Using STI Biomarkers to Validate the Reporting of Sexual Behavior Within an Experimental Evaluation of Interviewing Methods

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Introduction

With an estimated 40 million people now living with HIV, and 5 million new infections every year, the need to understand and accurately measure sexual behaviors that place populations at risk of sexually transmitted infections (STI) and HIV grows more urgent. The study of sexual behavior is critical not only for understanding one of the proximate determinants of infection, but also for guiding appropriate and effective strategies for reducing transmission. While, the AIDS pandemic has heightened the need for comprehensive data on sexual behavior and the relationship between behaviors, STIs and HIV, the ability to evaluate interventions and monitor reproductive health programs is compromised if reporting of risk activity is inaccurate and unreliable. Not knowing who is having sex in a given population, with whom, and under what circumstances is likely to provide estimates of STI and HIV risk that are seriously biased. Furthermore, when behavioral data are inaccurate, efficacy assessments of technologies designed to prevent or reduce transmission of STIs are undermined.

This paper will examine data from an experimental study evaluating home versus clinic based screening and diagnosis for STIs among women visiting a primary care clinic in São Paulo, Brazil. In addition to evaluating diagnostic technologies for STI, the study included an experimental evaluation of the use of computerized interviewing for obtaining more accurate reporting of sexual and other risk behaviors. In addition to random assignment to home or clinic based screening for STIs, women were randomized to be interviewed at enrollment in either a face-to-face (FTF) interviewer-administered survey or an audio-computer assisted self-interview (ACASI). Along with background demographic characteristics, the enrollment interview included questions about recent sexual activity and condom use, as well as specific information about each participants last three sexual partners. Biological specimens were obtained for gonorrhea, chlamydia and trichomoniasis. The objectives of this paper are to evaluate differentials in reporting of sensitive behaviors by interview mode (FTF and ACASI), and to discern whether the STI biomarkers can provide additional leverage in evaluating the validity of behavioral reporting.

Literature Review

Numerous articles have underscored the need for improved measurement of sexual behavior in survey and clinic based STI/HIV research and have reviewed the associated methodological issues in obtaining accurate behavioral data (Fenton, Johnson, McManus et al. 2001; Fishbein and Pequegnat 2000; Catania, Gibson, Chitwood et al. 1990). These investigators have rightfully pointed out that the quality of self-reported risk behavior data obtained in such studies is often of questionable validity, and that accurate reporting may be undermined by a variety of sources of measurement error and response biases. The authors argue for a greater focus on methodological evaluations and experimentation, with the goal of understanding the dynamics of behavioral reporting in diverse populations and settings. They also point to the need for multi-method approaches for determining best practices in collecting sensitive information. Two approaches that have been emphasized as possible lines of research for assessing the validity and reliability of reporting of sexual and other risk behaviors are the use of alternative modes of interview for evaluating the effect of interview context on reporting, and the use of biological markers.

To address the sensitive nature of questions in studies of sexual behavior and STI/HIV risk, researchers have increasingly utilized computerized self-interviewing techniques. The advantage of computerized over face-to-face interviews is that neither the investigator nor anyone else in the area where the interview is being conducted hears the question or the response, thus maximizing the degree of privacy and confidentiality afforded to the respondent. Computerized techniques have been used extensively for the collection of sensitive data in the United States, supported by a variety of experimental studies indicating that it provides higher reporting of stigmatizing behaviors relative to traditional interview techniques, including sexual behavior (Hewitt 2002; Gross, Holte, Marmor et al. 2000; Des Jarlais, Paone, Miliken et al. 1999; Turner, Ku, Rogers et al. 1998; Tourangeau and Smith 1996), drug and alcohol use (Metzger, Koblin, Turner et al. 2000; Gross, Holte, Marmor et al. 2000; Aquilino 1994), and abortion (Fu, Darroch, Henshaw et al. 1998). Recent studies in developing countries have increasingly begun to implement computerized interviewing techniques and have also found that it provides higher reporting of risk behaviors in diverse settings such as Kenya (Hewett, Mensch, and Erulkar 2004; Mensch, Hewett, and Erulkar 2003), Malawi (Mensch, Hewett, and Gregory 2006), Thailand (Rumakom, Philip Guest, Waranuch Chinvarasopak et al. 1999), India (Potdar and Koenig 2005) and Vietnam (Linh, Blum, Hewett et al. Forthcoming); though one study in Mexico found ACASI produced lower reporting than either random-response techniques or paper-and-pencil self interview (Lara, Ellertson, Diaz et al. 2001). However, the results of these studies clearly indicate that computerized interviewing is not a panacea and its' benefits are often moderated by the types of questions asked, the setting, and the population involved in the study.

