067		
	(0.068)			(0.046)		
Non-main partnership (0 = no concurrency)		0.12**			0.0077	
		(0.053)			(0.066)	
Main partnership (0 = no concurrency)		0.16**			0.089*	
		(0.066)			(0.051)	
Concurrency: always used condom (0 = no concurrency)			0.11**			0.06
			(0.055)			(0.058)
Concurrency: inconsistent condom use (0 = no concurrency)			0.18***			0.085
			(0.064)			(0.056)
Circumcised (0 = uncircumcised)	0.035	0.029	0.033	0.041	0.036	0.041
	(0.082)	(0.083)	(0.083)	(0.081)	(0.082)	(0.081)
Education (0-13)	-0.0045	-0.004	-0.0035	-0.0068	-0.0065	-0.0061
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Logged per capita household income (Wave 1: 2002)	-0.031	-0.032	-0.03	-0.033	-0.033	-0.033
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Age at first sex	-0.012	-0.013	-0.012	-0.011	-0.013	-0.011
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Years sexually active	0.0049	0.0047	0.0049	0.0041	0.0038	0.0041
	(0.0089)	(0.009)	(0.009)	(0.0091)	(0.0091)	(0.0091)
5 or more sex partners (0 = less than 5)	0.093**	0.093**	0.094**	0.10**	0.097**	0.099**
	(0.044)	(0.044)	(0.044)	(0.045)	(0.045)	(0.045)
Contraception used at first sex (0 = no)	0.026	0.024	0.025	0.024	0.024	0.027
	(0.047)	(0.047)	(0.047)	(0.046)	(0.046)	(0.047)
Observations	439	439	439	439	439	439
Pseudo R-squared	0.04	0.04	0.04	0.03	0.03	0.03

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5. Probit marginal effects for STD status for individual concurrency as measured via self-administered questions

Dependent variable: Had an STD	**Individual concurrency**		
	5.1	5.2	5.3
Concurrency "Yes" (0 = no concurrency)	0.19***		
	(0.042)		
2 partners concurrently (0 = no concurrency)		0.16***	
		(0.056)	
3 or more partners concurrently (0 = no concurrency)		0.36***	
		(0.069)	
Missing data on number of partners concurrently (0 = no concurrency)		0.14	
		(0.094)	
Concurrent partnership shorter than 6 months (0 = no concurrency)			0.15**
			(0.06)
Concurrent partnership longer than 6 months (0 = no concurrency)			0.25***
			(0.057)
Length of concurrent partnerships missing (0 = no concurrency)			0.30**
			(0.13)
circumcised (0 = uncircumcised)	0.041	0.06	0.049
	(0.082)	(0.08)	(0.081)
Education (0-13)	0.0071	-0.005	-0.0075
	(0.012)	(0.012)	(0.012)
Logged per capita household income (Wave 1: 2002)	0.031	-0.034	-0.03
	(0.024)	(0.024)	(0.024)
Age at first sex	0.0094	-0.009	-0.011
	(0.014)	(0.014)	(0.014)
Years sexually active	0.0074	0.008	0.0067
	(0.0091)	(0.0091)	(0.009)
5 or more sex partners (0 = less than 5)	0.082*	0.049	0.086*
	(0.044)	(0.047)	(0.044)
Contraception used at first sex (0 = no)	0.015	0.0064	0.018
	(0.047)	(0.047)	(0.047)
Observations	439	439	439
Pseudo R-squared	0.06	0.07	0.06

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The final regression models are presented in Table 6. Here the multivariate regression analysis controlled for the same demographic and sexual behaviour variables as in previous models, but now both partner *and* individual concurrency variables were included. The association between STD risk and one form of concurrency (partner/individual) was therefore assessed independently from the other. The models included both the partner concurrency variables (partnership type and condom use) and the individual concurrency variables from the wave 5 self-administered module (number of partners concurrently and

maximum length of concurrent partnership) as these showed the greatest variation and statistical significance in the previous analysis.

