American Journal of Epidemiology
Vol. 168, No. 2
DOI: 10.1093/aje/kwn113
Advance Access publication June 4, 2008

Practice of Epidemiology

Using Sexually Transmitted Infection Biomarkers to Validate Reporting of Sexual Behavior within a Randomized, Experimental Evaluation of Interviewing Methods

Paul C. Hewett[1], Barbara S. Mensch[1], Manoel Carlos S. de A. Ribeiro[2], Heidi E. Jones[1,3], Sheri A. Lippman[4,5], Mark R. Montgomery[1], and Janneke H. H. M. van de Wijgert[1,6]

[1] Population Council, New York, NY.
[2] Department of Social Medicine, Santa Casa School of Medical Sciences, São Paulo, Brazil.
[3] Division of Family Planning and Preventive Services, Department of Obstetrics and Gynecology, Columbia University Medical Center, New York, NY.
[4] Division of Epidemiology, University of California Berkeley, Berkeley, CA.
[5] Population Council, Campinas, Brazil.
[6] Center for Poverty-Related Communicable Diseases, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands.

Received for publication October 16, 2007; accepted for publication April 3, 2008.

This paper examines the reporting of sexual and other risk behaviors within a randomized experiment using a computerized versus face-to-face interview mode. Biomarkers for sexually transmitted infection (STI) were used to validate self-reported behavior by interview mode. As part of a parent study evaluating home versus clinic screening and diagnosis for STIs, 818 women aged 18–40 years were recruited in 2004 at or near a primary care clinic in São Paulo, Brazil, and were randomized to a face-to-face interview or audio computer-assisted self-interviewing. Ninety-six percent of participants were tested for chlamydia, gonorrhea, and trichomoniasis. Reporting of STI risk behavior was consistently higher with the computerized mode of interview. Stronger associations between risk behaviors and STI were found with the computerized interview after controlling for sociodemographic factors. These results were obtained by using logistic regression approaches, as well as statistical methods that address potential residual confounding and covariate endogeneity. Furthermore, STI-positive participants were more likely than STI-negative participants to underreport risk behavior in the face-to-face interview. Results strongly suggest that computerized interviewing provides more accurate and reliable behavioral data. The analyses also confirm the benefits of using data on prevalent STIs for externally validating behavioral reporting.

biological markers; computing methodologies; condoms; data collection; regression analysis; sexual behavior; sexually transmitted diseases; social desirability

Abbreviations: ACASI, audio computer-assisted self-interviewing; HIV, human immunodeficiency virus; RSB, risky sexual behavior; STI, sexually transmitted infection.

With an estimated 33 million people now living with human immunodeficiency virus (HIV) and 2–3 million new infections every year (1), the need to understand and accurately measure sexual behaviors that place populations at risk of sexually transmitted infections (STIs) and HIV grows more urgent. The study of sexual behavior is critical not only for understanding the proximate determinants of infection but also for guiding appropriate and effective strategies and interventions for reducing transmission. Numerous authors have identified the need for improved

Correspondence to Dr. Paul C. Hewett, Population Council, One Dag Hammarskjold Plaza, New York, NY 10017 (e-mail: phewett@popcouncil.org).

measurement of sexual behavior in STI/HIV research and have reviewed the associated methodological challenges in obtaining accurate behavioral data (2–4). Such authors have argued for a greater focus on methodological evaluations and experimentation, the need for multimethod approaches to determine best practices, and the use of external validation to assess the accuracy of sexual behavior reporting.

To address the issue of misreporting of sexual and STI/HIV risk behavior in face-to-face interviews, researchers in the United States have increasingly turned to audio computer-assisted self-interviewing (ACASI) techniques. Randomized experimental evaluations comparing reporting by interview mode have found higher reporting with ACASI across an array of sensitive behaviors, including sexual behavior (5–9), drug use and alcohol consumption (6, 7, 10, 11), and abortion (12). Similar studies conducted in developing countries have also generally found that ACASI produces higher reporting of risk behaviors in such diverse settings as Kenya (13, 14), Malawi (15), Thailand (16), India (17), and Vietnam (18). However, one study in Mexico found that ACASI reported a lower prevalence of abortions than paper-and-pencil self-administration and random-response techniques (19).

Although the evidence from multiple studies bolsters confidence in the benefits of computerized interviewing, the need for externally validating self-reports remains (2–4). Given the stigmatization of many sexual and risk behaviors, it is often assumed in interview-mode experiments that the higher reporting of behavior is the more accurate. External validation provides an objective criterion to test this assumption, despite the absence of a single and definitive ‘‘gold standard’’ for self-reports of sexual behavior (3, 20). A variety of methods for externally validating self-reporting of risk behavior have been used (20–23), but few studies have *combined* randomized interview mode experimentation and collection of STI outcomes as markers for risky behavior (24, 25).

The empirical linking of STI outcomes and reports of sexual behavior is not straightforward. Infection probabilities are often moderated by factors extraneous to the particular risk behavior, including the background prevalence of infection in the general or subpopulation; partner status; the biological susceptibility of the individual; and the availability, cost, and effectiveness of STI testing and treatment, to name only a few (3, 4, 26, 27). To properly capture empirical associations, a range of appropriate behaviors should be accurately measured and controlled. Often, methods for measuring association control for a only a limited number of relevant covariates. Unmeasured covariates and potential endogeneity of behavioral measures can lead to biased inferences regarding the associations between risk factors and STI (3, 27).

