The reliability of sexual partnership histories: implications for the measurement of partnership concurrency during surveys

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Abstract

Objectives: To measure the reliability of sexual partnership histories collected during survey interviews, and to assess the impact of measurement error on survey estimates of partnership concurrency.

Methods: We used sociocentric data collected on Likoma Island (Malawi). Up to 5 of the respondents' most recent sexual partners were identified in population rosters. We assessed inter-partner agreement (IPA) in reports of sexual partnerships (i.e., whether partners concordantly report that they have had sexual relations with each other) and its association with respondent and partnership characteristics. We estimated the extent of bias in the point prevalence of concurrency and the duration of overlap between concurrent partnerships according to two scenarios: one in which only partnerships reported by both partners were considered as "true" ("concordant scenario"), one in which partnerships reported by either partner were included ("complete scenario").

Findings: IPA was low in non-marital relations, but was significantly higher in ongoing than in dissolved non-marital relations. IPA was further associated with the number of other partners the respondents or their partner(s) had, as well as with the duration of ongoing partnerships. Biases in measurements of the prevalence of concurrent partnerships (CP) were large: CPs were rare in the concordant scenario, but common in the complete scenario. This was particularly true among never married women. Estimates of the average duration of overlap between CPs derived from self-reported survey data were also biased, particularly among married respondents.

Conclusions: Future empirical tests of the "concurrency hypothesis" and interventions targeting CPs should take reporting biases into account.

Abstract: 246 Words.

Text: 3,426 Words

Concurrent partnerships (CPs) can accelerate the transmission of HIV (and other sexually transmitted infections) in a population [1-4]. CPs have been described as the "key driver" of generalized HIV epidemics [5]. Long-term CPs (i.e., partnerships that overlap for months, possibly years) in particular, may play a crucial role in connecting the sexual networks that transmit HIV [6].

Despite a recent surge of interest in targeting CPs for HIV prevention [7], the evidence that they are an important risk factor of HIV transmission remains limited [8-12]. The lack of association between partnership concurrency and HIV infection in empirical investigations could in part be due to the poor quality of survey data on CPs. To estimate the extent of CPs, survey respondents are typically asked questions about their 3–5 most recent sexual partners, including the dates at first and last sex, as well as whether the relationship with a given partner is still ongoing. These questions are used to check whether relationship intervals overlap [13, 14].

Such data are potentially affected by large biases [15-19], but few studies have evaluated the impact of measurement errors on survey estimates of partnership concurrency [14, 20], particularly in sub-Saharan settings. Only Morris and O'Gorman [15] argued that "measurement errors introduce a slight positive bias in estimates of the prevalence of CPs, and a slight negative bias in the length of the overlap [between CPs]". This pioneering study suffers from two major limitations however: first, it only considered the impact of date heaping and recall errors on survey reports of partnership dates, but it did not consider the likely hypothesis that partnership histories (on which estimates are based) may not be reliable; second, it hypothesized that reporting errors occurred at random among population members, in ways that are unrelated to parameters of partnership concurrency. If patterns of misreporting are associated with partnership duration (for example), biases in concurrency measurements are likely to be significantly larger than previously thought.

We use *sociocentric network data* collected on Likoma (an island located in the northern region of Lake Malawi) to (*i*) assess the inter-partner reliability of partnership histories collected during sexual behaviors surveys, and (*ii*) test whether reliability varies with partnership duration and timing. In doing so, and contrary to Morris and O'Gorman's previous assessment, we show that biases in survey measurements of CPs are large and of unknown direction.

2 Data & Methods

2.1 General approach

Virtually all strategies used for estimating the rates of partnership concurrency rely on *self-reported survey data*—also referred to as *egocentric data* [21]—about sexual relationships (see Figure 1, panel A). The major innovation of the present study is the use of *sociocentric network data* [21-23] to improve inferences about the prevalence and other parameters of CPs in a sub-Saharan African population. Rather than being based on a random sample of respondents, as egocentric data, sociocentric studies attempt to enroll *all* members of a population of interest (Fig 1. Panel B), and then seek to identify their sexual partners among members of the population. Each sexual relationship is thus potentially *concordantly* reported by both sexual partners engaged in the relationship or *discordantly* reported by only one of the two interviewed partners [24]. Previous assessments of the inter-partner reliability of data on partnership concurrency have narrowly focused on concordantly reported relationships to investigate whether partners who both reported their relation during a survey also agreed on the start and end dates of their relationship [20]. In this paper, we expand on such studies by estimating the relative frequency of both concordantly and discordantly reported partnerships.

[Figure 1 about here]

2.2 Data sources

The data used in this paper come from the Likoma Network Study (LNS) and were collected in 2005/06 (**20–22**, **24**). We first conducted a census of the entire island to establish a roster of potential sexual partners (November 2005). Second, a sexual network survey (N = 923) was conducted with all inhabitants aged 18–35 in seven villages using audio computer-assisted self-interviewing (ACASI) technologies [17, 18]. This survey took place between December 30th, 2005 and February 28th 2006. Respondents were asked to provide the names of up to 5 of their most recent sexual partners, and detailed information about each partner and sexual relationship was elicited. In total, 1,858 reports of sexual relationships were collected. Finally, the network of sexual relationships was constructed by linking nominated partners to an individual record in the household rosters. Eleven percent of eligible participants declined to be interviewed or were absent at the time we visited them. More than 80% of nominated partners residing on Likoma were linked to records in the rosters of potential network members, and roughly 46% of nominated partners were also interviewed during the sexual network survey [25]. We refer to this latter subset of relationships as "in-sample" whereas we call "out-of-sample" the relationships in which only one of the two partners was interviewed. The median time interval between the interviews of sexual partners in in-sample relations was 2 days for spouses vs. 7 days for non-marital partners. 8 relationships in which a respondent's partner had nominated 5 partners during the survey were excluded.

2.3 Measures of data quality

The reliability of sexual partnership data is measured by the inter-partner agreement (IPA) in reports of sexual partnerships. Specifically, IPA is the proportion of all in-sample relationships self-reported by a respondent, which are also concordantly reported by his/her partner(s). In figure 1, panel B, the IPA of A is 100% (the sole relationship self-reported by A is also reported by A's partner), but the IPA of D is 0 (D's reported relationship with A is not reported by A). In Panel C, the IPA of A remains 100% but the IPA of D is now estimated at 50% since F and D concordantly report their relationship. In some cases, partners mention each other as sex partners but do not agree that the relationship is still ongoing. We report the frequency of such discordant reports.

2.4 Measures of respondent and partnership characteristics

We measure the association between IPA and characteristics of the respondents, their partners and the index relationship. Respondents' characteristics included gender, number of self-reported sexual partners and marital status (ever vs. never married). Partners' characteristics included the number of times they were reported by another respondent (outside of the index relationship) during the survey. Relationship characteristics included timing and duration. Respondents were asked to classify their relationships as still ongoing or not at the time of the survey, and as having started/ended within one month, one year or more than a year prior to the survey. Among partnerships ongoing at the time of the survey, data on start dates were used to create a categorical measure of partnership duration: *short* (having started less than one year prior to the survey, hence having lasted less than one year) vs. *long* (having lasted more than one year) partnerships. Among dissolved partnerships, data on end dates were used to categorize partnerships as *recent* partnerships (having ended less than one year before the survey) versus *distant* partnerships (having ended more than one year before the survey). We used non-parametric tests (Wilcoxon rank sum test) to detect associations between respondent/partner/partnership characteristics and IPA.

2.5 Estimates of partnership concurrency parameters

2.5.1 Point prevalence of partnership concurrency

The *point prevalence of partnership concurrency* is the proportion of the population having more than one ongoing sexual partnership at a point in time. Because only categorical measures of the start and end dates of sexual relationships are available in the LNS [25], we measure the point prevalence of CPs at the time of the survey. A respondent is thus defined as having CPs at the time of the survey if s/he is engaged in two or more partnerships reported as ongoing. We measure the prevalence of CPs according to two scenarios. In the first scenario ("concordant scenario"), we consider that a respondent is engaged in a relationship as long as both s/he *and* his/her partner reported the relationship during the survey. According to that scenario, in panel c) of Figure 1, only respondent F is classified as having CPs. The relation between D and A (reported by D only) is considered *over-reported* by D. In a second scenario ("complete scenario"), we consider that a respondent is engaged in a relationship as long as s/he *or* his/her partner reports the relationship. In that case, not only F, but also A and D are classified as having CPs. The relationship between D and A is thus considered *under-reported* by A. We report estimates of the prevalence of CPs according to concordant, self-reported and complete data for respondents who self-reported having in-sample relationships. Prevalence estimates according to self-reported and complete data are reported for the total study population.

