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ORIGINAL PAPER

Self-reported Sex Partner Dates for Use in Measuring Concurrent Sexual Partnerships: Correspondence Between Two Assessment Methods

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Abstract Although prevalence of concurrent sexual partnerships is increasingly investigated as a driver of HIV epidemics, its measurement varies and its role in transmission dynamics remains contested. Relying on different methods of obtaining self-reported partnership histories may lead to significant differences in prevalence. This study examined the reliability of two methods for assessing dates of sex and the implications for measuring concurrent sexual partnerships. We conducted a cross-sectional reliability study using self-reported survey data from 650 women ages 18–65 years, recruited online nationwide for human papillomavirus natural history studies from 2007 to 2012. Intermethod reliability of first and last sex with the most recent partner was assessed using weighted kappa. Intraclass correlation coefficient was estimated for intramethod reliability across two consecutive questionnaires administered 4 months apart. Point prevalence of concurrent sexual partnerships at 6 months prior to the questionnaire date was similar between the two question formats (10.5 % for categorical and 10.9 % for continuous). The range between the minimum and maximum cumulative prevalence for 12 months was larger when using the categorical questions (17.0–29.6 % compared to 27.6–28.6 % using the continuous questions). Agreement between the two question formats was moderate for the date of first sex with the most recent partner ($\kappa = 0.56$, 95 % CI 0.48–0.64) and almost perfect for the date of last sex ($\kappa = 0.93$, 95 % CI 0.91–0.94). Longitudinal agreement for date of first sex was high for the continuous date question (ICC = 0.89, 95 % CI 0.86–0.92). Results of this reliability study can be used to inform the design of future studies of concurrent sexual partnerships and their association with HIV.

Keywords HIV/AIDS · Sexually transmitted infections · Concurrent partnerships · Prevalence · Survey methodology

Introduction

In an effort to explain the heterogeneity of the HIV/AIDS pandemic, researchers have hypothesized that concurrent sexual partnerships can result in a larger, faster-growing HIV epidemic (Mah & Halperin, 2010a). While this has been demonstrated by mathematical modeling, empirical evidence is more sparse (Morris & Epstein, 2012) and the epidemiological methods used to study HIV and concurrent sexual partnerships are often debated in the literature (Epstein & Morris, 2011; Goodreau, 2011; Lurie & Rosenthal, 2010a, b; Mah & Halperin, 2010b; Sawers & Stillwaggon, 2010). An individual with concurrent sexual partnerships has a higher chance of passing an infection to a partner, but not a higher chance of acquiring an infection (Fox, 2014; Goodreau & Morris, 2012). This is often a misunderstood aspect of concurrency and can lead to errors in measuring its

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association with HIV transmission on a population level. Better measurement of concurrent sexual partnerships allows for better empirical estimation of transmission risk. Although the influence of concurrency has increasingly been studied in relation to sexually transmitted infections, lack of standardization and precision in its measurement may contribute to the limited evidence for its role in disease transmission (Allais & Venter, 2012; Helleringer, Mkandawire, & Kohler, 2014).

For over a decade, the definition and measurement of concurrent partnerships has varied (Lurie & Rosenthal, 2010a; Mah & Halperin, 2010a; Manhart, Aral, Holmes, & Foxman, 2002). Measuring sexual behavior is reliant on self-report, which is subject to both recall bias and social desirability bias (Aral, 2010; Schroder, Carey, & Vanable, 2003). Establishing concurrent partnerships is dependent upon accurate recall of both the number of partners and the dates of the relationship (Aral, 2010). Questions used to determine the start and end dates of partnerships are critical to obtaining accurate prevalence of concurrent sexual partnerships. Investigators rely on various formats of self-reported variables to calculate concurrency, particularly when the survey instrument was not specifically designed to measure overlapping partnerships.