The objective of this study was to compare the reporting of sexual and risk behaviors collected in computerized and face-to-face interviews and to utilize STI outcomes to externally validate self-reporting. We used two alternative techniques, logistic and bivariate probit regression, to empirically estimate the association between self-reported behavior and STI outcomes.

MATERIALS AND METHODS

Study design and population

Data for this paper were collected as part of a larger study to determine the effectiveness, acceptability, and feasibility of using participant self-collected vaginal swabs for STI diagnosis in a home versus clinic environment (28). The broader purpose of the study was to assess whether a home-based screening strategy using self-collection of specimens would increase detection and accurate treatment of STIs (gonorrhea, chlamydia, and trichomoniasis) in young women in a low-income area of São Paulo, Brazil. From April to November 2004, a total of 818 women aged 18–40 years participated in the study.

Women were recruited during educational meetings on STI diagnosis and prevention at the Centro de Saúde Escola Dr. Alexandre Vranjac, Barra Funda (CSEBF), a primary care health center operated by the Santa Casa Faculty of the Medical Sciences. Women from within the clinic population participating in family planning, cervical cancer screening, mothers' groups, pediatric care, and general services were invited to attend study recruitment sessions, with one third of participants recruited from the catchment area of the clinic. To be eligible for the study, women were required to be aged 18–40 years, self-identify as literate, and not need immediate care for a gynecologic-related problem. After the purposes and procedures of the study were explained, informed consent from participants was obtained. The study protocol was approved by the ethical committees of the Irmandade Santa Casa de Misericórdia de São Paulo, the Brazilian National Ethics Committee (Comissão Nacional de Ética em Pesquisa), and the Population Council Institutional Review Board.

Women were randomized at enrollment to either home-based (experimental group) or clinic-based (control group) self-sampling. Women in the experimental group were given a kit for self-collection and were asked to return the materials to the clinic within 2 weeks of their enrollment visit. Women in the control group were given an appointment for self-sampling at the clinic 1 day to 2 weeks after enrollment. In all, 96 percent of study participants completed self-collection and were tested for gonorrhea, chlamydia, and trichomoniasis, with no differences between groups in the proportion of participants diagnosed and treated. Details regarding the results of the screening initiative are discussed elsewhere (28).

As part of the parent study, women were also randomized at enrollment to either a face-to-face, interviewer-administered survey or ACASI. Stratification and block randomization methods were used to assure an equal number of ACASI and face-to-face respondents in the experimental and control groups (ACASI/home, ACASI/clinic, face-to-face/home, face-to-face/clinic). A baseline questionnaire was administered to all women, collecting basic demographic information, reproductive history, sexual behavior, contraceptive use, prior history of STIs, alcohol consumption and drug use, and information about the participant's last three sexual partners. Participants assigned to the face-to-face mode were interviewed by trained research staff in a private room at the clinic. Respondents completing the ACASI interview were assigned to a computerized interview isolated from the main clinic room by protective screens. The computerized interviewing software was developed at the Population Council by using Microsoft Visual Basic 6.0 and Microsoft Access (Microsoft Corporation, Redmond, Washington). EPI Info 6.0 (Centers for Disease Control and Prevention, Atlanta, Georgia) software was used for double data entry of the face-to-face surveys.

Laboratory procedures

Biological specimens for gonorrhea, chlamydia, and trichomoniasis diagnosis were obtained from dry, self-administered vaginal swabs. Sensitivity and specificity have been shown to be good for self-collected vaginal swabs compared with clinician-obtained swabs, when combined with nucleic acid amplication testing (29, 30). The presence of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* was identified by using COBAS Amplicor CT/NG polymerase chain reaction (Roche Molecular Diagnostics, Pleasanton, California). *Trichomonas vaginalis* was diagnosed by using an in-house polymerase chain reaction test adapted from a previously validated assay (31). All polymerase chain reaction protocols were reviewed by the San Francisco General Hospital Chlamydia Laboratory.

Statistical methods

To compare the reporting of sensitive behaviors by interview mode (ACASI vs. face-to-face), two-sided t tests for differences in means for continuous variables and z tests for differences in proportions for dichotomous variables were conducted; differences were evaluated with and without adjustment for participants' sociodemographic characteristics. Prior to study implementation, sample sizes were calculated such that hypotheses tests could be evaluated on the full sample of women with 0.80 power, an alpha value of 0.05, and a minimum of 10 percent effect size by interview mode (32, 33).

As a means of externally validating reporting, we estimated the association between various reported risky sexual behaviors (RSBs) and STI status by interview mode. Given the relatively low prevalence of gonorrhea, chlamydia, and trichomoniasis in study participants, a combined measure of *any* STI was used as the outcome variable; similar combined measures have been used elsewhere in the literature (34, 35). Prevalent STI was modeled as a function of a single RSB, controlling for a range of sociodemographic variables by using logistic regression estimated separately for each interview mode (m), as in the following:

$$\begin{aligned} \mathrm{STI}_m &= \mathrm{RSB}_m \phi_m + x'_m \beta_m + \varepsilon_m, \\ \mathrm{STI}_m &= 1 \text{ if } \mathrm{STI}^*_m > 0, \quad 0 \text{ otherwise.} \end{aligned} \tag{1}$$

To statistically test differences in the associations by interview mode, the data were pooled and interaction terms between RSB and mode of interview were estimated. Given that the coefficients of the interaction terms are difficult to interpret (36) and the approach in equation 1 allows the β coefficients to vary by interview mode, odds ratios from the separate regressions by interview mode are presented in this paper.