2.5.2 Misclassification of survey respondents

Finally, we estimate the probability of misclassification (i.e., a survey respondent reporting concurrent partners when he is in a serial relation or has no partners, and vice-versa) when the point prevalence concurrency is measured at the time of the survey ($t=0$) or at time t=-6 months prior to the survey (as recommended by UNAIDS [26]). Assuming independence between partnership reports of a respondent, the probability that a survey respondent with two partners at t=0 or t =-6 is misclassified as having less than two partners in our complete scenario is simply $1-p[SR(t)]^2$, where p[SR(t)] is the proportion of all relations involving a respondent that are self-reported at time t. In figure 1, panel c), for example, p[SR] = 100% for B and D, but p[SR] = 50% for A (since A does not report the partnership with D). In the concordant scenario, the probability that a survey respondent who has no partners at the time of the survey or at time t =-6 is misclassified as having two partners is simply $1-p[OR(t)]^2$, where p[OR(t)] is the proportion of self-reported relations that are not concordantly reported at time t. In figure 1, panel c), p[OR] = 100% for A, but p[OR] = 50% for D (since A does not report a partnership with D).

2.5.3 Average duration of overlap between concurrent partnerships

The average duration of overlap between CPs refers to the number of days two CPs are ongoing at the same time. We use a probabilistic model to investigate whether observed correlations between partnership duration and reporting of partnership histories introduce significant biases in measures of overlap duration derived from self-reported data. We explore the size of this bias using numerical examples (see appendix A1).

2.6 Robustness analyses

Our analyses are possibly affected by two limitations of sociocentric studies. First, respondents may occasionally not provide sufficient information to identify their partners. As a result, a report may not be correctly linked to a potentially concordant report made by another survey respondent. Second, two partners may provide discordant information that is still reliable [24]. This is the case if their relationship starts during the interval of time between interviews of each partner. We assess the impact of such data limitations on our assessment of data quality (appendix A2).

3 Results

3.1 Descriptive statistics

There were 845 reports of in-sample relationships. In-sample relationships were more likely to be marital than out-of-sample relationships, but there were few differences between in and out-of-sample marital relations [25]. Differences between non-marital in-sample and out-of-sample relationships were more common (Table 1). Among both ongoing and dissolved non-marital relationships, out-of-sample relationships of women were more likely to be reported by older respondents. Dissolved relationships with out-of-sample partners reported by women were more likely to have taken place long before the survey (i.e., > 1 year prior to the survey). There were few systematic differences between in and out-of-sample reported by men.

[Table 1 about here]

3.2 Association of inter-partner agreement (IPA) and concurrency parameters

Marital relationships were reliably reported [25], but IPA in non-marital relationships was low. It was higher for relationships reported by women, and was more than twice as high in ongoing relationships as in dissolved relationships (Table 2). IPA was significantly reduced for partnerships reported by a respondent who also self-reported other ongoing partnerships during the survey interview, as well as in relationships where the partner was nominated by other survey respondents (outside of the index respondent). For both men and women, IPA was almost twice as large in long than in short partnerships. Among dissolved relationships, the timing of a relationship was not significantly associated with IPA. These findings are robust to possible errors in data linkages and limited overlap between respondents' reporting windows (see appendix A2).

[Table 2 about here]

3.3 Completeness of sexual partnership histories

In figure 2, we show that men self-reported 72% of all the short partnerships in which they were involved, but more than 84% of their longer ongoing relations (p=0.02). Women self-reported a little more than half of their short relationships vs. 71% of their long ongoing partnerships ($p<0.01$). Men were also more likely than women to self-report dissolved relationships, but the patterns of reporting were not significantly associated with the timing of dissolved relationships. The proportion of a respondent's sexual relationships concordantly reported by both partners increased with partnership duration in ongoing relationships, but was not associated with timing in dissolved relationships.

[Figure 2 about here]

3.4 Implications for the measurement of concurrency indicators

3.4.1 Point prevalence of partnership concurrency

Among 416 respondents who only reported in-sample relationships, 1% of women self-reported having CPs at the time of the survey (Figure 3a). Sociocentric data however suggested that CPs could be much more common: 6.5% of ever married and 17.4% of never married women were classified as having CPs in the complete scenario. Among men (Figure 3b), the prevalence of CPs ranged from 3.5% (concordant scenario) to 16.5% (complete scenario), whereas 8.5% self-reported having CPs. Among all 923 respondents of the LNS (Figure 3c), 23 women (4.6%) and 51 men (12.1%) self-reported having CPs at the time of the survey, but 56 (11.2%) women and 79 (18.9%) of men were classified as having CPs in the complete scenario. Discrepancies between self-reported and sociocentric data varied strongly by gender and marital status.

[Figure 3 a, b & c about here]

3.4.2 Misclassifications

In the complete scenario, the probability of misclassifying a respondent who had two non-marital partners as not having any CP was 29-48% for men and 49-74% for women (depending on the duration of these partnerships) if the prevalence was measured at the time of the survey. It was 62% for men (79% for women) if the prevalence was measured at time t=-6 months prior to the survey and both relationships had ended prior to the survey. In the concordant scenario, a man without any partner had 25-50% probability of being misclassified as having CPs (10-40% for women) if the point prevalence of CPs was measured at the time of survey vs. 75% (64% for women) if the point prevalence was measured at time t=-6 months.

3.4.3 Duration of overlap between concurrent partnerships

An association between partnership duration and the probability of reporting a partnership implies that when compared to the complete (concordant)scenario, the estimated average overlap of relationships is biased upward (downward) in self-reported survey data on sexual partnerships. We formally prove this claim in appendix A1. Numerical examples indicate that the size of the bias is greatest for respondents with at least one marital relation, and when the duration of a respondent's CPs is highly heterogeneous (e.g., two long-term partnerships and one short-term partnership).

4 Discussion

In this paper, we used sociocentric network data to assess the inter-partner reliability of partnership histories collected during surveys of sexual behaviors. We found very low reliability in reports of non-marital partnerships particularly among dissolved relationships and the shortest ongoing relationships (i.e., relationships that had lasted for less than a year). In addition, reports were also significantly less reliable when one of the two partners was engaged in other sexual partnerships outside of the index relationship. Contrary to previous assessments [15], we thus found that biases in estimates of partnership concurrency based on self-reported survey data were likely large and of unknown direction. Among women, we found no partnership concurrency in one scenario (concordant reports), and very low levels of concurrency according to self-reported data. On the other hand, 8% of all women and close to 20% of never married women had CPs according to our complete scenario, which includes reports made by a respondent's partner(s). This is an important finding in light of the apparent discrepancy between qualitative studies having indicated that CPs may be pervasive among women in SSA [27-31] and quantitative surveys having documented very low levels of concurrency among women[12, 32]. This gap could thus be attributed to the poor quality of survey data on CPs.

Among men, we also found significantly higher levels of CPs in our complete scenario. This was however not true for never married men, for whom there were no differences between self-reported and complete data. Because the reliability of partnership reports is much lower in dissolved partnerships, misclassifications of survey respondents as (not) having CPs are much more likely when the point prevalence of partnership concurrency is measured at time t=-6 months prior to the survey, rather than at the time of the survey. Finally, because reporting of partnerships was associated with partnership duration, estimates of the average duration of overlap between CPs based on self-reported data were biased. This was particularly true for the relationships of respondents in marital unions, and with both short-term and long-term partnerships (e.g., respondents having extra-marital affairs or polygamous men with short-term non-marital relations).

There are however several important limitations to our analyses. First, our approach does not allow assessing the validity of sexual partnership data. As a result, we cannot decipher whether the "true" level of partnership concurrency among the population is closer to its upper estimate (i.e., complete data), or from its lower estimate (i.e., concordant data). This depends on whether under or over-reporting of sexual partnerships is the most prevalent form of misreporting. Whereas researchers have frequently emphasized under-reporting in sexual behavior data [17, 19], self-reports may also be affected by both forms of bias [16, 33]. Men can indeed "swagger", i.e., exaggerate the number of their partnerships, while women may exaggerate the duration of their relationships [33].

There are strong indications that LNS respondents under-reported the extent of their sexual partnerships. For example, during a follow-up survey conducted in 2007/08, we found that a large number of relationships discordantly reported in 2005/6 were subsequently reported by the "secretive" partner, thus corroborating the claim of under-reporting (see appendix A3 for a full description). Our results also indicate that if over-reporting is indeed present in our data, it did not present itself along the gendered patterns reported by Nnko et al [33], for example. The sexual histories of both men and women were incomplete, suggesting either that men may have under-reported some of their partnerships or that women may have over-reported some of theirs. Similarly, both men and women may have occasionally over-reported the duration of their partnerships. In 27 relationships, we found that partners disagreed about whether or not their relationship was still ongoing at the time of the survey, but men were as likely as women to report the relationship as ongoing.

Other limitations of the analyses presented here include the lack of precise data on the start and end dates of sexual partnerships and the selective inclusion of relationships in our analytical sample. Both unit and item non-response were limited in the LNS, but sexual relationships with members of age groups, which were not eligible for the sexual network interview (adolescents below age 18 and adults over 35), and with partners residing outside of the study villages were common [25]. If respondents were more likely to under or over-report the partnerships they engaged in with residents of the mainland or with older/younger inhabitants of Likoma, then estimates of inter-partner reliability derived from sociocentric data are likely biased.