Only two studies that we are aware of have combined experimental evaluation of interview methodology, including computerized interviewing, and the collection of biomarkers for assessing the accuracy of reporting (Macalino, Celentano, Latkin et al. 2002; van Griensven, ataphana Naorat, Peter H. Kilmarx et al. 2005). In the Macalino et al study, 1,142 injection drug in users in Baltimore, M.D. were randomized to either an ACASI or FTF questionnaire and tested for HIV. The authors utilized the respondents' HIV status to validate the reporting of risk behaviors. The authors found that respondents in the ACASI interview revealed a greater amount of HIV risk behavior related to both drug use (binging and sharing needles) and sexual behavior (sexual exchange for money, non-condom use).[1] When stratified by HIV status, the authors found interview mode effects only for condom use and among HIV positive participants. ACASI respondents who were HIV positive reveal significantly less condom use than HIV positive FTF respondents, while there were no differences for HIV negative participants. Overall, the results of this study provide only limited support for validating the reporting of risk behaviors using biomarkers.

The van Griensven et al. study focused on the reporting of sexual behavior, alcohol and drug use among a sample of 1,283 students age 15-21 years attending vocational schools in Chiang Rai, Thailand. Participants were randomized to one of four methods of interview: palm-top computer assisted self-interview (PASI), ACASI, paper-and-pencil self-administered and FTF interview, and asked about their sexual behavior and drug use. Urine samples were collected from all respondents to detect the presence of nicotine and amphetamines. The authors found consistent differences in the reporting of sexual behavior for the PASI and ACASI modes relative to the other methods of interview, with both modes of computerized administration producing significantly higher reporting.[2] However, only one out of nine alcohol and drug use questions were significantly differentiated by interview mode. When evaluating the relationship between the urine results and reported drug use by interview mode, only for self-reported smoking was there a significantly greater association, with the PASI and ACASI modes revealing more accurate reporting based on the nicotine biomarker. The authors concluded that PASI and ACASI are relatively similar in the quality of data obtained, and generally superior to paper-and-pencil self-administration and FTF interviewing for collecting sensitive data.

Although the accumulation of evidence generated from multiple experimental studies provides confidence in the benefits of computerized interviews, the usefulness of STI/HIV biomarkers to validate the reporting remains inconclusive. Partially this is a reflection of the limited number of studies that have collected biomarker data in the context of methodological experiments, but it is also due to the lack of a one-to-one relationship between risk behaviors and infection. In other words, the probability of infection is

[1] It should be noted that the results did not always reveal higher reporting in ACASI. For the number and amount of drugs used, the bleaching of shared needles, and sex with other intravenous drug users reporting was higher in FTF. The authors speculate that there was likely over-reporting of drug use and bleaching in the FTF mode, given that the former was a requirement for participation in a broader program of services, while bleaching was strongly promoted by program counselors.

[2] Interestingly, one question in which FTF revealed significantly higher reporting was the use contraception at last sex, a result that parallels results of condom use reporting found the data reported on in this paper. Along with the question of bleaching needles in Macalino et al., these results indicate a pattern over-reporting of behaviors that are protective.

moderated by a variety of factors extraneous to the particular behavioral risk factor, including the prevalence of infection in the general population, the biological susceptibility of the individual, the risk behaviors of partners and their other partners, the availabilty, and cost and effectiveness of STI testing and treatment protocols, to name a few (Catania, Gibson, Chitwood et al. 1990; Boerma and Sharon S. Weir 2005; Fishbein and Pequegnat 2000). Several studies that have examined the association between self-reported sexual behavior, collected via FTF interviews, and STI have failed to find clear relationships. For example, a study of self-reported condom use and incidence of STIs did not find any association between the frequency of use and infection, leading the authors to question the validity of reporting (Zenilman, Weisman, Rompalo et al. 1995). Similarly, a prospective study of antenatal clients in urban Malawi found that the incidence of STIs did not decline among women who reported consistent condom use, suggesting considerable over-reporting (Taha, Canner, Chiphangwi et al. 1996). Although these results suggests the potential benefits of computerized interviewing, they also forewarn about assuming a direct relationship between reported behavior and biological outcomes, even when behavior is accurately reported.

With these difficulties and potential limitations in mind, the next section of the paper discusses the study design and sample from which our data and analyses are drawn. The analyses and results are then discussed, including basic demographic characteristics and STI prevalence of the sample. The observed differences in reporting of risk factor by interview mode are then presented, followed by a further discussion of the empirical consequences of misreporting on capturing the relationship between behavior and infection. A final table of the observed associations between behaviors and a composite measure of STIs by interview mode is presented, followed by a brief conclusion and discussion.