A potential drawback of estimating equation 1 is that it assumes that the error term (ε_m) is distributed independently of the RSB variables. However, unmeasured factors that influence STI acquisition are also likely to be correlated with behavior, for example, the biological susceptibility of the individual; the risk behaviors of partners and their sexual networks; and the availability, cost, and effectiveness of STI testing and treatment protocols (3, 4, 27). Hence, the independence assumption might fail to hold, leading to inconsistent estimates of the association between RSBs and STIs. This large-sample bias is particularly problematic for our analysis because we used the measured associations to validate reporting by mode of interview.

To account for unmeasured confounding, as well as potential endogeneity in the various measures of sexual behavior, we also examined the partial correlation between STI and RSB net of the influence of the sociodemographic variables. Because STI and RSB are binary variables, we estimated the partial correlation by using a bivariate probit method, which has been used previously in the epidemiologic and medical literature when addressing similar issues (37–40). In the bivariate probit procedure, STI propensities (STI*) and RSB propensities (RSB*) are modeled solely as a function of exogenous sociodemographic indicators (x). The regression coefficient vectors (α) and (δ) link the sociodemographic variables to the respective outcome. This method is illustrated in the following set of equations:

$$\begin{aligned} \mathrm{STI}^*_m &= x'_m \alpha_m + \eta_m, \\ \mathrm{STI}_m &= 1 \text{ if } \mathrm{STI}^*_m > 0, \quad 0 \text{ otherwise.} \end{aligned} \tag{2}$$

$$\begin{aligned} \mathrm{RSB}^*_m &= x'_m \delta_m + \lambda_m, \\ \mathrm{RSB}_m &= 1 \text{ if } \mathrm{RSB}^*_m > 0, \quad 0 \text{ otherwise.} \end{aligned} \tag{3}$$

The bivariate probit procedure simultaneously estimates infection and behavior, producing consistent coefficients for the exogenous variables. The residuals obtained represent the remaining variance of STI and RSB. When these residuals are used, the bivariate probit generates an unbiased estimate of the correlation of the disturbance terms $\rho_{\varepsilon\lambda} = \mathrm{cov}\ (\eta_m, \lambda_m)$; for variables measured as counts, negative binomial regressions were used to obtain residuals. Ranging from 0 to 1, ρ can be interpreted as being analogous to a partial correlation coefficient, capturing the linear association between RSB and STIs, controlling for sociodemographic factors. Given the randomized study design, the correlation (ρ) was statistically compared across interview modes (m) based on z tests by using Fisher's transformation (41). Estimates of the correlations were tested against the null hypothesis of zero correlation (or no association) between STI status and behavior by using Wald or Lagrange multiplier statistics.

RESULTS

The baseline sociodemographic characteristics of the 818 study participants are provided in table 1, separately by interview mode. The differences do not indicate any systematic selectivity in the sociodemographic profile of women by interview mode.

Table 2 summarizes the reporting of sexual behavior and unprotected sex for women by interview mode at the time of enrollment, coded in the direction of increased risk of STI. Significant differences in self-reporting by interview mode indicate the significance level of the p value obtained.

Seventeen of the 21 indicators revealed higher reporting of risk behaviors in the ACASI group, with five being statistically significant at the $p < 0.10$ level. Face-to-face interviews produced a significantly higher percentage of women reporting having had vaginal sex in the last month. A significantly greater percentage of women in the ACASI group reported having oral ($p < 0.10$) and anal ($p < 0.01$) sex within the last 6 months. Reported unprotected sexual behavior was also greater among ACASI respondents: all eight measures of unprotected sex were in the expected direction, with three significantly different from each other at $p \leq 0.10$. Even in the five instances in which comparisons did not reach statistical significance, the differences were substantively meaningful and the lack of statistical significance was likely a function of smaller subgroup sample sizes. The three indicators at the bottom of table 2 are proxy measures of heightened STI/HIV risk, combining several risk factors into a single indicator. Whereas the first two of these indicators show that ACASI respondents were more likely to report combined risks than those interviewed face-to-face, the third indicates higher reporting in the face-to-face mode; none were statistically significant.

The distribution of infections by type and interview mode is provided in table 3. A combined indicator of any STI was constructed from the three individual STI measures. Of all sample women, 13 percent were found to have at least one STI, with chlamydia being the most common. Only four participants in the study presented with multiple infections. Furthermore, there was little difference in observed STI prevalence by interview mode, which provides some assurance of the success of the randomization by interview mode procedures.

Table 4 shows the estimated associations between self-reported sexual behavior and STI status. The first two columns of results are odds ratios from the logistic regression models estimated separately for each interview mode. In the logistic regression analyses that included interaction terms, no statistically significant differences by interview mode were observed (not shown). Although the interaction terms were not significant, the pattern of odds ratios presented in table 4 indicates that, in general, ACASI revealed stronger associations between sexual behavior and STI, with 15 of the 21 measures evidencing a stronger positive association in the ACASI group; nine of the ACASI odds ratios were significantly different from the behavioral reference group, relative to two in the face-to-face group (table 4). In addition, the odds ratios were consistently stronger with the ACASI mode for the measure of unprotected sexual behavior and the behavioral risk combination variables.