Despite the above limitations, however, our findings have important implications for the measurement of partnership concurrency (and other sexual behaviors) in sub-Saharan populations, and for the roll-out of behavioral interventions targeting CPs for HIV prevention [7]. On the one hand, whereas UNAIDS [34] recently recommended that the prevalence of CPs should be measured at time t=-6 months prior to the survey, our results indicate that partnership concurrency is best measured at the time of the survey, when IPA in reports of sexual partnerships is the highest. On the other hand, our analyses indicate that gender differences in the practice of CP could have been overstated among younger unmarried adults and adolescents. Interventions aiming to reduce CPs should thus not be solely focused on the behaviors of men[35], but also target younger, unmarried women. Finally, whereas much of the debate on CPs has been focused on long-term CPs [6], our results indicate that they may be less prevalent than initially thought. "Experimental" or "transitional" CPs [36] may thus also represent common types of concurrency in sub-Saharan settings. In order to quantify our uncertainty and improve our inferences about the extent of partnership concurrency in SSA, major surveys of sexual behaviors should seek to systematically assess the inter-partner reliability of the self-reported data they collect. This requires tracing the non-marital, non co-residing partners of a sub-sample of respondents.

References

1. Morris M, Kretzschmar M. **Concurrent partnerships and the spread of HIV**. *AIDS* 1997,11:641-648.
2. Morris M, Kurth AE, Hamilton DT, Moody J, Wakefield S. **Concurrent partnerships and HIV prevalence disparities by race: linking science and public health practice**. *Am J Public Health* 2009,99:1023-1031.
3. Potterat JJ, Zimmerman-Rogers H, Muth SQ, Rothenberg RB, Green DL, Taylor JE*, et al.* **Chlamydia transmission: concurrency, reproduction number, and the epidemic trajectory**. *Am J Epidemiol* 1999,150:1331-1339.
4. Koumans EH, Farley TA, Gibson JJ, Langley C, Ross MW, McFarlane M*, et al.* **Characteristics of persons with syphilis in areas of persisting syphilis in the United States: sustained transmission associated with concurrent partnerships**. *Sex Transm Dis* 2001,28:497-503.
5. Shelton JD. **Ten myths and one truth about generalised HIV epidemics**. *Lancet* 2007,370:1809-1811.
6. Epstein H. **AIDS and the irrational**. *BMJ* 2008,337:a2638.
7. Shelton JD. **Why multiple sexual partners?** *Lancet* 2009,374:367-369.
8. Lurie MN, Rosenthal S. **Concurrent partnerships as a driver of the HIV Epidemic in sub-Saharan Africa? The evidence is limited**. *AIDS Behav*,14:17-24; discussion 25-18.
9. Lurie MN, Rosenthal S. **The Concurrency Hypothesis in Sub-Saharan Africa: Convincing Empirical Evidence is Still Lacking. Response to Mah and Halperin, Epstein, and Morris**. *AIDS Behav*,14:34.
10. Reniers G, Watkins S. **Polygyny and the spread of HIV in sub-Saharan Africa: a case of benign concurrency**. *AIDS*,24:299-307.
11. Lagarde E, Auvert B, Carael M, Laourou M, Ferry B, Akam E*, et al.* **Concurrent sexual partnerships and HIV prevalence in five urban communities of sub-Saharan Africa**. *AIDS* 2001,15:877-884.
12. Mishra V, Bignami-Van Assche S. **Concurrent sexual partnerships and HIV infection: Evidence from national population-based surveys**. In: *DHS working papers*; 2009.
13. Nelson SJ, Manhart LE, Gorbach PM, Martin DH, Stoner BP, Aral SO, Holmes KK. **Measuring sex partner concurrency: it's what's missing that counts**. *Sex Transm Dis* 2007,34:801-807.
14. Manhart LE, Aral SO, Holmes KK, Foxman B. **Sex partner concurrency: measurement, prevalence, and correlates among urban 18-39-year-olds**. *Sex Transm Dis* 2002,29:133-143.
15. Morris M, O'Gorman J. **The impact of measurement error on survey estimates of concurrent partnerships**. *Mathematical Population Studies* 2000,8:231-249.
16. Cleland J, Boerma JT, Carael M, Weir SS. **Monitoring sexual behaviour in general populations: a synthesis of lessons of the past decade**. *Sex Transm Infect* 2004,80 Suppl 2:ii1-7.
17. Mensch BS, Hewett PC, Erulkar AS. **The reporting of sensitive behavior by adolescents: a methodological experiment in Kenya**. *Demography* 2003,40:247-268.
18. Hewett PC, Mensch BS, Erulkar AS. **Consistency in the reporting of sexual behaviour by adolescent girls in Kenya: a comparison of interviewing methods**. *Sex Transm Infect* 2004,80 Suppl 2:ii43-48.
19. Plummer ML, Ross DA, Wight D, Changalucha J, Mshana G, Wamoyi J*, et al.* **"A bit more truthful": the validity of adolescent sexual behaviour data collected in rural northern Tanzania using five methods**. *Sex Transm Infect* 2004,80 Suppl 2:ii49-56.
20. Brewer DD, Rothenberg RB, Muth SQ, Roberts JM, Jr., Potterat JJ. **Agreement in reported sexual partnership dates and implications for measuring concurrency**. *Sex Transm Dis* 2006,33:277-283.
21. Morris M. **Overview of network survey designs**. In: *Network Epidemiology*. Edited by Morris M. Oxford: Oxford University Press; 2004.
22. Helleringer S, Kohler HP. **Sexual network structure and the spread of HIV in Africa: evidence from Likoma Island, Malawi**. *AIDS* 2007,21:2323-2332.
23. Bearman PS, Moody J, Stovel K. **Chains of affection: The structure of adolescent romantic and sexual networks**. *American Journal of Sociology* 2004,110:44-91.
24. Adams J, Moody J. **To tell the truth: Measuring concordance in multiply reported network data**.

Social Networks 2007,29:44-58.

25. Helleringer S, Kohler HP, Chimbiri A, Chatonda P, Mkandawire J. **The Likoma Network Study: Context, data collection, and initial results**. *Demogr Res* 2009,21:427-468.
26. Owen G. **An 'elephant in the room'? Stigma and hepatitis C transmission among HIV-positive 'serosorting' gay men**. *Culture Health & Sexuality* 2008,10:601-610.
27. Leclerc-Madlala S. **Cultural scripts for multiple and concurrent partnerships in southern Africa: why HIV prevention needs anthropology**. *Sex Health* 2009,6:103-110.
28. Leclerc-Madlala S. **Age-disparate and intergenerational sex in southern Africa: the dynamics of hypervulnerability**. *AIDS* 2008,22 Suppl 4:S17-25.
29. Miller CL, Bangsberg DR, Tuller DM, Senkungu J, Kawuma A, Frongillo EA, Weiser SD. **Food Insecurity and Sexual Risk in an HIV Endemic Community in Uganda**. *AIDS Behav*.
30. Mah TL, Halperin DT. **Concurrent sexual partnerships and the HIV epidemics in Africa: evidence to move forward**. *AIDS Behav*,14:11-16; dicussion 34-17.
31. Harrison A, O'Sullivan LF. **In the absence of marriage: long-term concurrent partnerships, pregnancy, and HIV risk dynamics among South African young adults**. *AIDS Behav*,14:991-1000.
32. Mishra V, Bignami-Van Assche S. In; 2009.
33. Nnko S, Boerma JT, Urassa M, Mwaluko G, Zaba B. **Secretive females or swaggering males? An assessment of the quality of sexual partnership reporting in rural Tanzania**. *Soc Sci Med* 2004,59:299-310.
34. **HIV: consensus indicators are needed for concurrency**. *Lancet*,375:621-622.
35. Wilson D, Halperin DT. **"Know your epidemic, know your response": a useful approach, if we get it right**. *Lancet* 2008,372:423-426.
36. Gorbach PM, Stoner BP, Aral SO, WL HW, Holmes KK. **"It takes a village": understanding concurrent sexual partnerships in Seattle, Washington**. *Sex Transm Dis* 2002,29:453-462.