Study design and sample

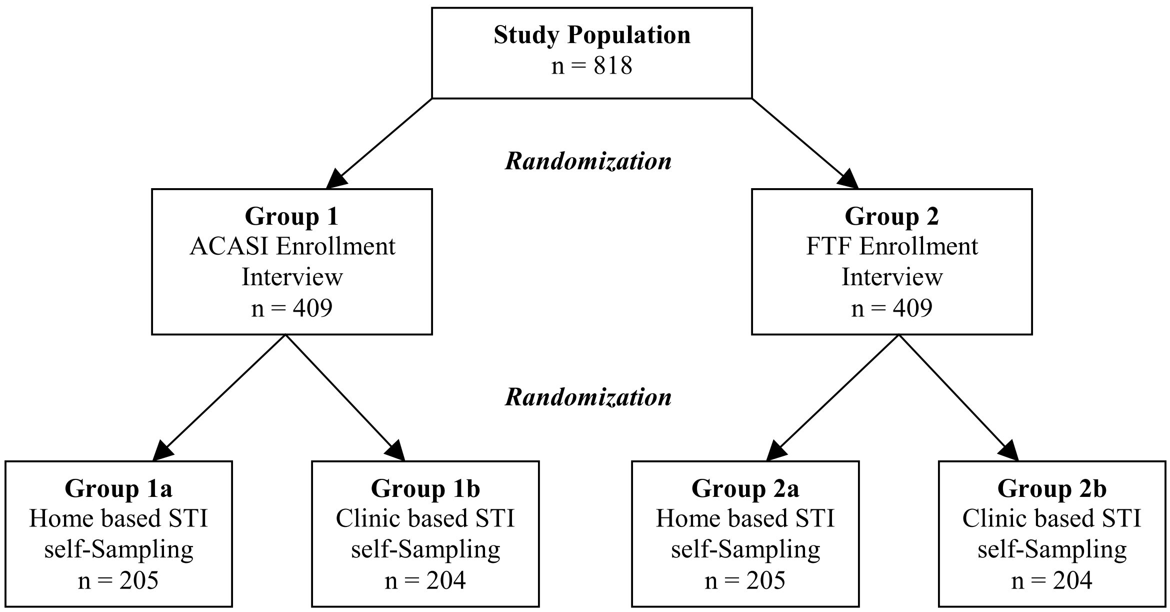
The data used in this paper were collected for an experimental study evaluating home versus clinic based screening and diagnosis for sexually transmitted infections (STI) in São Paulo, Brazil. The goal of the study was to increase the number of gonorrhea, chlamydia and trichomoniasis infections diagnosed and treated by evaluating the effectiveness of participant self-sampling and rapid testing for STIs in a home (experimental group) and clinic environment (control group).[3] The primary analysis in the study was to evaluate whether a greater proportion of women were tested for STIs in the experimental group, with the expectation that women in the home group would be more willing to complete the STI testing regimen than women in the clinic group; the latter were required to return to the clinic for self-sampling, a pelvic exam and testing. The study also set out to evaluate the acceptability and feasibility of self-sampled vaginal swabs, and to compare these outcomes by randomized group.

A total of 818 women age 18–40 were recruited during educational meetings on STIs diagnosis and prevention at the "Centro de Saúde Escola Dr. Alexandre Vranjac, Barra Funda (CSEBF)," a health center run by the Santa Casa Faculty of the Medical Sciences in a low income area of São Paulo.[4] Women from within the clinic population participating in family planning, cervical cancer screening, mother's groups, pediatric care and general services were invited to attend study recruitment sessions, while efforts were made to recruit at least one-thrid of participants from the clinic catchment area. To be eligible for the study women had to be within the age range, self-identifying as literate and not requiring immediate care for a gynecological-related problem. After consenting to participate, women were randomized to either an audio computer-assisted self-interview (ACASI) or a face-to-face (FTF) enrollment interview and randomized a second time to either the home or clinic group for STI sampling (Figure 1).

[3] In Brazil, there were an estimated 3.5 million new cases of chlamydia, 2,5 million new cases of gonorrhea, and 6.1 million new trichomonal infections in 1996 out of a population of approximately 160 million (Coordenacao Nacional de DST e Aids 2003). Over 610,000 people in Brazil are now estimated to be living with HIV (UNAIDS 2002).

[4] For the primary analysis, the sample size allows for hypothesis testing with .80 power, given an alpha of .05 and assuming a minimum of 10% effect size in the outcome by experimental group.

Figure 1. Study Design and Sample



The enrollment quesionnaire included basic demographic information, reproductive history, sexual behavior, contraceptive use, prior STI infections, and alcohol and drug use questions. Participants assigned to the FTF mode were interviewed by trained research staff and clinicians in a private room of the clinic. Respondents completing the ACASI interview were assigned to use one of three computers that were isolated from each other and the main clinic room by protective screens. For the computerized interview, respondents were instructed how to answer the questions, utilizing a external mini-keypad connected to a notebook computer. Although some keys were color coded to simplify tasks, e.g., moving to the next question, replaying the audio, repeating the previous question, repondents were required to enter numeric responses to answer, e.g., 1 = yes or 2 = no. Respondents heard instructions and questions through headphones, while reading text on the computer screen. Although the computerized questionnaire skipped not-applicable questions, the program did not enforce logical consistency in the respondent's answers.[5]

All participants in the study were tested for gonorrhea, chlamydia and trichomoniasis using a Dacron self-administered vaginal swab.[6] The self-administered vaginal swabs were laboratory tested for all three STIs using polymerase chain reaction (PCR) diagnostics. Women in the experimental group were asked to complete self-sampling at home and to return the collection materials to the clinic within 2 weeks of their enrollment visit, while women in the clinic group were given an appointment for sampling and testing at a follow-up visit 1 day to 2 weeks of after enrollment. All participants were asked to return for a six-week follow-up visit, at which point they were interviewed a second time. At the follow-up visit all women were interviewed using ACASI. Since all women returning for the six week follow-up visit were interviewed with the computer, only data from enrollment are used in this paper. The STI data used in this study are based on the results of PCR tested vaginal swabs.