Models 6.1 and 6.2 in Table 6 illustrate that, controlling for the maximum number of partners concurrently and maximum length of individual concurrency respectively, the difference in risk associated with partner concurrency with main versus non-main partners is slightly greater than in Table 4 (6-7% compared to 4%). Similarly, partner concurrency with inconsistent condom use is associated with a greater difference in the probability of reporting an STD than partnerships in which condoms were always used. The finding that partner concurrency with main partners is associated with similar risk of reporting an STD (15-16%) to partner concurrency with inconsistent condom use (17-18%) may reflect the finding from Table 3 that main partnerships involved less consistent condom use. In other words, these variables may proxy for partner concurrency with similar characteristics in terms of coital frequency and condom use.

In terms of individual concurrency, Table 6 further highlights the importance of variation in concurrency for STD risk. Models 6.1 and 6.3 show that, controlling for partner concurrency, having had three or more sexual partners concurrently was associated with a significantly greater probability of reporting an STD than having had two partners concurrently: 35-36% versus 15%. Furthermore, respondents who reported concurrent partnerships of longer than 6 months were twice as likely to report an STD than respondents in shorter concurrent partnerships, when compared to their counterfactuals.

Table 6. Margin effects from probit regression models of STD status, including both partner and individual concurrency variables

Dependent variable: Had an STD	**Partner & Individual Concurrency**			
	6.1	6.2	6.3	6.4
Partner concurrency, non-main partner (0 = no concurrency)	0.078	0.098*		
	(0.055)	(0.055)		
Partner concurrency, main partner (0 = no concurrency)	0.15**	0.16**		
	(0.065)	(0.066)		
Partner concurrency: always used condom (0 = no concurrency)			0.059	0.086
			(0.055)	(0.055)
Partner concurrency: inconsistent condom use (0 = no concurrency)			0.17***	0.18***
			(0.064)	(0.065)
2 concurrent partners (0 = no concurrency)	0.15**		0.15***	
	(0.058)		(0.058)	
3 or more concurrent partners (0 = no concurrency)	0.35***		0.36***	
	(0.07)		(0.07)	
Missing data on number of concurrent partners (0 = no concurrency)	0.11		0.11	
	(0.092)		(0.091)	
Concurrent partnership less than 6 months (0 = no concurrency)		0.11*		0.11*
		(0.06)		(0.06)
Concurrent partnership more than 6 months (0 = no concurrency)		0.24***		0.24***
		(0.058)		(0.058)
Length of concurrent partnerships missing (0 = no concurrency)		0.27**		0.26**
		(0.13)		(0.13)
Circumcised (0 = uncircumcised)	0.052	0.039	0.059	0.045
	(0.08)	(0.082)	(0.079)	(0.081)
Education (0-13)	-0.0016	-0.0038	-0.00086	-0.003
	(0.012)	(0.012)	(0.012)	(0.012)
Logged per capita household income (Wave 1: 2002)	-0.034	-0.029	-0.031	-0.027
	(0.024)	(0.025)	(0.024)	(0.025)
Age at first sex	-0.01	-0.012	-0.0087	-0.011
	(0.014)	(0.014)	(0.014)	(0.014)
Years sexually active	0.0077	0.0063	0.0079	0.0065
	(0.009)	(0.0089)	(0.0091)	(0.009)
5 or more sex partners (0 = less than 5)	0.026	0.064	0.025	0.064
	(0.048)	(0.046)	(0.047)	(0.045)
Contraception used at first sex (0 = no)	0.0066	0.02	0.0061	0.021
	(0.047)	(0.047)	(0.047)	(0.047)
Observations	439	439	439	439
Pseudo R-squared	0.08	0.07	0.09	0.08

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Discussion

Substantial differences between concurrent sexual partnerships were observed and these variations were associated with different disease risk in the models predicting STD status, suggesting that concurrent partnership dynamics must be taken into account in studies assessing the role of concurrency in STD transmission and in STD prevention programs.