Table

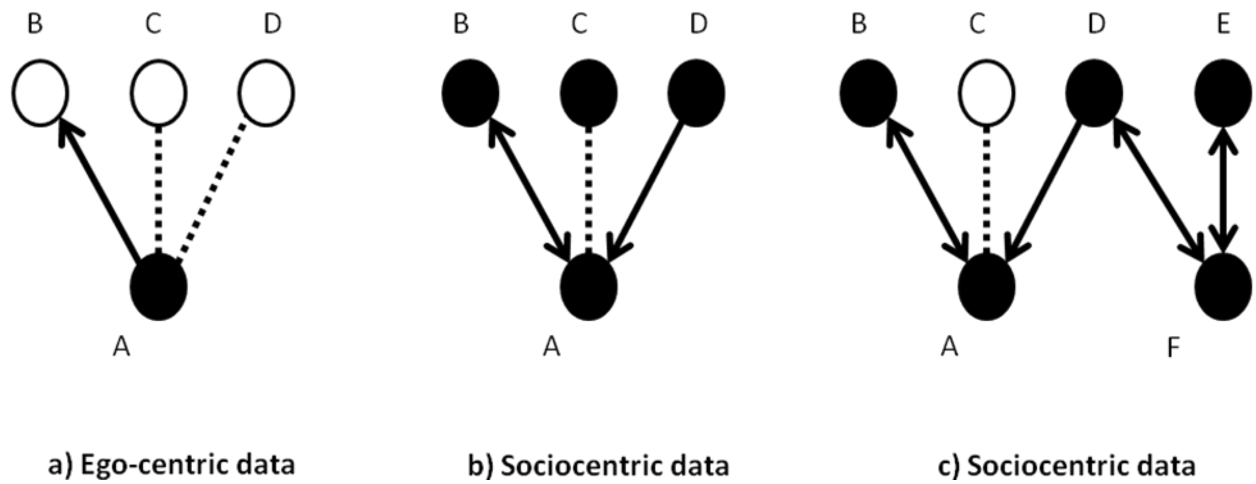


Figure 1: Egocentric and Sociocentric survey designs.

Notes: Circles represent individuals and lines represent sexual partnerships between these individuals.
Solid black circles represent individuals interviewed during the survey.
Arrows indicate that an individual nominated the individual the arrow is pointing towards as his/her sexual partner during the survey.
Broken lines indicate partnerships existing partnerships of A that A did not mention during his/her survey interview.

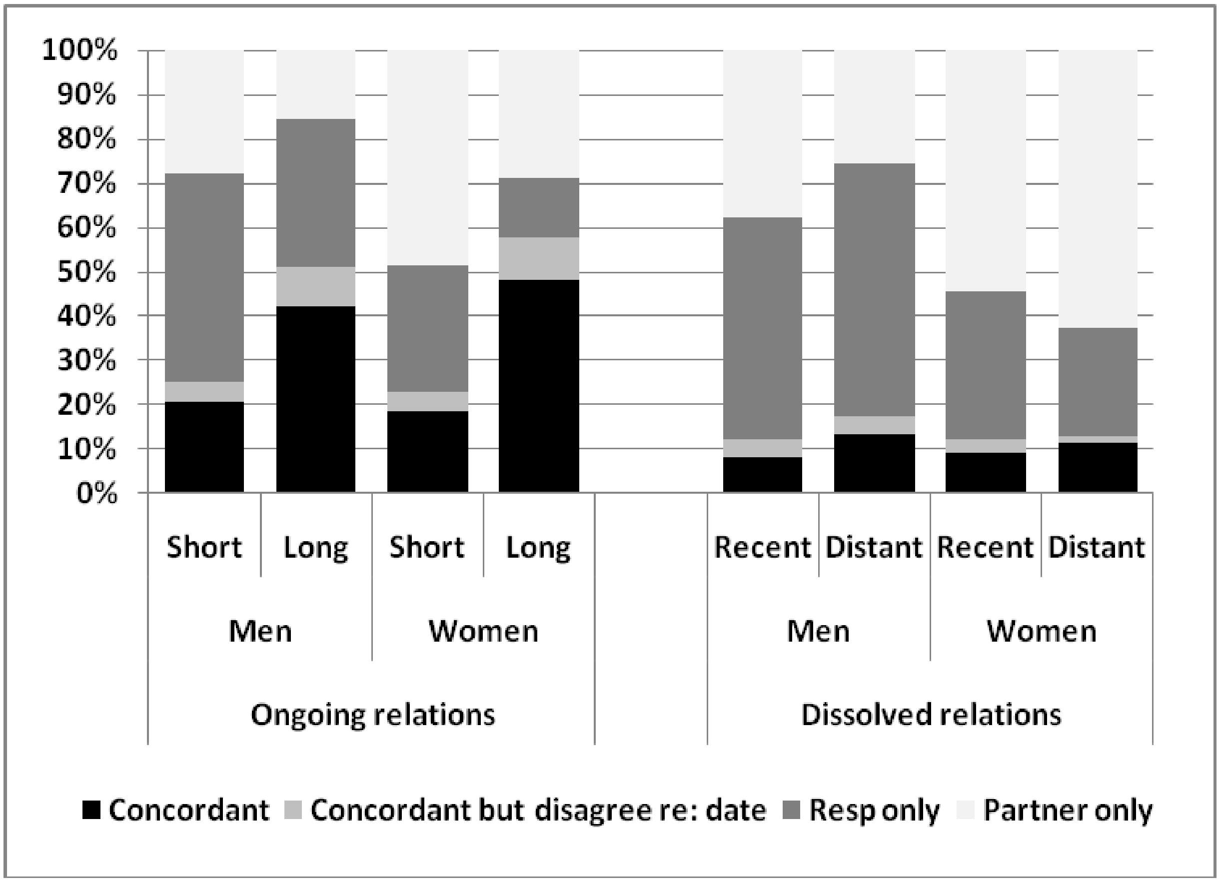


Figure 2: Proportion of non-marital sexual partnerships concordantly or discordantly reported by a respondent and his/her partner, by respondent gender and partnership duration/timing

Notes: “Concordant” refers to partnerships reported by both partners; “Concordant but disagree re: date” refers to partnerships reported by both partners, but one partner reported the partnership as ongoing whereas the other reported it as dissolved’; “Resp only” refers to relationships only reported by the respondent; “Partner only” refers to relationships only reported by the partner.

p[SR] = 100 – “Partner only”; p[OR] = 100 – “Concordant”

The bars represent the total number of relationships in which respondents were involved according either to their own self-reports or to the report of their partners. Bars are stacked to sum up to 100%.

Figure 3: Prevalence of partnership concurrency at the time of the survey according to three different scenarios.

Notes: The first scenario (“concordant scenario”) includes only partnerships reported by both partners; the second scenario (“self-reported data”) considers only the relationships reported by the respondent; the last scenario (“completed scenario”) considers all relationships involving the respondent, whether they are reported by the respondent her/himself or her/his partner(s).

Panel a: among women who only self-reported in-sample relationships

Panel b: among men who only self-reported in-sample relationships

Panel c: among all LNS respondents.

We do not represent estimate from the concordant scenario in panel c, because some respondents did not report any in-sample relationships. As a result, their relationships could not be concordantly reported and estimates of the prevalence of partnership concurrency based on concordant would be biased downwards.

	Ongoing Relationships					Dissolved Relationships			
	Women		Men			Women		Men	
	Out of sample	In sample	Out of sample	In sample		Out of sample	In sample	Out of sample	In sample
Respondent's characteristics									
Age									
< 20	39(36.8)	35(46.7)	25(25.5)	24(26.7)		66(22.8)	38(28.8)	50(13.9)	42(19.3)
20—24	33(31.1)	28(37.3)	42(42.9)	37(41.1)		107(36.9)	65(49.2)	129(35.9)	87(39.9)
25—29	19(17.9)	6(8.0)	19(19.4)	17(18.9)		74(25.5)	20(15.2)	86(24.0)	60(27.5)
≥ 30	15(14.1)	6(8.0)	12(12.2)	12(13.3)		43(14.8)	9(6.8)	94(26.2)	29(13.3)
Marital status									
Never married	75(70.8)	49(65.3)	82(83.7)	69(76.7)		124(43.1)	78(59.1)	209(58.2)	132(60.5)
Ever married	31(29.2)	26(34.7)	16(16.3)	21(23.3)		164(56.9)	54(40.9)	150(41.8)	86(39.5)
Relationship characteristics									
Reason relationship ended									
Unfaithfulness	--	--	--	--		74(27.6)	30(24.0)	88(28.1)	67(34.5)
Other reasons	--	--	--	--		194(72.4)	95(76.0)	225(71.9)	127(65.5)
Duration									
Started < 1 year PS	53(51.0)	36(48.6)	55(56.1)	52(57.8)		--	--	--	--
Started ≥ 1 year PS	51(49.0)	38(51.4)	42(42.9)	38(42.2)		--	--	--	--
Timing									
Ended < 1 year PS	--	--	--	--		130(45.6)	72(55.4)	179(50.0)	95(44.8)
Ended ≥ 1 year PS	--	--	--	--		155(54.4)	58(44.6)	179(50.0)	117(55.2)

Table 1: Characteristics of reported relationships

Notes: Figures reported in this table are sample sizes and column percentages.