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[5] The computerized interviewing software was developed at the Population Council using Microsoft Visual Basic 6.0 and Access. EPI Info 6.0 was used to data enter the face-to-face surveys, which were double entered.

[6] Syphilis and HIV were collected for a sub-sample of women, but were not available for use in this analysis. Also, for women in the clinic group, clinician-obtained samples were stored and tested for HPV and mycoplasma genitalium.

Analysis and Results

The baseline study and socio-demographic characteristics by interview mode of the 818 study participants can be observed in Table 1. The mean age of women in the sample was 28 years, with an average of 9 years of schooling or 1 year post-primary. The average number of children born to women in the sample was 1.4 , with twenty four women in each interview mode (6%) reporting being pregnant at the time of enrollment. Although most socio-demographic characteristics were the same across the randomized groups, there are statistically significant differences between the ACASI and FTF interview modes for several variables, including marital status, working for cash, type of household sanitation, nature of housing materials, and ownership of a selection of consumer durables. Although individually significant, these differences do not seem to indicate any selectivity in the demographic profile of respondents by interview mode.

Table 1: Study and socio-demographic characteristics of participants

	ACASI (n=409)	**Face-to-Face** (n=409)
Study Characteristics		
Randomized to home group for STI testing	50%	50%
Randomized to clinic group for STI testing[b]	50%	50%
Socio-demographic Characteristics		
Mean age[a]	27.5	27.7
Mean years of schooling[a]	9.1	8.9
Mean number of births	1.4	1.4
Currently pregnant: self-reported	6%	6%
Single[b]	37%	33%†
Married or living together	52%	59%**
Separated, divorced or widowed	11%	9%
Mean family income last month (Real,1R≈$.48)[a]	930	895
Works for cash	51%	72%**
Works as a domestic laborer	55%	77%
Owns home	35%	39%
Rents house or apartment	32%	32%
Lives with relative, employer, favela, others[b]	67%	71%
House has internal plumbing	84%	89%*
House made of finished brick or cement	18%*	10%
Mean number of household durables owned	4.5	4.7†
Self identified skin color: white[b]	39%	41%
Self identified skin color: black	15%	14%
Self identified skin color: mixed	42%	40%
Self identified skin color: indigenous	1%	2%
Self identified skin color: yellow	3%	3%

† p<.10, * p<.05, ** p<.01, significance across mode of interview
[a] Captured in face-to-face eligibility interview prior to enrollment survey
[b] Group used as reference category in multivariate analyses
Note: samples sizes for particular variables vary marginally due to missing values
Note: Household durables include tv, vcr, refrigerator, washing machine, phone and car.

Ninety-six percent of women in the study completed self-sampling and were tested for STIs. The distribution of infection by type and interview mode, can be viewed in Table 2. Among sample women, 13 percent were found to have at least one sexually transmitted infection, with chlamydia representing the most common infection. Only 4 participants in the study presented with multiple infections.[7] Further, there is little difference in observed prevalence by interview mode, which provides some assurance of the success of the randomization procedures despite the relatively small number of infections. The prevalence of infection in the sample is also consistent with a study conducted among a similar population of women aged 18-30 observed at family planning clinics in Brazil, where prevalence was 11% for chlamydia, 1% for gonorrhea, 2% syphilis, and 3% for HIV (Codes, Cohen, Melo et al. 2002). The slightly lower prevalence of chlamydia in our study is likely due to the older age cohort.

Table 2 : Prevalence of STIs by Interview Mode

	ACASI (n=390, 96%) %	**Face-to-Face** (n=391, 96%) %	**Total** (n=781, 96%) %
STI			
Trichomoniasis	4	2	3
Gonorrhea	2	2	2
Chlamydia	9	8	9
Any infection	14	12	13

Our approach for linking self-reported risky sexual behavior and biomarkers of STIs is to capture the association between STIs and risk factors by interview mode. If, as hypothesized, respondents are less likely to report risky sexual behavior in FTF interviewer-administered surveys, the empirical association between STI status and self-reported risk behavior should be lower than that observed in the ACASI group, other things being equal. Of course, this hypothesis suggests that there exist consistent and significant differences in reporting of behavior by interview mode. Table 3 summarizes the reporting of sexual behavior and unprotected sex for women at the time of enrollment. Significant differences in reporting by interview mode are marked by symbols indicating the p-value observed, while boxes highlight results that are consistent with expectations, in other words, where ACASI produced higher reporting than the FTF interview. As can be observed, although the reporting patterns are generally consistent with expectations, not all differences by interview mode are statistically significant.