Partner concurrency

Individuals who perceived any of their sexual partners to have a concurrent partner were associated with greater STD risk. The degree of this risk was not, however, similar for all partner concurrency: main partners who had other partners represented almost twice the risk as other partners; and partner concurrency in relationships that involved inconsistent condom use represent more than twice the risk compared to those when condoms were always used. Almost a fifth of the study sample reported partner concurrency with these higher risk characteristics, indicating their relevance for a substantial number of men. As partnership type and condom use are associated – condom use was less consistent with main partners – STD risk is thus greatest with long-term partners who have other partners, presumably because sex with these partners is relatively frequent *and* unprotected. Furthermore, knowledge of being connected to extended sexual networks (perceived partner concurrency) was not associated with safer sexual behaviour (more consistent condom use), indicating that knowledge of partner concurrency itself is not moderating STD risk via the use of condoms.

Individual concurrency

No significant association was found between individual concurrency variables drawn from sexual partner history tables and STD risk. In contrast, measures of *ever* engaging in individual concurrency, created from the self-administered module in the last survey wave (2009), were strongly correlated with STD risk. These questions assessed two aspects of concurrent sexual behaviour that are rarely measured: (1) the largest number of partners someone has concurrently had and (2) the longest period of time in a concurrent partnership. A significant proportion of men (18%) reported partnerships involving three or more partners concurrently. These men were significantly more likely (35-36%) to report an STD than men who had not reported concurrency, and this was twice as likely compared to men who had reported concurrency involving two partners. Concurrency in this sample comprised longer term partnerships that lasted six months or more and partnerships of shorter than six months, with slightly more men reporting 'long-term' concurrency. These long-term concurrent partnerships represented significantly greater risk for STDs (24%) than no concurrency, and more than twice as much compared to short-term concurrency.

The mechanism driving the stronger relationship between the self-administered measures and STD-risk is unknown. Differences between partnership tables and self-administered measures of individual concurrency could arise from various sources. Firstly, social desirability bias could play a role. Qualitative research among Xhosa men and women in Cape Town found that the most common term for a concurrent or additional partner was 'roll-on' or *khwapheni* in Xhosa (Mah & Maughan-Brown, 2009). The etymology in English of the term 'roll-on' refers to the placement of roll-on deodorant under the arm – the 'roll-on' is thus something that should be hidden from others (Oxlund, 2007, Selikow, 2004). Men

might thus have under-reported concurrency in face-to-face interviews in order to hide this behaviour. However, the data does not support this as the majority of cases of inconsistent data comprised 21% of men who reported concurrency in the face-to-face questions but subsequently did not report concurrency in the self-administered module.

Another hypothesis is that differences between the measures were generated by recall bias. When asked to think about any lifetime concurrent partnerships in the self-administered module, respondents might have only reported partners that overlapped for a period of time that made these concurrent partnerships memorable. The self-administered module may therefore indicate respondents who have had the type of concurrent partnerships (not once off or of extremely short overlap) that represent greater STD risk.

Assuming that the self-administered measures of concurrency are picking up real effects, we need to consider how these can be interpreted. According to Morris (2001, 2010) individual concurrency increases individual risk of transmitting an STD, not of acquiring it. If this were the case, the large and significant effect of the maximum number of partners men have had concurrently and longer durations of individual concurrency would have to proxy for something else. Other studies of concurrency using the CAPS wave 3 data (Kenyon et al., 2010, Mah, 2010), and in Kenya (Xu et al., 2010) found a significant correlation between individual and partner concurrency. Mah (2010) suggests two potential explanations for this correlation: individuals who engage in concurrency may choose partners who also do, or individual concurrency may motivate partner concurrency.