Some in-sample relationships are reported by both the male and the female partners in the relationship. Source: Likoma Network Study

	Relationships reported by women			Relationships reported by men	
	Ongoing relations	**Dissolved relations**		**Ongoing relations**	**Dissolved relations**
N (total number of reported relationships)	75	133		90	218
Reciprocated nominations	48(64.0)	40(30.1)		41(45.6)	47(21.6)
Respondent's Characteristics					
Marital status					
Never married	29(59.2)	24(30.8)		30(43.5)	25(18.9)
Ever married	19(73.1)	16(29.6)		11(52.4)	22(25.6)
Number of self-reported relations					
1	14(77.8)	2(18.2)		9(52.9)	5(27.8)
2 or more	34(59.6)	38(31.1)		32(43.8)	42(21.0)
Number of self-reported relations ongoing at time of survey					
1	45(69.3)	18(46.1)		32(58.2)	17(21.5)
2 or more	3(30.0)**	22(23.4)**		9(25.7)***	30(21.6)
Partner's characteristics					
Number of times partner reported by other respondents					
0	24(72.7)	14(29.2)		23(60.5)	23(32.9)
1	16(64.0)	17(36.2)		10(45.5)	16(21.1)
2 or more	8(47.1)*	9(23.7)		8(19.5)***	8(11.1)***
Number of times partner reported in an ongoing relation by other respondents					
0	40(76.9)	38(30.4)		36(52.9)	45(22.4)
1	8(34.8)***	2(25.0)		5(22.7)**	2(11.8)
Relationship Characteristics					
Duration					
Short (Started < 1 year PS)	16(44.4)	--		18(34.6)	--
Long (Started ≥ 1 year PS)	31(81.6)***	--		23(60.5)**	--
Reason relationship ended					
Unfaithfulness	--	5(16.7)		--	12(17.9)
Other reasons	--	32(33.7)*		--	24(19.3)
Timing					
Ended < 1 year PS	--	18(25.0)		--	17(17.9)
Ended ≥ 1 year PS	--	20(34.5)		--	27(23.1)

Table 2: Association of inter-partner Agreement (IPA) and respondent/relationship characteristics

Notes: Figures reported in this table represent the raw count of relationships jointly reported by both partners. In parentheses, we report the IPA, i.e., the proportion of all in-sample relationships reported by a respondent who are also reported by the respondent's partner. PS = Prior to survey. *** $p<0.01$, ** $p<0.05$, * $p<0.1$, p-values are based on non-parametric tests (Wilcoxon rank sum tests) of the null hypothesis of no difference in IPA between categories of the variable describing a given respondent/relationship characteristic.

	Women				Men			
	Best Match Network		Re-assigned Network		Best Match Network		Re-assigned Network	
	All reporting windows[a]	**Relations older than 1 month**	**All reporting windows**	**Relations older than 1 month**	**All reporting windows[a]**	**Relations older than 1 month**	**All reporting windows**	**Relations older than 1 month**
N (total number of reported relationships)	75	67	83	74	90	79	87	77
Reciprocated nominations	48(64.0)	44(65.7)	61(73.5)	55(74.3)	41(45.6)	39(49.4)	53(60.9)	49(63.6)
Respondent's Characteristics								
Marital status								
Never married	29(59.2)	26(60.5)	37(68.5)	33(70.2)	30(43.5)	29(48.3)	42(62.7)	39(79.6)
Ever married	19(73.1)	18(75.0)	24(82.8)	22(81.5)	11(52.4)	10(52.6)	11(55.0)	10(52.6)
Number of self-reported relations								
1	14(77.8)	13(76.5)	24(92.3)	22(91.7)	9(52.9)	9(64.3)	14(70.0)	14(82.3)
2 or more	34(59.6)	31(62.0)	37(64.9)***	33(66.0)**	32(43.8)	30(46.1)	39(58.2)	35(58.3)*
Number of self-reported relations ongoing at time of survey								
1	45(69.3)	42(71.2)	57(78.1)	53(80.3)	32(58.2)	31(64.6)	42(75.0)	40(81.6)
2 or more	3(30.0)**	2(25.0)**	4(40.0)**	2(25.0)***	9(25.7)***	8(25.8)***	11(35.5)***	9(32.1)***
Partner's characteristics								
Number of times partner reported by other respondents								
0	24(72.7)	21(72.4)	33(91.7)	20(90.6)	23(60.5)	22(64.7)	34(91.9)	32(94.1)
1	16(64.0)	15(65.2)	18(66.7)	17(68.0)	10(45.5)	10(55.6)	11(50.0)	10(55.6)
2 or more	8(47.1)*	8(53.3)	10(50.0)***	9(52.9) ***	8(19.5)***	7(25.9)***	8(15.1)***	7(28.0)***
Number of times partner reported in an ongoing relation by other respondents								
0	40(76.9)	36(78.3)	51(89.5)	46(90.2)	36(52.9)	35(59.3)	48(71.6)	45(76.3)
1	8(34.8)***	8(38.1)***	10(38.5)***	9(39.1)***	5(22.7)**	4(20.0)**	5(25.0)***	4(22.2)***
Relationship Characteristics								
Duration								
Short (Started < 1 year PS)	16(44.4)	12(42.9)	23(62.2)	17(60.7)	18(34.6)	16(39.0)	27(56.2)	23(60.5)
Long (Started ≥ 1 year PS)	31(81.6)***	31(81.6)***	37(82.2)**	37(82.2)**	23(60.5)**	23(60.5)*	26(66.7)	26(66.7)

Table A1: Robustness tests of the association of inter-partner agreement with selected relationship and respondent characteristics.Best match and Reassigned Network Data, Ongoing relationships

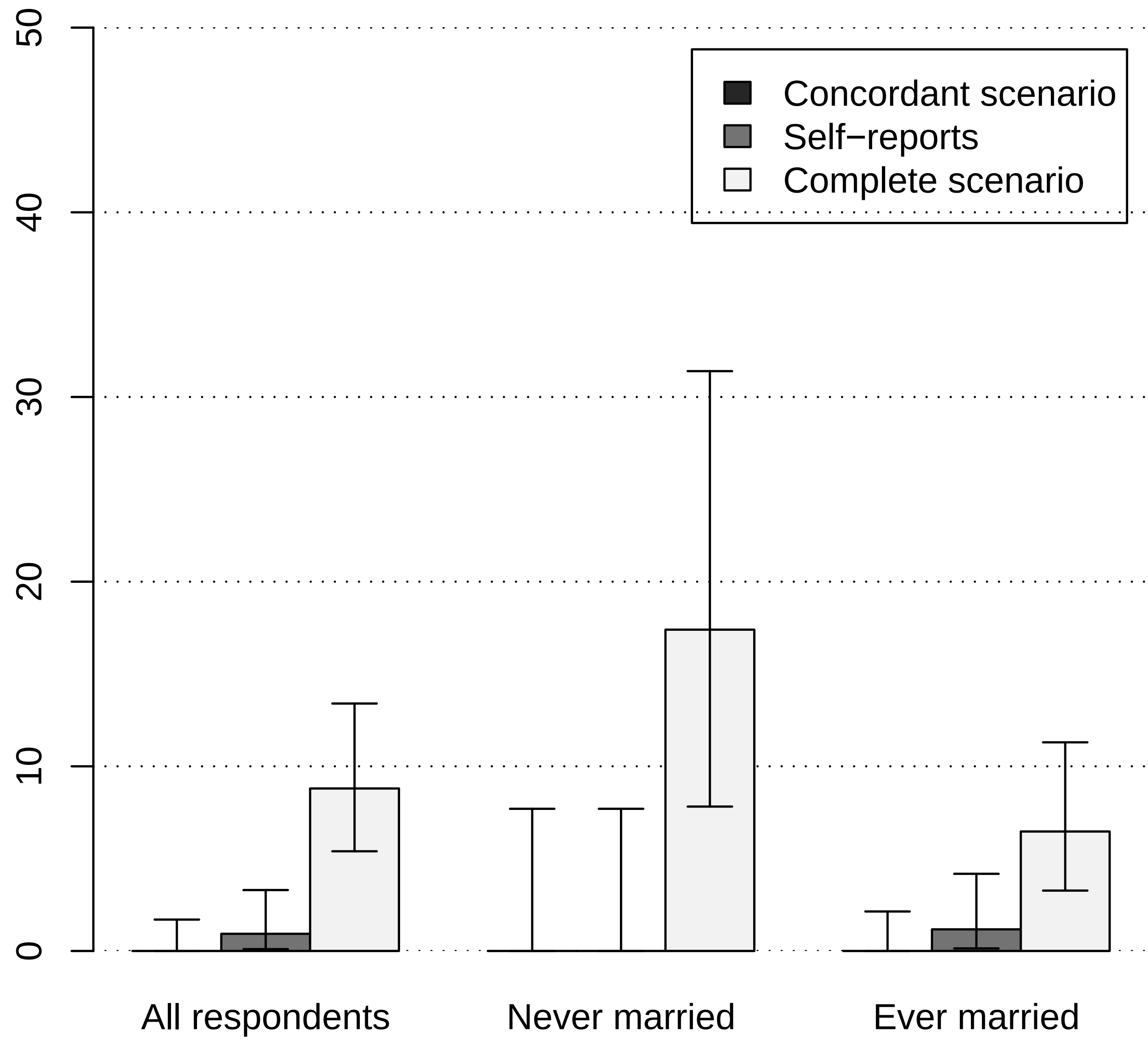
Notes: * p<0.1, ** p<0.05, *** p<0.01

[a] Re-printed from table 2 for ease of comparison.