[7] All women found to have an STI who returned to the clinic were subsequently treated using drug regimens recommended in the Brazilian “Protocols for the Management of a Person with a Sexually Transmitted Disease, According to the Essential Drugs List.”

Table 3: Reporting of STI Risk Factors by Interview Mode

	Sample Estimate		Sample Size	
	ACASI	FTF	ACASI	FTF
Among all women				
% with a sexual partner in the last six months	90	94*	409	409
Mean number of sexual partners in the last six months	1.6†	1.3	409	408
Sexual behavior among those with partners in the last six months				
Mean number of vaginal sex acts in the last month	7.8	8.2	368	385
% having vaginal sex within last month	83	90**	368	385
% having oral sex within last 6m	68*	60	368	385
% having anal sex within last 6m	37**	25	368	385
% using alcohol or drugs prior to sex	29	27	353	380
% with overlapping sexual partners in the last six months	20	17	367	385
% exchanged sex for money, drugs or favors in the last six months	3	2	365	384
% with a partner in the last six months who has been in prison	8	6	365	384
Unprotected sex among those having [type]sex in the last six months				
% having at least one vaginal sex without condom in last six months	81	77	357	384
% not currently using male or female condom to prevent pregnancy	53*	46	359	382
% not using condom last vaginal sex	67	63	366	385
% not using condom last oral sex	90**	83	236	228
% not using condom last anal sex	69	61	122	93
% having at least one vaginal sex without condom in last month	78†	73	304	348
% never using a condom during vaginal sex in the last month	59**	50	304	348
Mean number of sexual acts without a condom in the last month	6.9*	5.8	304	348

† p<.10, * p<.05, ** p<.01, significant level of unadjusted difference by interview mode

As indicated by the boxed results, differences in the reporting of sexual activity by interview mode are generally in the direction hypothesized. However, FTF interviews do produce significantly higher reporting of having had a sexual partner in the last six months and who having had vaginal sex in the last month. These results are not completely surprising given that having a sexual partner and vaginal sexual relations is normative among this sample of women.[8] In fact, it is conceivable that respondents over-report partnerships and vaginal sex in the FTF mode in an attempt to appear more desireable to the interviewer. If nothing else, these findings underscore the difficulty of determing 'true' or 'actual' reporting. Without a fixed external standard of comparison, one can only observe whether the results conform to expectations, even linking behavior with STIs does not provide assurance of the validity of reporting ({Fishbein and Pequegnat 2000}; Catania, Gibson, Chitwood et al. 1990).[9]

Table 3 indicates that in ACASI there is a higher level of reporting of the number of sexual partners in the last six months, although the difference is only significant at the $p < .10$ level. Also, the ACASI group has a greater percent of women reporting oral and anal sex, with anal sex revealing the greatest differences in

[8] For never married women, who may be less inclined to report sexual activity, the reporting of a partner in the last six months is not significantly different by interview mode (88% ACASI and 87% FTF). The differences in the percent having vaginal sex in the last month for these women are in the same direction as the full sample, albeit at lower levels (74% ACASI and 83% FTF).

[9] The STI biomarkers collected in this study and among this population cannot validate individual responses, nor can they empirically capture the degree of bias in point estimates of prevalence; rather, they can suggest via their associations with behavior which interview mode produces the more accurate data. One biomarker that can be used to validate individual level reporting among women is prostate specific antigen (PSA), which tests for the presence of semen in the vagina. PSA can be used to validate the reporting of sexual activity without a condom or other barrier method in the 2 days prior to testing (Macaluso, Lawson, Hortin et al. 2003).

reporting at 12 percent. These latter findings are consistent with expectations that oral and anal sex are stigmatizing and difficult to admit to in a FTF interview. It should be noted, however, that the results for a selection of other potentially stigmatizing behaviors, including the use of alcohol and drugs prior to sex, concurrent sexual partnerships, sexual exchange, and partners in prison reveal only marginal differences in reporting between the two interview modes. Although the results for these latter questions are directionally consistent with expectations, the interview mode differences are of little substantive consequence. Taken in isolation, these particular results provide only limited confirmation that ACASI obtains higher reporting for questions that are thought to be highly stigmatizing and/or embarrassing to study participants.