TABLE 1. Study and sociodemographic characteristics of participants by interview mode, São Paulo, Brazil, 2004‡

	ACASI§ (n = 409)	FTF§ (n = 409)
Study characteristics		
% Randomized to home group for STI§ testing	50	50
% Randomized to clinic group for STI testing¶	50	50
Sociodemographic characteristics		
Mean age (years)#	27.5	27.7
Mean years of schooling#	8.9	8.9
Mean no. of births	1.3	1.4
% Currently pregnant: self-reported	6	6
% Single¶	37†	33
% Married or living together	52	59†
% Separated, divorced, or widowed	11	9
Mean family income last month (real; 1 R$ ≈ $0.48 US)#	819	837
% Works for cash	51	72**
% Works as a domestic laborer	7	10†
% Owns her home	35	39
% Rents a house or apartment	32	32
% Lives with relative, employer, in a favela, others¶	67	71
% Has house with internal plumbing	84	89*
% Has house made of finished brick or cement	17**	10
Mean no. of household durables owned‡‡	4.5	4.7
% Self-identified skin color: white¶	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

* $p < 0.05$; ** $p < 0.01$: significance level across interview mode.
† $p < 0.10$: significance level across interview mode.
‡ Sample sizes for particular variables vary marginally because of missing values.
§ ACASI, audio computer-assisted self-interviewing; FTF, face-to-face; STI, sexually transmitted infection.
¶ Group used as the reference category in multivariate analyses.
# Captured in an FTF eligibility interview prior to enrollment survey.
‡‡ Includes television, videocassette recorder, refrigerator, washing machine, telephone, and car.

The bivariate probit results presented in the last two columns of table 4 provide alternative estimates of the association between risk behavior and STI outcomes by interview mode. The results revealed statistically significant differences by interview mode, with 10 of the 21 ACASI correlations significantly different from face-to-face at the $p < 0.10$ level. Furthermore, all but five behavioral indicators showed stronger positive correlations with ACASI, with only one (sexual exchange) having a statistically significant

TABLE 2. Reporting of sexual behavior by interview mode, São Paulo, Brazil, 2004‡

	Estimate		Sample size	
	ACASI§	FTF§	ACASI	FTF
Among all women				
% With a sexual partner in the last 6 months	92	94	409	409
Mean no. of sexual partners in the last 6 months	1.6	1.3	409	408
Sexual behavior among those with partners in the last 6 months				
Mean no. of vaginal sex acts in the last month	7.9	8.2	378	385
% Having vaginal sex within the last month	83	90**	378	385
% Having oral sex within the last 6 months	67†	60	355	382
% Having anal sex within the last 6 months	33**	24	355	383
% Consuming alcohol or using drugs prior to the last sex act	28	27	373	381
% With overlapping sexual partners in the last 6 months	20	17	376	385
% Exchanged sex for money, drugs, or favors in the last 6 months	4	3	376	385
% With a partner in the last 6 months who has been in prison	8	6	365	384
Unprotected sex among those having [type of] sex in the last 6 months				
% Having at least one vaginal sex act without a condom in the last 6 months¶	81	77	364	384
% Not currently using a male or female condom to prevent pregnancy¶	52	46	377	385
% Not using a condom during last vaginal sex¶	67	63	375	385
% Not using a condom during last oral sex¶	90†	84	236	228
% Not using a condom during last anal sex¶	69	61	122	93
% Having at least one vaginal sex act without a condom in the last month¶,#	78	73	311	348
% Never using a condom during vaginal sex in the last month¶,#	59*	51	311	348
Mean no. of sex acts without a condom in the last month¶,#	7.0*	5.8	311	348
Risk combinations among those having [type of] sex in the last 6 months				
% Not using a condom during last vaginal sex and not using a condom during last oral sex¶,‡‡	69	62	236	228
% With a partner in the last 6 months who has been in prison and not using a condom during vaginal sex¶,‡‡	6	4	363	384
% Consuming alcohol or using drugs prior to sex, having overlapping partners, and not using a condom during last vaginal sex¶,‡‡	6	8	308	345

* $p < 0.05$; ** $p < 0.01$: significance level across interview mode.

† $p < 0.10$: significance level across interview mode.

‡ Sample estimates are unadjusted for the demographic characteristics listed in table 1. Analysis (not shown) revealed insignificant differences from adjusted results.

§ ACASI, audio computer-assisted self-interviewing; FTF, face-to-face.

¶ Asked only of those reporting having had this type of sex; male or female condom not explicitly distinguished.

These indicators were generated from two questions asked about each of three partners: the number of vaginal sex acts in the last month with that partner and the number of vaginal sex acts without a condom in the last month with that partner.

‡‡ These variables were generated by using combinations of other measures in the table and hence are not mutually exclusive from them.

correlation favoring the face-to-face mode. In addition, 12 of the ACASI correlations, but only three of the face-to-face correlations, were significantly different from zero (or no association) at the $p < 0.05$ level (table 4).

Table 5 stratifies participants by their STI status and examines the reporting of sexual behaviors by interview mode. Results indicated that, in general, women who were STI positive were more likely to report risk behaviors than their counterparts who were STI negative. The results for STI-positive women interviewed with the ACASI method were stronger, with 16 of the 21 behavioral risk indicators showing higher reporting; five were significant at the $p < 0.10$ level. For STI-negative women, the interview mode differences were not as significant despite the larger sample of women; 14 indicators were directionally consistent, with only three statistically significant.