	Women					Men			
	Best Match Network		Re-assigned Network			Best Match Network		Re-assigned Network	
	All reporting windows [a]	Relations older than 1 month	All reporting windows	Relations older than 1 month		All reporting windows [a]	Relations older than 1 month	All reporting windows	Relations older than 1 month
N (total number of reported relationships)	133	114	140	120		218	187	215	188
Reciprocated nominations	40(30.1)	36(31.6)	63(45.0)	56(46.7)		47(21.6)	44(23.5)	72(33.5)	66(35.1)
Respondent's Characteristics									
Marital status									
Never married	24(30.8)	21(32.8)	41(50.0)	35(52.2)		25(18.9)	23(20.5)	42(33.3)	37(33.6)
Ever married	16(29.6)	15(30.6)	21(37.5)	20(39.2)		22(25.6)	21(28.0)	29(32.9)	28(36.4)
Number of self-reported relations									
1	2(18.2)	2(25.0)	16(88.9)	13(92.9)		5(27.8)	4(26.7)	16(72.7)	14(73.7)
2 or more	38(31.1)	34(32.1)	47(38.5)***	43(40.6)***		42(21.0)	40(23.3)	56(29.0)***	52(30.8)***
Number of self-reported relations ongoing at time of survey									
0	18(46.1)	15(48.4)	34(73.9)	28(75.7)		17(21.5)	15(23.1)	35(44.9)	31(46.3)
1 or more	22(23.4)**	21(25.3)**	29(30.8)***	28(33.7)***		30(21.6)	29(23.8)	37(27.0)***	35(28.9)**
Partner's characteristics									
Number of times partner reported by other respondents									
0	14(29.2)	12(30.8)	31(58.5)	28(65.1)		23(32.9)	20(32.8)	38(53.5)	34(53.1)
1	17(36.2)	25(37.5)	22(45.8)	18(43.9)*		16(21.1)	16(25.4)	18(23.4)***	17(26.6)***
2 or more	9(23.7)	9(25.7)	10(25.6)***	10(27.8)***		8(11.1)***	8(12.7)***	16(23.9)***	15(25.0)***
Number of times partner reported in an ongoing relation by other respondents									
0	38(30.4)	34(32.1)	61(46.6)	54(48.6)		45(22.4)	42(24.4)	69(34.3)	63(35.8)
1	2(25.0)	2(25.0)	2(22.2)	2(22.2)		2(11.8)	2(13.3)	3(21.4)	3(25.0)
Relationship Characteristics									
Reason relationship ended									
Unfaithfulness	5(16.7)	5(20.0)	12(36.4)	11(40.7)		12(17.9)	12(21.4)	19(28.8)	19(33.9)
Other reasons	32(33.7)*	28(34.6)	46(47.9)	40(48.8)		24(19.3)	21(19.6)	41(33.3)	35(33.0)
Timing									
Ended < 1 year PS	18(25.0)	14(26.4)	31(41.9)	24(44.4)		17(17.9)	14(21.9)	29(32.9)	23(37.7)
Ended ≥ 1 year PS	20(34.5)	20(34.5)	29(46.8)	29(46.8)		27(23.1)	27(23.1)	40(33.1)	40(33.1)

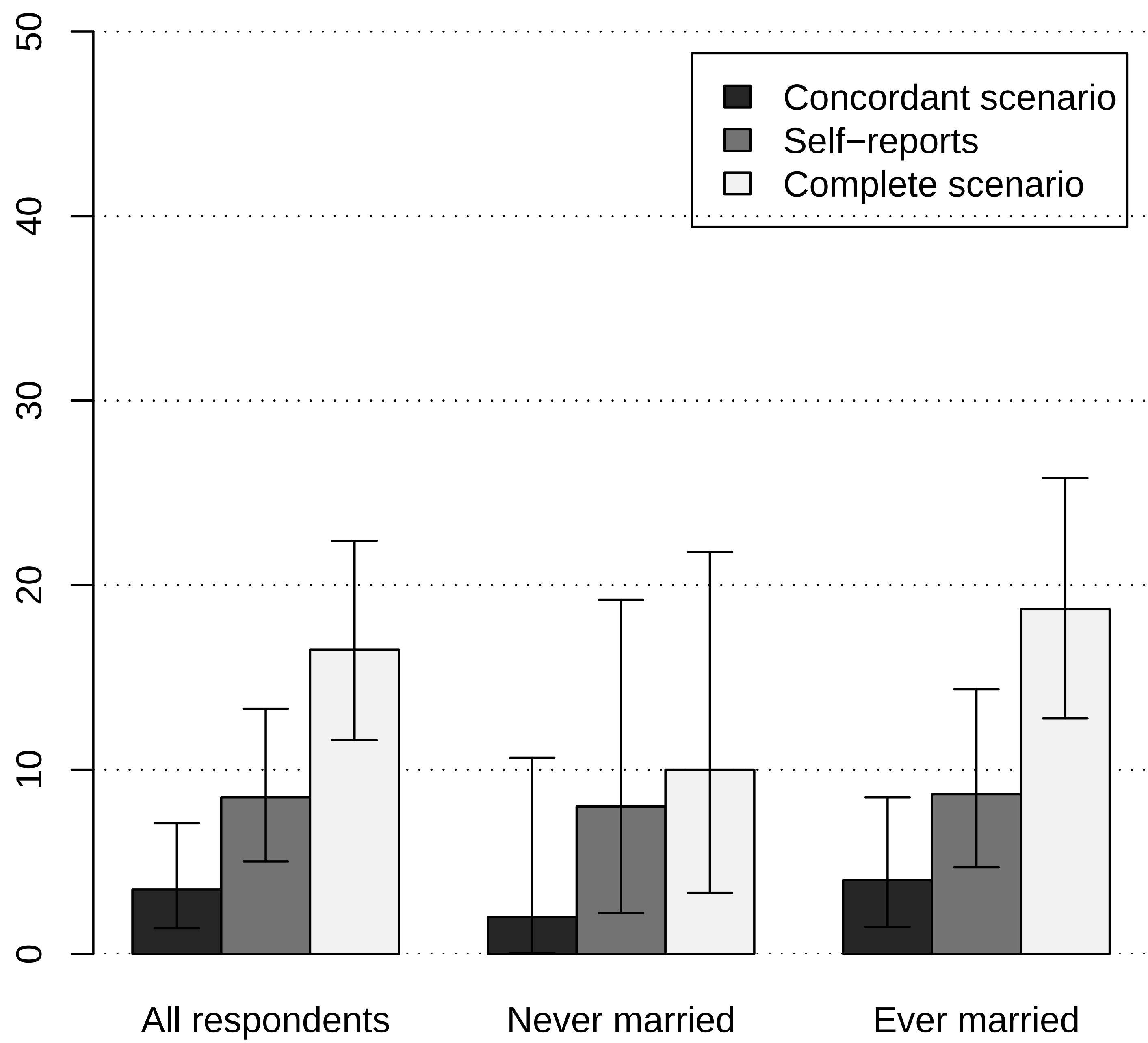
Table A2: Robustness tests of the association of inter-partner agreement with selected relationship and respondent characteristics.Best match and Reassigned Network Data, Dissolved relationships.
Notes: * $p<0.1$, ** $p<0.05$, *** $p<0.01$
[a] Re-printed from table 2 for ease of comparison.