However, ACASI does reveal greater differences in reporting of unprotected sexual behavior. All 8 measures of unprotected sex are in the expected direction, while 5 are significantly different at p-values of .10 or lower. Even in the three cases where comparisons across mode do not reach a level of significance, the interview mode differences are substantively meaningful and, for anal and oral sex, the lack of statistical significance is likely a function of smaller sample sizes. These results confirm that in settings in which condoms are promoted, women will tend to over-report use to providers in FTF interviews. In this study, the enrollment interview followed shortly after a recruitment presentation where issues of STI diagnosis, treatment and prevention were discussed. However, it is likely that regardless of the relatively short period between STI prevention messages and respondent interview, given the clinic setting and use of professional staff to conduct the interviews, similar patterns of responses would be found even without such counseling.

After establishing systematic reporting differences in risk behaviors by interview mode, we now turn toward assessing whether the observed associations between risk factors and STI further inform us about accuracy of the reporting. If the higher levels of reporting of risk behaviors in ACASI more precisely capture true behavior among women in the sample, the association between infection and behavior should be higher for those in the ACASI group, other things being equal. An alternative way of stating this is that reporting biases attentuate the association between risk and outcome (Catania, Gibson, Chitwood et al. 1990). However, the effect of misreporting depends on the strength of the association between the STI and the particular behavior in the population and whether misreporting is dependent or independent of women's STI status. In this study, these factors remain unknown and unmeasured, hence the 'true' association between risk and infection in this population is not known. Thus, it should be clear that we are left with relative, rather than absolute comparisons of associations.[10]

To provide clarification of the effect of misreporting on the assocation between a risk factor and STI outcome, the following theoretical 2x2 table is offered. On the left hand side of the table, a 'true' association in a sample between STI outcome and risk behavior (condom use) that is known and fixed. In the example, the utilization of condoms (the risk factor) has a signficant odds ratio of infection for non-use relative to use preset at 1.8. That is, women in the population who do not use condoms have an 80% greater odds of aquiring a STI than do women who use. Now, assuming that 10% of women who do *not* use condoms report that they do in a FTF interview, while no women who use a condom report that they do not. Assume further that misreporting is independent of infection. Based on our fixed sample characteristics on the left hand side of the table, this hypothetical produces the observed distribution in the right hand side of the table.[11]

[10] Another problematic issue in capturing the association between reported behavior and STI status is the timing of infection relative to reported behavior, as well as the fact that STI status may affect subsequent sexual behavior. Without repeated observation of respondents over time and the ability to capture changes in behavior and STI status, these issues cannot be adequately addressed.

[11] The distribution in the right hand side of the table was obtained by taking 10% of STI negative women who report "No Condom" (n=50) and 10% of STI positive women who report "no condom" (n=15) in the left hand side of the table and adding them to those who report using "Condoms."

Table 4: Effect of misclassification of risk factor on the measured association with STI

True Association				Misclassified Association			
	Risk factor				Risk factor		
STI	Condom	No Condom	total	STI	Condom	No Condom	total
-	300	500	800	-	350	450	800
+	50	150	200	+	65	135	200
total	350	650	1000	total	415	585	1000
OR=1.80 (SE log OR = .18) CI: 1.27 to 2.56				OR=1.62 (SE log OR = .17) CI : 1.16 to 2.24			

As can be observed in the change in the odds ratio, there is an attenuation in the association between the risk factor and STI status when misclassification due to systematic misreporting is observed. In the misclassified data, non-users have a 62% greater odds of aquiring an STI than condom users, a biased estimate of the risk of non-use. If misreporting were not independent of STI status, for instance if women who were at higher risk of STIs were more likely to misreport, the attenuation of the odds ratio would be even greater. However, as should be noted for this particular example, and given size of the OR, the overall conclusion of a statistically significant relationship would not change. Hence, although odds ratios are biased, such biases would not always be so great as to lead to the acceptance of an erroneous null hypothesis (a Type II error) even at rather high levels of misreporting.[12]

Although one could produce similar 2x2 tables for each risk factor presented in Table 3 by interview mode, we instead calculated correlation coefficients to capture the association between STIs and risk factors. Given the relatively low prevalence of chlamydia, trichomoniasis and gonorrhea in our sample, as well as the limited size of our sample, we focused on the combined measure of participants having *any* STI.[13] The association between STI and risk behaviors was measured by estimating − for each interview mode m − reduced form bivariate probit models in which STI propensities STI^* and risky sexual behavior propensities RSB^* are modeled as a function of a vector of exogenous socio-demographic indicators x (Table 1). This approach for validating reporting obviates the need for a robust, fully specified model of STI infections that would require interaction terms for each risk behavior or reported symptom by interview mode. It also avoids potential problems associated with mutivariate models with unmeasured covariates, as well as the potential endogeneity between STIs and risk behaviors. By simultaneously estimating infection and behavior, an estimate of the covariance of the disturbance terms $\rho_{\varepsilon\lambda} = \text{cov}(\varepsilon_m, \lambda_m)$ can be obtained through the following set of latent variable equations:

$$STI^*_m = x'_m\beta_m + \varepsilon_m, \quad STI_m = 1 \text{ if } STI^*_m > 0, \text{ 0 otherwise}$$
$$RSB^*_{mj} = x'_m\delta_m + \lambda_m, \quad RSB_m = 1 \text{ if } RSB^*_m > 0, \text{ 0 otherwise}$$