DISCUSSION

This research contributes to the literature by experimentally evaluating the use of computerized interviewing to

TABLE 3. Prevalence (%) of STIs* by interview mode, São Paulo, Brazil, 2004

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

* STIs, sexually transmitted infections; ACASI, audio computer-assisted self-interviewing; FTF, face-to-face.

obtain more accurate reporting of sensitive behaviors. It is one of only a few studies that have attempted to validate the reporting of behavior with STI biological markers within a randomized interview mode experiment. On the basis of findings from previous studies, it was expected that, compared with face-to-face interviews, computerized interviewing—which provides a greater degree of privacy and confidentiality in the interview context—would produce higher reporting of stigmatizing sexual behaviors and lower reporting of condom use. Furthermore, it was expected that, if more accurate, the behavioral reporting in ACASI would reveal stronger associations with STI outcomes than those

TABLE 4. Estimated associations between reported sexual behavior and STI,‡ São Paulo, Brazil, 2004§

	Equation 1: odds ratios		Equations 2 and 3: correlations (ρ)	
	ACASI‡	FTF‡	ACASI	FTF
Measures of sexual behavior				
Sexual partner in the last 6 months	1.41	3.00	0.10	0.13
No. of sexual partners in the last 6 months	1.00	1.02	0.04	0.08
No. of vaginal sex acts in the last month	1.05	0.99	0.15¶	−0.03
Vaginal sex within the last month	1.92	0.94	0.28†,¶	0.06
Oral sex within the last 6 months	2.47¶	0.82	0.32*,¶	−0.05
Anal sex within the last 6 months	1.27	1.61	0.14	0.17
Consumption of alcohol or use of drugs prior to last sex	2.00¶	2.16¶	0.16	0.30¶
Overlapping sexual partners in the last 6 months	1.55	1.34	0.16	0.11
Exchanged sex for money, drugs, or favors in the last 6 months#	1.88	5.01¶	0.20	0.49*,¶
Partner in the last 6 months who has been in prison	3.34¶	0.81	0.42*,¶	−0.01
Measures of unprotected sexual behavior				
Not currently using a male or female condom to prevent pregnancy	3.57¶	1.24	0.39*,¶	0.10
At least one vaginal sex act without a condom in the last 6 months	3.34¶	0.99	0.48*,¶	−0.01
Not using a condom during last vaginal sex	3.13¶	0.82	0.41*,¶	0.04
Not using a condom during last oral sex	2.30	1.78	0.26¶	0.13
Not using a condom during last anal sex	1.39	0.57	0.06	−0.34¶
At least one vaginal sex act without a condom in the last month	4.72¶	1.15	0.41*,¶	0.04
Never using a condom during vaginal sex in the last month	1.47	1.49	0.17¶	0.11
No. of vaginal sex acts without a condom in the last month	1.05	1.01	0.16	0.03
Risk combinations				
No condom during last vaginal sex and no condom during last oral sex	2.80¶	1.31	0.32*,¶	0.15
Partner in the last 6 months who has been in prison and no condom during last vaginal sex	5.20¶	0.94	0.52*,¶	−0.07
Consumption of alcohol/use of drugs prior to sex, overlapping partners, and no condom during last vaginal sex	2.76	0.98	0.37*,¶	0.13

* $p < 0.01$: significance level across interview mode; no significant differences were observed using logistic regression.

† $p < 0.10$: significance level across interview mode; no significant differences were observed using logistic regression.

‡ STI, sexually transmitted infection; ACASI, audio computer-assisted self-interviewing; FTF, face-to-face.

§ Odds ratios and correlations were adjusted for sociodemographic variables listed in table 1. Refer to the Materials and Methods section of the text for the definitions of equations 1–3.

¶ Odds ratio different from 1.0 and correlation different from 0 at $p < 0.05$.

Family income, works for cash, ownership of durables, and quality of housing were removed from the regression equation because of potential endogeneity with sexual exchange.

TABLE 5. Reporting of sexual behavior by STI‡ status and interview mode, São Paulo, Brazil, 2004§

	STI positive			STI negative		
	ACASI‡	FTF‡	No.	ACASI	FTF	No.
Among all women						
% With a sexual partner in the last 6 months	94	98	102	92	94	680
Mean no. of sexual partners in the last 6 months	1.6	1.3	100	1.6	1.3	680
Sexual behavior among those with partners in the last 6 months						
Mean no. of vaginal sex acts in the last month	10.4	7.0	97	7.6	8.4	634
% Having vaginal sex within the last month	86	87	97	82	91**	634
% Having oral sex within the last 6 months	76†	59	95	66†	61	612
% Having anal sex within the last 6 months	33	35	95	33*	23	613
% Consuming alcohol or using drugs prior to last sex	39	41	97	26	25	627
% With overlapping sexual partners in the last 6 months	26	22	96	19	16	633
% Exchanged sex for money, drugs, or favors in the last 6 months	6	7	97	3	2	623
% With a partner in the last 6 months who has been in prison	18†	7	97	6	6	621
Unprotected sex among those having [type of] sex in the last 6 months						
% Having at least one vaginal sex act without a condom in the last 6 months¶	90	78	96	79	77	621
% Not currently using a male or female condom to prevent pregnancy¶	68†	50	96	49	46	634
% Not using a condom during last vaginal sex¶	82*	63	97	65	64	632
% Not using a condom during last oral sex¶	95	89	66	88	83	383
% Not using a condom during last anal sex¶	65	50	33	70	65	173
% Having at least one vaginal sex act without a condom in the last month¶,#	89	75	84	76	73	550
% Never using a condom during vaginal sex in the last month¶,#	59	57	84	59*	50	550
Mean no. of sexual acts without a condom in the last month¶,#	9.5	6.5	84	6.6	5.7	550
Risk combinations among those having [type of] sex in the last 6 months						
% Not using a condom during last vaginal sex and not using a condom during last oral sex¶,‡‡	82	70	66	66	63	383
% With a partner in the last 6 months who has been in prison and not using a condom during vaginal sex¶,‡‡	18*	4	97	4	4	619
% Consuming alcohol or using drugs prior to sex, having overlapping partners, and not using a condom during last vaginal sex¶,‡‡	14	8	83	5	8	546