Figure 3a



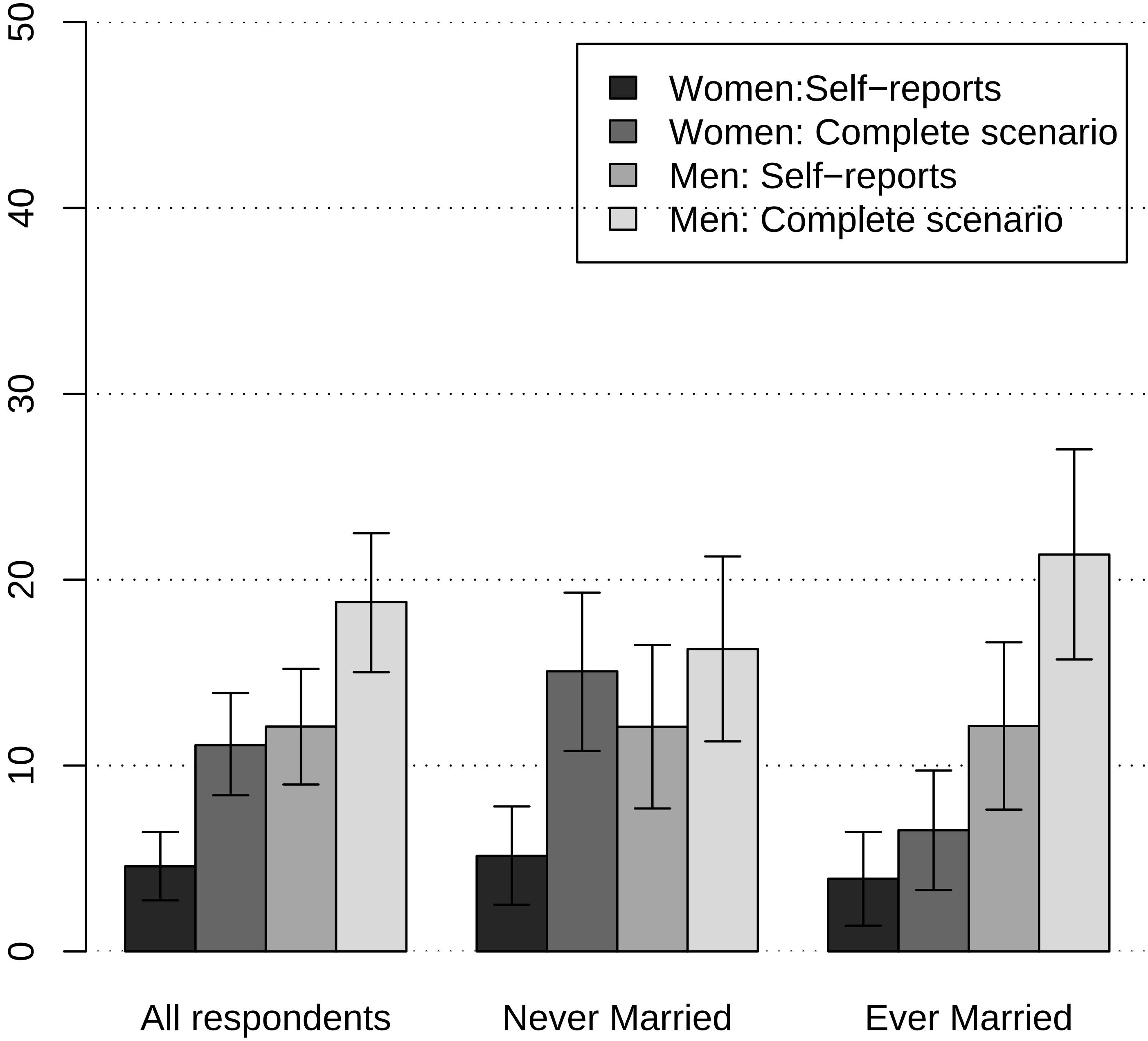
0
10
20
30
40
50
Concordant scenario
Self−reports
Complete scenario
All respondents
Never married
Ever married

Figure 3b



50
40
30
20
10
0
Concordant scenario
Self−reports
Complete scenario
All respondents
Never married
Ever married

Figure 3c


Women:Self−reports
Women: Complete scenario
Men: Self−reports
Men: Complete scenario
0
10
20
30
40
50
All respondents
Never Married
Ever Married

Appendices

A1. Biases in estimates of mean duration of overlap between concurrent partnerships (section 3.4.3)

(a)Mathematical proof

We use a probabilistic framework for partnership formation and duration to justify the claim made in Section 3.4.3 that, when compared to the complete (concordant)scenario, the estimated average overlap of relationships is biased upward (downward) in self-reported survey data on sexual partnerships (i.e., ego-centric sexual network). We prove this claim for complete scenario. The proof for the concordant scenario is analogous and symmetric. Consider a respondent with n relationships, and let $Q(i,j)$ be a random variable representing the duration of the overlap between relationships i and j. Then the expected average duration of overlap between all n relationships of the respondent (assuming all are reported), which we denote by x, is $x = \sum_{i \neq j} \mathrm{E}[Q(i,j)] / (n^2-n)$. Here n^2-n is the number of pairs (i,j) with $i \neq j$. By definition, $Q(i,j) = Q(j,i)$ and for convenience, each relationship is counted twice in both the numerator and denominator.

Let $T(i)$ be a random variable representing the duration of relationship i. We assume that $T(i)$ comes from a family of distributions such that the quantiles of any $T(i')$ are either all greater or all smaller than those of $T(i)$. Mathematically, we assume that if $\mathrm{E}[T(i')] \geq \mathrm{E}[T(i)]$, then $T(i')$ stochastically dominates $T(i)$, i.e., that $\mathrm{P}[T(i) \leq t] \geq \mathrm{P}[T(i') \leq t]$ for any t. Most one-parameter families of distributions, such as exponential distributions, have this property. We further assume that the durations of any pair of relationships i and j, $T(i)$ and $T(j)$, are independent. Let the random variable $S(i,j)$ be the elapsed time from the start of relationship i to the start of relationship j. Thus if relationship j begins before relationship i, then $S(j,i) > 0$. Since i and j are assigned arbitrarily to each relationship, we assume that $S(j,i) > 0$ occurs with 50% probability, independently of the length of the relationships, $T(i)$ and $T(j)$. We assume that when relationship j begins before relationship i, (i.e., $S(j,i) > 0$), then the start time of the later relationship is uniformly distributed: $S(j,i) \sim \mathrm{U}(0,T(j))$. These assumptions allow us to conclude that longer relationships are involved in overlaps of longer duration, specifically the following.

Claim: For any j, if $\mathrm{E}[T(i')] > \mathrm{E}[T(i)]$, then $\mathrm{E}[Q(i',j)] > \mathrm{E}[Q(i,j)]$.

Proof: Suppose $S(j,i) > 0$. Then the length of overlap between two relationships i and j can be expressed as $Q(i,j) = \max \{0, \min\{T(i), T(j)-S(j,i)\}\}$, where the second term, $T(j)-S(j,i)$, is the duration of relationship j after the start of relationship i. Our assumptions imply that $T(i)$ is independent of $T(j)-S(j,i)$. Then $Q(i,j)$ is an increasing function of $T(i)$ with an independent source of randomness, $T(j)-S(j,i)$. Such functions preserve stochastic dominance. Suppose $\mathrm{E}[T(i')] > \mathrm{E}[T(i)]$, i.e., relation i' is on average longer than i. Then by assumption, $T(i')$ stochastically dominates $T(i)$ and thus $Q(i',j)$ stochastically dominates $Q(i,j)$. Hence $\mathrm{E}[Q(i',j)] > \mathrm{E}[Q(i,j)]$. A similar argument holds when $S(j,i) < 0$. ♦

Now we define a binary random variable, $R(i)$, for each relationship of the respondent that takes the value 1 if the relationship is reported and 0 otherwise. With probability $p(i) := \Pr[R(i) = 1]$ relationship i is reported during the survey. The data suggest that the longer relationships are more likely to be reported. We therefore assume in this formal model, that if $p(i') > p(i)$, then $E[T(i')] > E[T(i)]$. From the previous claim it then follows that for any j, if $p(i') > p(i)$, then $E[Q(i',j)] > E[Q(i,j)]$. In other words, the relationships more likely to be reported are not only longer but have longer overlaps with other relationships of the respondent.

Let $K = \sum_i R(i)$ be the number of relationships reported by the respondent. Then, the average overlap of the reported relationships, which we denote by Y, is $Y = \sum_{i \neq j} R(i)\, R(j)\, Q(i,j) \,/\, (K^2-K)$. We then claim the following.

Claim: The expectation of the average reported overlap is greater than the true average overlap, that is $E[\, Y \mid K \geq 2 \,] \geq x$.

Proof: Let $S = \{\, i : R(i) = 1 \,\}$ be the set of relationships that are disclosed. Thus S is a subset of $\{1,\ldots,n\}$ and has $K=|S|$ elements. With probability $\Pr[\, S \,] = \prod_{i \in S} p(i)$, these relationships are reported. Given the set of reported relationships S, $E[\, Y \mid S \,] = \sum_{i \neq j,\, i,j \in S} E[Q(i,j)] \,/\, (K^2-K)$. Our assumption implies that for any two sets, S and S' of the same size, $|S| = |S'|$, $\Pr[\, S \,] > \Pr[\, S' \,]$ if and only if $\sum_{i \neq j,\, i,j \in S} E[Q(i,j)] > \sum_{i \neq j,\, i,j \in S'} E[Q(i,j)]$. As these sets are of the same size, this is equivalent to $E[\, Y \mid S \,] > E[\, Y \mid S' \,]$. Thus the average of $E[\, Y \mid S \,]$ weighted by $\Pr[\, S \,]$ is bigger than a straight average: $\sum_{S\,:\,|S| \geq 2} E[\, Y \mid S \,] \Pr[\, S \,] \geq \sum_{S\,:\,|S| \geq 2} E[\, Y \mid S \,] \,/\, |\{S : |S| \geq 2\}|$. By symmetry, the value of the straight average is x: $x = \sum_{S\,:\,|S| \geq 2} E[\, Y \mid S \,] \,/\, |\{S : |S| \geq 2\}|$. The left-hand side is the definition of $E[\, Y \mid K \geq 2 \,]$. This proves the claim. ♦

(b)Numerical examples

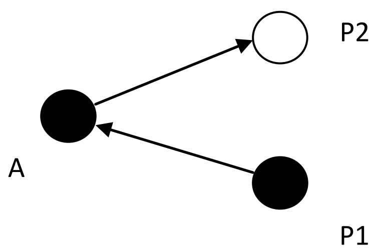
We explore the size of the bias in measures of the average overlap between CPs through simple numerical examples. For example, we consider that a respondent (index case) has 3 CPs of varying durations. For simplicity, we assume that all partnerships ended on the same day (e.g., immediately after the survey interview or 6 months prior to the survey). The duration of overlap between any two partnerships is thus equal to the duration of the shorter of the two partnerships. The "true" mean duration of overlap between these three partnerships is simply the mean of all pairwise partnership overlaps, but the "observed" mean duration of overlap depends on the probability of inclusion (i.e., p[SR] as defined in 2.5.2) of each partnership in the sexual histories collected during the survey. We use the estimates of p[SR] in Figure 2 to approximate these probabilities of inclusion. For example, an ongoing partnership of a male respondent that has started less than a year ago is reported with probability 0.722, whereas a partnership that had started more than a year prior to the survey is reported with probability 0.844. Marriages are reported with probability 0.99.