This approach is the binary variable analog to partial correlation analysis, with the covariance of error terms representing the residual association between STIs and reported behavior when other factors are controlled. As with correlation in general, the coefficient produced via the bivariate probit model can be interpreted as the linear association between infection and risk behavior, partialed by socio-demographic indicators.[14] Further, for each interview mode, estimates of the correlations can be tested against the null hypothesis of zero correlation using Wald or Lagrange multiplier statistics. In multivariate probit systems,

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[12] Of course, measurement error could have a greater impact on estimated relationships if one were trying to model STI infections multivariately, particularly if multiple correlated risk factors were mismeasured.

[13] Given that the infections in our study have different transmissibility rates, symptoms and reinfection rates the combined measure of any infection is not optimal (Fishbein and Pequegnat 2000). However, each of these infections is preventable by condom use.

[14] For behavioral variables that are measured as counts, e.g., the number of sexual partners, vaginal sex acts and unprotected sex acts in the last month, poisson regressions were used to obtain residuals, which were then correlated with the residuals from similarly modeled probit estimation of STI infection.

correlations across interview mode *m* can also be statistically compared with each other. If significantly higher associations are consistently obtained for the ACASI mode, it would provide strong evidence that computerized self-interviewing provides more accurate data on STI risk than traditional face-to-face interviewing.

Table 5 provides the correlation between error terms of the bivariate probit estimation as an adjusted correlation (using the demographic variables in Table 1) on the right hand side of the table, while also providing a comparative unadjusted bivariate correlation. The unadjusted bivariate correlation is generated using techniques that are appropriate for dichotomously measured variables that are assumed to have an underlying bivariate normal distribution. Such correlations have been found to provide more consistent estimates than techniques that do not account for the distribution of the observed variables (Greer, Dunlap, and Beatty 2003). As before, boxed results indicate cases in which the results are consistent with expectations, i.e., where correlations between infection and risk behavior in the ACASI group are greater than those in the FTF group. Additionally, the shaded boxes indicate statistical significance that the observed correlation is different from zero at p-values less than .05; answering the question of whether there is a significant relationship between the risk factor and infection. Additionally, tests of comparisons across the two modes of interview are evaluated statistically with symbols that indicate their associated p-values. These tests answer the question as to whether ACASI is different than FTF in detecting associations between risk and infection.[15]

Table 5: Association between reported behavior and sexually transmitted infection (STI)

	Correlation coefficient between behavior and STI			
	unadjusted[a]		adjusted	
	ACASI	FTF	ACASI	FTF
Measures of sexual behavior				
Number of sexual partners in the last six months	.00	.02	.00	.09
Number of vaginal sex acts in the last month	.13	-.09	.16	-.04
Vaginal sex within last month	.16	-.17	.30	.27
Oral sex within last 6m	.14	-.04	.31**	-.07
Anal sex within last 6m	-.04	.22†	.04	.17
Use of alcohol or drugs prior to last sex	.17	.29	.09	.30†
Overlapping sexual partners in the last six months	.18	.15	.15	.14
Exchanged sex for money, drugs or favors in the last six months[b]	.11	.42**	.02	.42**
Partner in the last six months who has been in prison	.42**	.02	.45**	.02
Measures of unprotected sexual behavior				
Not currently using male or female condom to prevent pregnancy	.33*	.05	.42**	.08
At least one vaginal sex without condom in last six months[c]	.32**	.02	.44**	-.03
No condom last vaginal sex[c]	.32**	-.06	.38**	-.06
No condom last oral sex[c]	.33	.18	.25	.05
No condom last anal sex[c]	-.09	-.24	-.01	-.43
At least one vaginal sex without condom in last month[c]	.33*	.05	.40**	.02
Never using a condom during vaginal sex in the last month[c]	-.01	.12	.18	.12
Number of vaginal sex acts without a condom in the last month[c]	.12	.07	.17	.01

† p<.10, * p<.05, ** p<.01 significance across experimental groups
[a] Unadjusted correlations are captured by tetrachoric correlations for dichotomous indicators and polyserial correlations for mixed continuous and dichotomous variables.
[b] Family income, works for cash, ownership of durables and quality of housing removed from bivariate probit equation due to potential endogeniety with sexual exchange.
[c] For these questions, male or female condom was not explicitly distinguished.

[15] The statistical comparison of correlations by experimental group are z-tests after conversion using Fisher's transformation. Although such tests are problematic when the correlations are themselves correlated (Steiger 1980), given the randomized study design, this method provides a robust assessment of interview mode differences.