* $p < 0.05$; ** $p < 0.01$: significance level across interview mode.
† $p < 0.10$: significance level across interview mode.
‡ STI, sexually transmitted infection; ACASI, audio computer-assisted self-interviewing; FTF, face-to-face
§ Sample estimates are unadjusted for the demographic characteristics listed in table 1. Analysis (not shown) revealed insignificant differences from adjusted results.
¶ Asked only of those reporting having had this type of sex; male or female condom was not explicitly distinguished.
# These indicators were generated from two questions asked about each of three partners: the number of vaginal sex acts in the last month with that partner and the number of vaginal sex acts without a condom in the last month with that partner.
‡‡ These variables were generated by using combinations of other measures in the table and hence are not mutually exclusive from them.

observed for women interviewed face-to-face. If these two expectations were confirmed by the data, it would strongly suggest that computerized interviewing produces more valid self-reports of behavior than face-to-face interviewing.

Reporting of sexual behaviors was generally higher in ACASI than in face-to-face interviews. A statistically significant higher percentage of ACASI women reported anal and oral sex, although a higher percentage of women interviewed face-to-face reported vaginal sex, with table 5 indicating that this latter result was largely a function of reporting by STI-negative women. The reporting of unprotected sexual relations (vaginal, oral, anal) revealed lower reporting of condom use with ACASI, with the differences between face-to-face and ACASI statistically significant for oral sex. These results suggest that, when responding to questions posed by research staff or health care providers, women overreport protective behaviors. The pattern of results reinforces the findings from other studies that have suggested that socially desirable and norm-driven responding are common in face-to-face interviewers (5–9). The benefits of using ACASI, however, may come at some expense; women tend to be more inconsistent in their responses perhaps because the face-to-face interviewer is able to reconcile discrepancies during the interview (15, 42, 43).

By comparing interview-mode differences in reporting of risk behaviors between STI-positive and STI-negative respondents, the results suggest that the differences by interview mode were greatest for those who were STI positive. In other words, STI-positive participants were more likely than STI-negative participants to misreport their behavior in the face-to-face mode. For example, STI-positive women in the ACASI mode reported an additional three unprotected sex acts on average than women interviewed face-to-face, whereas STI-negative ACASI respondents reported only one additional unprotected sex act relative to their face-to-face counterparts. These results are similar to those noted by Macalino et al. (24), who found an interaction between mode of interview and STI status. Further research is required to more fully understand the linkages between behavioral reporting and STI status.

The prevalence of trichomoniasis, gonorrhea, and chlamydia in our sample was consistent with that in a study conducted among a similar population of women aged 18–30 years observed at family planning clinics in Brazil (44). Although most (79 percent) women with an STI reported a symptom (genital itching, vaginal discharge, or abdominal pain), 71 percent of women without an STI also did so. The combined measure of any STI used in this analysis is not optimal given that each STI has different transmission rates, symptoms, treatment, and reinfection rates (3). These differences are likely to weaken the observed association between behavior and STI outcomes when a combined measure is used, given increased measurement error in the STI variable. That said, each of the infections in the combined measure is preventable by condom use and hence is germane to the behavioral measures of risk analyzed. Because transmission probabilities for the STIs under consideration in this analysis are greatest for vaginal sex, and because the tested specimens were collected via vaginal swabs, we expected to find the strongest associations between risk behavior and STI outcomes to be among indicators of unprotected vaginal sex. The results obtained support this expectation.

To validate the reporting of RSB, we empirically captured the association between behavior and STI status by interview mode; two alternative statistical modeling approaches were utilized, logistic regression and partial correlation implemented by bivariate probit regression. The bivariate probit procedure serves as an alternative estimation technique for modeling STI when standard regression techniques fail to account for including unmeasured confounding and endogeneity of the behavioral variables of interest (3, 26, 27, 45). The two approaches yielded similar results: stronger associations between STI outcomes and behavior were observed among ACASI-interviewed women. That said, only in the bivariate probit models were the differences in association statistically significant by mode of interview. A significant limitation of this analysis is that it relied on cross-sectional data, with prevalent rather than incident infections. Panel data with repeat observations of women would improve measurement of the association between risk behaviors and STI outcomes.