The size of the upward bias in self-reported data (relative to complete data) is generally small (≈2 -10% according to reports of men, 4-15% according to reports of women) when a respondent only engages in non-marital relations. The bias is larger for a respondent with at least one marital relationship and it also increases with the underlying variation in pairwise overlaps. For example, the observed mean duration of overlap for a man with two marriages of more than one year (e.g., 500 days) and a short-term partnership of 15 days is 263 days, whereas the "true" mean duration of overlap is only 177 days, i.e., a 49% upward bias. If that respondent's non-marital partnership had lasted for 180 days, on the day, the observed average duration of overlap would only have been affected by a 20% upward bias. The size of the bias is thus largest when a respondent has both long-term concurrent partnerships (possibly marriages) *and* occasionally engages in a short-term relation. This type of bias is thus likely to severely affect men in polygamous unions who nonetheless engage in short-term extra-marital relationships.

In the concordant scenario, we also find that the size of the downward bias in estimates of the mean duration of overlap between CPs increases with the underlying variation in pairwise overlap. The bias is the largest when a respondent has multiple short-term CPs and one long-term relationship, e.g., a marriage.

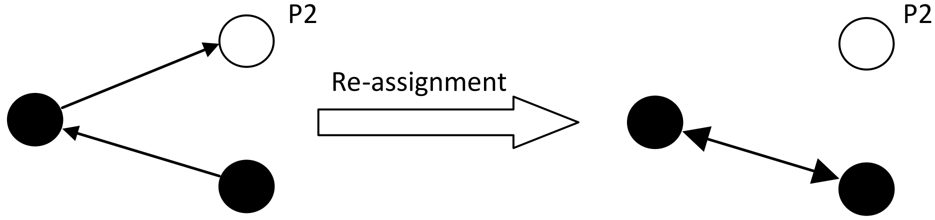
A2. Robustness analyses

The analyses presented here are possibly affected by two difficulties arising from the collection of sociocentric network data. First, respondents occasionally may not provide sufficient information to identify their partners precisely. As a result, such a report may not be correctly linked to a concordant report made by another survey respondent. This has the potential to under-estimate inter-partner agreement in reports of sexual relationships, as shown below.



In that example, both A and P1 are interviewed during the survey. P1 nominates A as his/her partner, while A makes a nomination that cannot be linked to P1. This may be because A is truly reporting a relationship with a different partner, or because A is instead reporting his relationship with P1 but does not do sufficiently specifically for the investigator to link this report to P1. This could be, for example, if A refused to report his partner's residence, or mistakenly reported it as "on the mainland". If additional (or more accurate) information would have allowed identifying P2 as P1 (a process known as "de-duplication"), then IPA would have been higher, since the relationship between A and P1 would have been concordantly reported.

In order to estimate the possible impact of this type of bias in our data, we conduct the following robustness test. In cases similar to the one depicted above, we systematically reassign the relation between A and P2 to P1 as follows, even if the characteristics of P2 reported by A do not match the characteristics of P1:

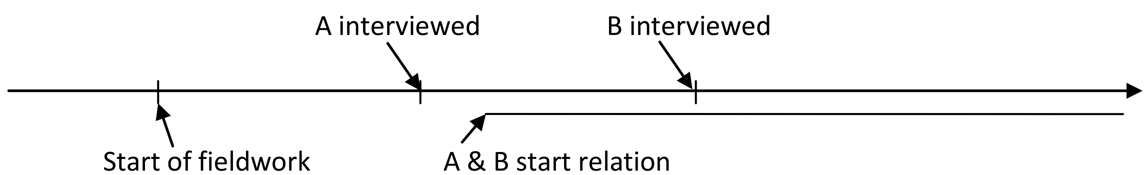


A A

P1 P1

Relationships are re-assigned if P2 was interviewed or not, as long as P2 does not also concordantly report the relationship. If A nominates multiple other partners (not just P2), we choose to reassign the one that best matches the characteristics of P1 (e.g., relationship is ongoing, same village of residence). This is a highly conservative test of the proposition that our results could be explained by limitations of the network linking process: it assumes that in all such triads, the respondent's report was falsely linked to another partner. In total, we re-assigned 47 relationships, 37 of which (78.7%) were non-marital.

Second, survey respondents were not all interviewed on the same day. As a result, their "reporting window" might differ by a number of days, introducing a downward bias in calculations of IPA. This is illustrated by the following diagram. Respondents A and B just started a relationship for example the day after A was interviewed.



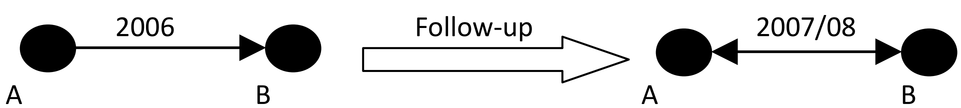
In that situation, the reports of the relationships between A and B cannot be concordant, because the relationship did not exist at the time A was interviewed. It is thus possible for A not to report this relationship and still provide reliable information.

Despite this possibility, the near totality of reporting windows in our study likely overlapped because the 1) median number of days between interviews of two partners was small (2 days for spouses and 7 days for non-marital partners) and 2) the number of relationships having started/ended within one month of the survey also was small (=46 relationships, i.e., 5.5% of the sample had started within one month of the survey). If we assume that the start/end dates of relationships are evenly distributed within each month, this implies that only roughly 1-2% of the total number of relationships reported during the survey had non-overlapping reporting windows. To test whether our results are robust to this assumption however, we replicate the analysis in table 2 after excluding all relationships having started or ended within one month of the survey. This effectively ensures that all reporting windows are overlapping. The results are presented below for both our best match network and the reassigned network.

Table A1 describes results from these robustness tests for ongoing relations. As expected, IPA is higher in the reassigned network data than it is in our best match network data. The main results reported in Table 2 however remain: IPA is negatively associated with the number of partners self-reported by a respondent, for both men and women; IPA also increased with partnership duration. The relationship between partnership duration and IPA among ongoing relationships of men is not significant anymore. This could however be due to more limited sample sizes among men, since the point estimate of the IPA remains higher in longer relationships. Similar results are also obtained if we exclude all relationships having started within one month of the survey. In dissolved relationships, the main results reported in table 2 also remained.

A3. Evidence of under-reporting of relationships during the sexual network interview: results from follow-up network survey

We describe initial results from a follow-up survey we conducted on Likoma in 2007-2008. This survey, based on a study protocol identical to that used in the first round, allows estimating the proportion of relationships discordantly reported in 2006, which were concordantly reported in 2007/08 when both partners were again interviewed. More specifically, we are able to identify how many relationships in which A reported B in 2006 but B did not report A, were concordantly reported in 2007/08 (see below). Here, we call A the "index partner" and B the "secretive partner".



Among the 357 discordantly reported relationships in 2006, we were able to interview both partners again in 2007/08 in 207 cases (58%). In 84 cases (23.5%), we were not able to re-interview the secretive partner, while in 66 cases (18.5%) we were not able to re-interview the index partner. Among the 207 relationships in which both partners were re-interviewed, the index partner reported his/her relationship with the secretive partner again in 48 relationships (23.2%).

If the index partner did not report the relationship again in 2007/08, few secretive partners also did so themselves (4/159 = 2.5%). On the other hand, if the index partner reported the relationship again in 2007/08, then the secretive partner was likely to report this relationship as well. Of the 48 relationships again reported by the index partner, 18(37.5%) relationships were reported by the secretive partner. This proportion further varied significantly with the status of the relationship at the time of the survey in 2006 and in 2007/08. If the index partner reported the relationship as ongoing both in 2006 and in 2007/08, then the secretive partner also reported the relationship in 2007/08 in 10 out 14 cases (71.4%). If the index partner reported the relationship as ongoing in 2006 but not in 2007/08, then the secretive partner also reported the relationship in 2007/08 in 4 out of 9 cases (44.4%). On the other hand, if the index partner reported the relationship as dissolved in 2006, then the secretive partner also reported the relationship in 2007/08 in only 4 out of 24 cases (16.7%).

These patterns of reporting during the follow-up survey are consistent with our findings about the impact of partnership status and duration on reporting: higher reliability in ongoing and long relationships. The large proportion of relationships that are subsequently reported by the secretive partner (particularly when the index partner reports the relationship again at follow-up) is evidence that under-reporting of sexual relationships is common in the 2006 survey analyzed in this paper.