There are two primary methods for measurement: (1) asking a direct question about additional sex partners during a specific partnership and (2) constructing partnership histories by collecting detailed information, including start and end dates (Nelson et al., 2007). The overlapping date method provides more complete information but requires multiple questions to be asked and can be subject to recall bias (Mah & Halperin, 2010a). In an effort to reduce bias, a calendar or timeline is often used during interviews to facilitate selection of the start and end dates and obtain a more accurate recording of duration of sexual partnerships (Carey, Carey, Maisto, Gordon, & Weinhardt, 2001; Delva et al., 2013; Fisher & Lee, 2013; Luke, Clark, & Zulu, 2011; Westercamp, Mattson, & Bailey, 2013). However, studies conducted using in-person interviews and visual aids are more expensive than studies that use self-administered questionnaires to measure sexual behavior (Weinhardt, Forsyth, Carey, Jaworski, & Durant, 1998; White et al., 2008). The variation in these methods may lead to significant differences in prevalence estimates of concurrent sexual partnerships, which could contribute to the lack of evidence for an association between concurrency and HIV (Morris & Epstein, 2012; Tanser et al., 2011).

In an effort to reach a consensus and advance research, in 2009 the UNAIDS Reference Group on Estimates, Modelling, and Projections convened a Work Group on Measuring Concurrent Sexual Partnerships. They agreed that concurrent sexual partnerships are defined as overlapping sexual partnerships in which sexual intercourse with one partner occurs between two acts of intercourse with another partner. The preferred measure is the point prevalence at 6 months prior to the interview. Other recommended measures include the cumulative prevalence of concurrent sexual partnerships over the past year (UNAIDS, 2010). Survey questions should capture how long ago (in days, weeks, months, years) first and last sex occurred with the three most recent partners in the past year (UNAIDS, 2009). These agreed upon measures were intended to improve study design and decrease discrepancies in studies measuring concurrent sexual partnerships.

We conducted a reliability study of sexual behavior variables that were used to construct sexual partnership histories. We then determined the prevalence of concurrent sexual partnerships using measurements recommended by the UNAIDS (2009). Intramethod and intermethod reliability were assessed between two question formats used to capture dates of first and last sex with the most recent partner.

Method

Participants

We conducted a cross-sectional study using self-reported survey data from 18 to 65 year-old women from across the United States. Data were derived from two previously conducted cohort studies of sexual behavior and risk of human papillomavirus (HPV) infection conducted from 2007 to 2010 (Population 1) (Winer et al., 2012) and from 2010 to 2012 (Population 2). In both studies, women were recruited through ads posted on the Internet. Women were eligible to participate if they were between the specified age ranges (25–65 years for Population 1; 18–24 years for Population 2), had used the Internet to search for romantic partners in the past year (to target women who were actively dating, although report of recent new sex partners was not required), and had ever had vaginal intercourse with a male partner. Those who at the time of screening were: (1) pregnant or breastfeeding; (2) had had a hysterectomy; (3) were immunocompromised (including positive for HIV); or (4) were unable to provide written informed consent were excluded. Of the 716 enrolled women who met the eligibility criteria (521 in Population 1, 195 in Population 2), women were included in our cross-sectional reliability study if they reported sex with a male partner in the 12 months prior to completing the initial questionnaire and answered at least one of the four survey questions about dates of first or last sex with a recent partner. This protocol was approved by the Institutional Review Board for Protection of Human Subjects at the University of Washington prior to the start of this study.

Procedure

Study coordinators sent questionnaires and vaginal specimen kits for self-collecting samples for HPV testing to enrolled participants at their home addresses every 4 months for 1 year. Women were provided with pre-paid envelopes to return both the self-

collected swabs and questionnaires. Details of the collection methods and HPV testing are described elsewhere (Winer et al., 2012). The initial questionnaire collected demographic information as well as a history of gynecological health, contraceptive use, sexually transmitted diseases, alcohol and tobacco use, and sexual behavior. Subsequent questionnaires recorded updated information related to these areas since completing the last survey. Survey questions were adapted from those used in our previous HPV natural history studies (Winer et al., 2003, 2006). The initial questionnaire asked for information about up to six male partners (identified by initials) over the past 12 months, starting with the most recent (referred to in this article as Partner 1), while subsequent questionnaires requested information about male partners since completing the last questionnaire. For each partner, the questionnaire included a categorical question, "When did you first have sex with him?", with five possible response options: (1) Less than a week ago, (2) More than a week ago, but less than a month ago, (3) More than a month ago, but less than 6 months ago, (4) More than 6 months ago, but less than a year ago, and (5) ___ years ago. The categorical question was immediately followed by a fill-in-the-blank question, "On what date did you first have sex with him?", with designated space to record the month, day, and year. Questions on date of last sex with each partner were worded similarly, with the exception that the categorical question did not include "___ years ago" as a response option.