Despite the potential problems and pitfalls of using STI/HIV biomarkers to validate the reporting of sexual behavior (3, 4, 26, 27), including the lack of a one-to-one association between STI and any given behavior, biomarkers may be the best validation tool available. As Fishbein and Pequegnat suggest, "when there are grounds for assuming an isomorphic relation between a biological assessment and a self-reported behavior, and when the biochemical measure is relatively noninvasive, biological and biochemical measures may provide the best evidence for the validity—or lack of validity—of behavioral self-reports" (3, p. 102). Although our measures of risk behavior and STI are not strictly one-to-one, we did find significant associations between behavior and infections, particularly for the ACASI mode of administration. The stronger associations found between unprotected sex acts and STIs in the ACASI group provide additional support for the conclusion that computer administration results in more valid estimates of the prevalence of sensitive sexual and risk behaviors.

ACKNOWLEDGMENTS

This research was supported by grants from the National Institutes of Health (R01-HD-047764-01), the William and Flora Hewlett Foundation, and the Office of Population and Reproductive Health, Bureau for Global Health, US Agency for International Development (HRN-A-00-99-00010).

The authors extend special thanks to Carla Gianni Luppi, Adriana Pinho, Maria Amelia Veras, Rute Loreto Sampaio De Oliveira, Helio Hehl Caiaffa, and Juan Diaz, as well as clinic staff at the Centro de Saúde Escola Dr. Alexandre Vranjac, Barra Funda. The authors also thank Stanley Mierzwa of the Population Council Information Technology Department for the design and development of the ACASI software and Barbara Miller for her administrative and editorial support.

The opinions expressed herein are those of the authors and do not necessarily reflect the views of the US Agency for International Development or the National Institutes of Health.

Conflict of interest: none declared.

REFERENCES

1. UNAIDS. AIDS epidemic update: December 2007. Geneva, Switzerland: UNAIDS, 2007. (http://data.unaids.org/pub/EPISlides/2007/2007_epiupdate_en.pdf).
2. Fenton K, Johnson AM, McManus S, et al. Measuring sexual behavior: methodological challenges in survey research. Sex Transm Infect 2001;77:84–92.
3. Fishbein M, Pequegnat W. Evaluating AIDS prevention interventions using behavioral and biological outcome measures. Sex Transm Dis 2000;27:101–10.