Table 5 is conceptually divided into behaviors that are indirectly assocated with STI infection and those that are more proximate, with the expectation that the strongest associations between behavior and infection should be related to the measures of unprotected sex, represented by indicators in the bottom half of the table. As is observed, the unadjusted and adjusted correlations are generally consistent with each other across the range of the behaviors, with the adjusted correlations in most instances indicating a somewhat stronger association. Additionally, as is indicated by the boxed results, 13 of the 17 measures are consistent with expecations, in that the strongest adjusted correlations between reporting and STI outcomes are in the ACASI group relative to the FTF group. Of course, of these 13 only 6 are signficantly different from the FTF mode at the $p < .05$ level. Of the 4 indicators that do not follow the expected pattern, two (alcohol and/or drug use prior to sex and sexual exchange), show fairly strong associations in the FTF but not ACASI mode. These associations in the FTF group are not easily explained, although along with women with partners who have been to prison, they are considered risk factors in this population of women in Brazil. Also, additional analyses (not shown) indicate that the interview mode differences for these indicators do not reflect differential condom use, as those who are positive for the risk factor in the FTF group have either a similar or higher level of general condom use than the ACASI group.[16]

The results are more consistent with our expectations for the series of indicators that are considered more proximate to STIs, specifically the measures of unprotected sexual relations. In most cases, the assocations between condom use and infection are strong and statistically significant in the ACASI mode, while being negligibly different from zero in the FTF group.17 The results in Table 5 also appear to be strongest for unprotected *vaginal* sex. Given that transmission probabilities for the STIs under consideration in this analysis (chlamydia, trichomoniasis, gonorrhea) are highest for vaginal sex, and given that the sampling for STIs was implemented through vaginal swabs, the pattern of these results is consistent with what one would expect and, hence, provide some reassuring support for the conclusion that ACASI interviews are providing more accurate behavioral information. Coupled with the results provided in Table 3, these results further suggest that women are over-reporting their condom use in FTF interviews, in effect, diluting the observed relationship between risk behavior and infection.

Although the ACASI group shows significant differences in unprotected sex overall, it should be noted that women interviewed via the computer report only one additional unprotected sex act than those in the FTF group. For instance, if one compares the mean number of vaginal sex acts and the mean number of vaginal sex acts where a condom is used, on average ACASI women report approximately 7 unprotected sex acts out of 8 in the last month, while women in the FTF group report 6 unprotected sex acts out of 8 in the last month. Further, the correlation between the number of unprotected vaginal sex acts and infection – albeit higher in the ACASI group – is nonetheless lower and non-significant relative to correlations of STIs with other measures of unprotected sexual relations. Given that transmission probabilities should increase with exposure, these results do not support our expectation that the number of unprotected vaginal sex acts should be highly correlated with STI infection. However, it is very possible – independent of mode of interview – that women are overestimating condom use when asked for an exact count of unprotected sex acts in the last month. Given the fairly lengthy recall period referenced by the question, repondents may over-estimate protective behaviors.[18]

[16] Note that information about condom use specific to sexual exchange was not obtained, which is unfortunate given the strength of the results for this question. It should be noted that, at least for sexual exchange, these results may partially reflect small numbers who are positive for the risk factor (Table 3).

[17] These results do not control for condom failure and misuse, which is considered important for properly capturing the association between use and infection (Crosby, Laura F. Salazar, Ralph J. Diclemente et al. 2005; Fishbein and Pequegnat 2000).

[18] The questions explicitly ask the respondent to provide an estimate of the number of times they had vaginal sex and the exact number of times they had vaginal sex with a condom if they did not know the exact number. These questions were asked for each of three sexual partners of which information was collected.

Discussion and Conclusions

This research adds to a long line of studies that have experimentally evaluated the use of computerized administration of interviews to obtain more accurate reporting of sensitive behaviors. As with much of the previous research, our results largely conform to expectations that ACASI produces significantly higher reporting of sexual and risk behaviors than traditional FTF interviews; presumably giving respondents greater privacy and confidentiality in revealing embarrassing and stigmatizing behaviors. Our results for the reporting of unprotected sexual relations that reveal much lower reporting of condom use in ACASI strongly suggest that women are over-reporting protective behaviors when asked by research staff or providers in a clinic setting. As suggested in the literature review, these results follow a pattern of responding in socially desirable ways that have been observed with other issues and behaviors, as well as among other populations and settings.

Despite potential problems with the use of biomarkers of STI/HIV in validating the reporting of sexual behavior, as Fishbein and Pequegnat, (2000: 102) suggest "when there are grounds for assuming an isomorphic relation between a biological asessment and a self-reported behavior, and when the biochemical measure is relatively non-invasive, biological and biochemical measures may provide the best evidence for the validity – or lack of validity – of behavioral self-reports." Although our measures of sexual and risk behavior are not strictly one-to-one, we did find significant associations between behavior and infections, particularly for the ACASI mode of administration. The degree of association found between unprotected sex acts and STIs in ACASI provides additional support to our hypotheses that computer administration is providing more valid estimates of behavior. Nonetheless, it bears emphasizing that, even with these findings, we cannot claim to have obtained point estimates of risk behaviors that are without measurement error.

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