Measures

Three measures of concurrent sexual partnerships were determined for each subject using both the continuous and categorical date questions. In accordance with UNAIDS (2009) recommendations, point prevalence of concurrent sexual partnerships was measured as the number of women having more than one ongoing sexual partnership 6 months before the questionnaire date, divided by the total number of participants. Using this measure, women were determined to have concurrent sexual partnerships if they reported at least two partnerships with the date of first sex prior to or equal to 6 months ago and the date of last sex less than or equal to 6 months ago. Cumulative prevalence was defined as the proportion of women who had overlapping sexual partnerships during the 12 months prior to completing the questionnaire. Overlapping sexual partnerships exist when sex with one partner occurs between the first and last acts of sexual intercourse with another partner (UNAIDS, 2010). A minimum cumulative prevalence was estimated by determining the number of overlapping sexual partnerships without allowing dates of sexual encounters to be the same for multiple partners. Maximum cumulative prevalence required overlapping sexual partnerships but allowed the date or time since last sex with one partner to be equal to the date or time since first sex with another partner. For example, last sex with Partner X could be on the same day (continuous question) or the during the same time period (categorical question) as first sex with Partner Y (Fig. 1).

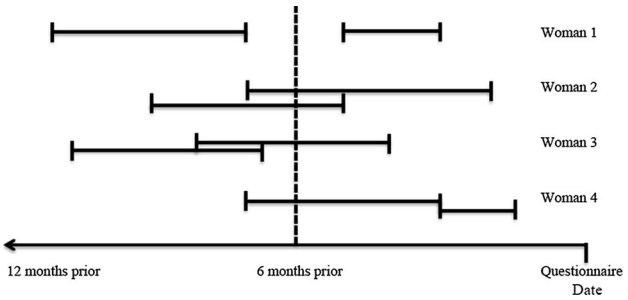

Fig. 1 Hypothetical estimates for prevalence of concurrent sexual partnerships. The point prevalence at 6 months prior to the interview is 25 % (*Woman 2*). The minimum cumulative prevalence is 50 % (*Women 2* and *3*), and the maximum cumulative prevalence is 75 % (*Women 2*, *3*, and *4*). *Woman 1* does not have concurrent sexual partnerships. Adapted from: UNAIDS Reference Group on Estimates, Modelling, and Projections: Working Group on Measuring Concurrent Sexual Partnerships (2010)

Women were asked to answer a series of questions about each of their male partners over the past 12 months, starting with Partner 1. The date questions used in our analyses were identical on all questionnaires in both cohort studies. In order to assess intermethod reliability between the two question formats, the fill-in-the-blank continuous date variable was recoded into an ordered categorical variable with response categories identical to the time periods included in the categorical question. Implausible date responses were recoded to the nearest day in the recorded month (e.g., September 31 was recoded as September 30). Dates that were incorrectly reported as a future date were excluded. Incomplete responses that were missing a year were described and then excluded from analyses. Responses that provided the current year but were missing values for month and day were imputed to be the mid-point between January 1 and the questionnaire date. Responses that were missing a value for the day but provided a month and year equal to that of the questionnaire date were imputed to the midpoint between the first of that month and the questionnaire date. Responses that reported a prior year but were missing values for month and day were imputed to July 1st of the specified year. Incomplete dates that were missing a value for day only were imputed to the 15th of the reported month.