4. Catania JA, Gibson D, Chitwood DD, et al. Methodological problems in AIDS behavior research: influences on measurement error and participation bias in studies of sexual behavior. Psychol Bull 1990;108:339–62.
5. Hewitt M. Attitudes toward interview mode and comparability of reporting sexual behavior by personal interview and audio computer-assisted self-interviewing: analyses of the 1995 National Survey of Family Growth. Sociol Methods Res 2002;31:3–26.
6. Gross M, Holte S, Marmor M, et al. Anal sex among HIV-seronegative women at high risk of HIV exposure. The HIV-NET Vaccine Preparedness Study 2 Protocol Team. J Acquir Immune Defic Syndr 2000;24:393–8.
7. Des Jarlais DC, Paone D, Miliken J, et al. Audio-computer interviewing to measure risk behavior for HIV among injecting drug users: a quasi-randomised trial. Lancet 1999;353: 1657–61.
8. Turner CF, Ku L, Rogers SM, et al. Adolescent sexual behavior, drug use and violence: increased reporting with computer survey technology. Science 1998;280:867–73.
9. Tourangeau R, Smith TW. Asking sensitive questions: the impact of data collection mode, question format, and question context. Public Opin Q 1996;60:275–304.
10. Metzger DS, Koblin B, Turner C, et al. Randomized controlled trial of audio computer-assisted self-interviewing: utility and acceptability in longitudinal studies. Am J Epidemiol 2000; 152:99–106.
11. Aquilino WS. Interview mode effects in surveys of drug and alcohol use: a field experiment. Public Opin Q 1994;58:210–40.
12. Fu H, Darroch JE, Henshaw S, et al. Measuring the extent of abortion underreporting in the 1995 National Survey of Family Growth. Fam Plann Perspect 1998;30:128–38.
13. Hewett PC, Mensch BS, Erulkar AS. Consistency in the reporting of sexual behavior among adolescent girls in Kenya: a comparison of interviewing methods. Sex Transm Infect 2004;80(suppl II):ii43–8.
14. Mensch BS, Hewett PC, Erulkar AS. The reporting of sensitive behavior by adolescents: a methodological experiment in Kenya. Demography 2003;40:247–68.
15. Mensch BS, Hewett PC, Gregory R. Sexual behavior and STI/HIV status among adolescents in rural Malawi: an evaluation of the effect of interview mode on reporting. Stud Fam Plann (in press).
16. Rumakom P, Guest P, Chinvarasopak W, et al. Obtaining accurate responses to sensitive questions among Thai students: a comparison of two data collection techniques. In: Jejeebhoy S, Shah I, Thapa S, eds. Sex without consent: young people in developing countries. London, United Kingdom: Zed Books, 2005:318–22.
17. Potdar R, Koenig MA. Does audio-CASI improve reports of risky behavior? Evidence from a randomized field trial among young urban men in India. Stud Fam Plann 2005;36:107–16.
18. Linh CL, Blum RW, Magnani R, et al. A pilot of audio-computer assisted self-interview for youth reproductive health research in Vietnam. J Adolesc Health 2006;38:740–7.
19. Lara D, Strickler J, Olavarrieta CD, et al. Measuring induced abortion in Mexico. Sociol Methods Res 2004;32:1–30.
20. Plummer ML, Ross DA, Wight D, 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.
21. Minnis AM, Muchini A, Shiboski S, et al. Audio computer-assisted self-interviewing in reproductive health research: reliability assessment among women in Harare, Zimbabwe. Contraception 2007;75:59–65.
22. Wood E, Kerr T, Hogg RS, et al. Validity of self-reported antiretroviral therapy use among injection drug users. J Acquir Immune Defic Syndr 2006;41:530–1.
23. Gallo MF, Behets FM, Steiner MJ, et al. Prostate-specific antigen to ascertain reliability of self-reported coital exposure to semen. Sex Transm Dis 2006;33:476–9.
24. Macalino GE, Celentano DD, Latkin C, et al. Risk behaviors by audio computer-assisted self-interviews among HIV-seropositive and HIV-seronegative injection drug users. AIDS Educ Prev 2002;14:367–78.
25. van Griensven F, Naorat S, Kilmarx PH, et al. Palmtop-assisted self-interviewing for the collection of sensitive behavioral data: randomized trial with drug use urine testing. Am J Epidemiol 2006;163:271–8.
26. Aral SO, Holmes KK. Social and behavioral determinants of the epidemiology of STDs: industrialized and developing countries. In: Holmes KK, Sparling PF, Mardh PA, et al, eds. Sexually transmitted diseases. 3rd ed. New York, NY: McGraw-Hill, 1999:39–76.
27. Boerma TJ, Weir SS. Integrating demographic and epidemiological approaches to research on HIV/AIDS: the proximate determinants framework. J Infect Dis 2005;191(suppl 1): S61–7.
28. Lippman SA, Jones HE, Luppi CG, et al. Home-based self-sampling and self-testing for sexually transmitted infections: acceptable and feasible alternatives to provider-based screening in low income women in São Paulo Brazil. Sex Transm Dis 2007;34:421–8.
29. Schachter J, McCormack WM, Chernesky MA, et al. Vaginal swabs are appropriate specimens for diagnosis of genital tract infection with *Chlamydia trachomatis.* J Clin Microbiol 2003; 41:3784–9.
30. Schachter J, Chernesky MA, Willis DE, et al. Vaginal swabs are the specimens of choice when screening for *Chlamydia trachomatis* and *Neisseria gonorrhoeae*: results from a multicenter evaluation of the APTIMA assays for both infections. Sex Transm Dis 2005;32:725–8.
31. Madico G, Quinn TC, Rompalo A, et al. Diagnosis of *Trichomonas vaginalis* infection by PCR using vaginal swab samples. J Clin Microbiol 1998;36:3205–10.
32. Cohen J. A power primer. Psychol Bull 1992;112:155–9.
33. Murphy KR, Myors B. Statistical power analysis: a simple and general model for traditional and modern hypothesis tests. Mahwah, NJ: Lawrence Erlbaum Associates, 1998.
34. Gallo MF, Steiner MJ, Warner L, et al. Self-reported condom use is associated with reduced risk of chlamydia, gonorrhea, and trichomoniasis. Sex Transm Dis 2007;34: 829–33.
35. Kamb ML, Fishbein M, Douglas JM Jr, et al. Efficacy of risk-reduction counseling to prevent human immunodeficiency virus and sexually transmitted diseases: a randomized trial. JAMA 1998;280:1161–7.
36. Norton EC, Wang H, Ai C. Computing interaction effects and standard errors in logit and probit models. Stata J 2004;4: 154–67.
37. Pracht EE, Tepas JJ 3rd, Langland-Orban B, et al. Do pediatric patients with trauma in Florida have reduced mortality rates when treated in designated trauma centers? J Pediatr Surg 2008;43:212–21.
38. Pracht EE, Tepas JJ 3rd, Celso BG, et al. Survival advantage associated with treatment of injury at designated trauma centers: a bivariate probit model with instrumental variables. Med Care Res Rev 2007;64:83–97.
39. Somi MF, Butler JR, Vahid F, et al. Is there evidence for dual causation between malaria and socioeconomic status?

Findings from rural Tanzania. Am J Trop Med Hyg 2007;77: 1020–7.
40. Creanga AA, Bradley HM, Kidanu A, et al. Does the delivery of integrated family planning and HIV/AIDS services influence community-based workers' client loads in Ethiopia? Health Policy Plan 2007;22:404–14.
41. Steiger JH. Tests for comparing elements of a correlation matrix. Psychol Bull 1980;87:245–51.
42. Hewett PC, Erulkar AS, Mensch BS. The feasibility of computer-assisted survey interviewing in Africa: experience from two rural districts in Kenya. Soc Sci Comput Rev 2004;22:319–34.
43. Mensch BS, Hewett PC, Jones HE, et al. Consistency in the reporting of sensitive behavior: an analysis of an interview mode experiment in Sao Paulo, Brazil. Paper presented at the Annual Meeting of the Population Association of America, New York, New York, March 30, 2007.
44. Codes JS, Cohen DA, Melo NA, et al. STD screening in a public family planning clinic in Brazil. (In Portuguese). Rev Bras Ginecol Obstet 2002;24:101–6.
45. Biemer P, Trewin D. A review of measurement error effects on the analysis of survey data. In: Lyberg L, Biemer P, Collins M, et al, eds. Survey measurement and process quality. New York, NY: John Wiley & Sons, 1997:602–32.