The individual concurrency variables presented in this paper could therefore potentially proxy for partner concurrency. However, as controls for partner concurrency were included in the final analysis, individual concurrency would have to proxy for another dimension beyond simply having a partner who has another partner. If individual concurrency motivates partner concurrency then having more partners concurrently and for a longer period of time would increase the opportunity for these partners also to have multiple concurrent partners for longer durations themselves. Extent and duration of individual concurrency could therefore proxy for the degree of STD risk presented by partner concurrency. This may be especially relevant for HIV acquisition due to the viral load spike during the short period directly after initial infection (Cohen et al., 2011). In other words, if person A engages in individual concurrency involving multiple partners for a long duration, thus increasing the number and duration of his partners' partners, then this increases the odds that one of his partners will be infected with HIV and thus the odds that person A will have sex with someone who recently seroconverted and is highly infectious.

Another, more simple, explanation is that individual concurrency, especially of longer duration and comprising three or more partners, does in and of itself increase STD risk compared to serial monogamy. The exact dynamics involved here are unclear.
The pattern of condom use within different partnerships found in this paper leads to the formulation of one theory. Condoms were used less consistently with main partners than in other partnerships, which presumably were shorter and involved less sex on average. This is consistent with results from previous studies (Gorbach & Holmes, 2003). Given this, it is possible that an individual with concurrent partners will have more unprotected sex than someone with the same number of sequential partners over a given time period. This would

play out if condoms were used for the same time period with each partner and then discontinued. The calendar months of protected sex with concurrent partners would thus overlap and could result in a greater period of unprotected sex with each partner than in the scenario involving consecutive monogamous partnerships.

The theories above involve several assumptions and different counter-scenarios could be proposed. They do however suggest that partnership dynamics between different concurrent partnerships and between concurrent and serial monogamous partnerships may influence the risk of an individual transmitting and acquiring STDs.

There are several limitations to this study, many of which motivate further research. First, STD status was self-reported. Second, omitted variables may confound the relationship between concurrency practices and STD status. While we attempted to address this by demonstrating the robustness of the results to the inclusion of a rich set of controls, we still cannot be sure that our estimates reflect causal relationships. Also complicating causal inference is the fact that some men may have had STDs prior to engaging in concurrent partnerships or may not have engaged in concurrency *because* they had an STD. Fourth, as mentioned previously, perceptions of another person's sexual behaviour almost certainly involve measurement error, and measures of partner concurrency must therefore be viewed with a healthy degree of scepticism. Fifth, and potentially most important, no information was available on the characteristics of partnerships making up partner concurrency. Risk differentials via number of partners' partners, length of partnerships, coital frequency and condom use are unknown. Finally, our results are for a specific population group and it is unclear whether they generalize to other populations.

Bearing these limitations in mind, the findings in this paper indicate that reducing concurrency (either in terms of number of partners or duration) and/or encouraging consistent condom use in concurrent partnerships would help reduce STD infections. In practice, identifying individuals who are in concurrent partnerships for targeted interventions would be challenging. We also don't know how sexual behaviour would change in response to a reduction in concurrency. Concurrency messages should therefore be included as one arm of a broader strategy to reduce multiple sexual partners. Behavioural interventions could thus be designed to reduce total number of sex partners *and* to discourage concurrent partnerships.

In addition, the importance of variations in concurrency highlighted in this paper indicates that future research on concurrency should include more nuanced analysis, using measures that incorporate such variation. The debate about the relationship between concurrency and HIV, in particular, is driven by inconsistent empirical evidence and it is clear that more and better empirical evidence is required. Morris (2010) suggests that an improved research design to assess this question would involve a prospective longitudinal study of incident HIV-infection among couples, where both are HIV-negative on enrolment and both are enrolled in the study. The findings in this paper indicate that such studies, and other attempts to assess this question, should include measures of concurrency that capture variation in partnership type, condom use, number of partners involved in concurrent partnerships and length of concurrent partnerships.

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southern africa labour and development research unit

The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy. In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.

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