Statistical Analyses

Multiple measures of concurrency were estimated using the methods described above. Reliability was measured between two sets of categorical and continuous questions about date of first and last sex with Partner 1. Intermethod reliability for both first and last sex with Partner 1 was estimated using weighted kappa (κ) between each categorical question and the recoded continuous question (as described above). Quadratic weights were assigned and bootstrap methods were used to obtain bias

corrected 95 % confidence intervals (CI) (Reichenheim, 2004). Sensitivity of the categorical date question to capture the "correct" time frame was calculated using the continuous date question as the "gold standard" or more accurate measure. We conducted univariate logistic regression to evaluate predictors of agreement. The outcome variable of agreement between dates for both first and last sex (yes or no) was created by determining whether or not the categorical date question was equivalent to the recoded continuous date question. We included the following covariates in our analyses: age (18–24, 25–29, 30–39, 40–65 years), current marital status (unmarried, unmarried living with a partner, married, separated), quintiles of lifetime number of male sex partners (1–4, 5–7, 8–12, 13–22, 23+), whether the participant thought Partner 1 had other concurrent sex partners ("Do you think he had sex with anyone else between the date you first had sex with him and the date you last had sex with him?" with response options yes, no, don't know), number of male sex partners in the past 12 months (1, 2+), type of sex partner (regular or casual), and whether the participant met that partner online (yes or no).

The intramethod reliability of date of first sex with partner 1 between the first two consecutive questionnaires was measured using intraclass correlation coefficient (ICC) for the continuous date question. Women with more than 6 months between their first and second questionnaires were excluded. The first and last initials for Partner 1 were matched to verify that the same partner was the subject of the questions in both questionnaires. Initials were matched for up to 3 letters although most women only reported 2 initials. Women had to report a date of first sex for Partner 1 on both questionnaires to be included in this analysis. STATA 12 was used for all data analyses (version 12.0, Stata Corporation, College Station, TX, USA).

Results

Study Population

Sixty-four (8.9 % of 716) women were excluded for answering no to the question, "Have you had sex with a male partner in the last 12 months?" Two additional women failed to answer any questions about dates of first or last sex with partners and therefore could not be included in any of the analyses, resulting in a total of 650 women in the study. The majority of women were white (62 %), non-Hispanic (88 %), and currently unmarried (71 %) (Table 1). Their mean age was 31.6 years (SD: 9.6), and their mean age at sexual debut was 17.2 years (SD: 3.5). Their median reported lifetime number of sex partners was 10 (interquartile range: 5–20), while the median reported number of sex partners in the past 12 months was 2 (interquartile range: 1–3). The median number of months since first sex with Partner 1 was 12.9 (interquartile range: 4.7–38.9) while the median number of

Table 1 Characteristics of 650 sexually active female online daters in the US, 2007–2012

	n	(%)
Age (years) (n = 650)		
18–24	179	(27.5)
25–29	190	(29.2)
30–39	160	(24.6)
40–65	121	(18.6)
Race (n = 643)		
White	399	(62.1)
African American	114	(17.7)
Asian	53	(8.2)
Other[a]	69	(10.7)
American Indian/Alaska Native	6	(0.9)
Native Hawaiian/Other Pacific Islander	2	(0.3)
Hispanic or Latina (n = 636)		
No	561	(88.2)
Yes	67	(10.5)
Don't know	8	(1.3)
Household income[b] (n = 469)		
<$34,999	161	(34.3)
$35,000–$49,999	115	(24.5)
≥$50,000	175	(37.3)
Don't know	18	(3.8)
Current marital status (n = 643)		
Unmarried[c]	456	(70.9)
Unmarried, living with a partner	98	(15.2)
Married	65	(10.1)
Separated	24	(3.7)
Education (n = 645)		
High school diploma, GED, or less	52	(8.1)
Some college credit, no degree	159	(24.7)
College associate's degree, technical school, or certification	101	(15.7)
College bachelor's degree	243	(37.7)
College master's or doctoral degree	90	(14.0)
Age at first sex with a male partner (n = 646)		
15 and under	188	(29.1)
16	109	(16.9)
17	102	(15.8)
18–19	145	(22.5)
20 and older	102	(15.8)
Lifetime number of male sex partners (n = 631)		
1–4	124	(19.7)
5–7	126	(20.0)
8–12	132	(20.9)
13–22	122	(19.3)
23+	127	(20.1)
Ever had an STD[d] (n = 611)		
No	341	(55.8)
Yes	270	(44.2)

Table 1 continued

	n	(%)
Thought any male partner in past 12 months had other concurrent sex partners (n = 633)		
No	222	(35.1)
Yes	286	(45.2)
Don't know	125	(19.8)
Number of male sex partners in past 12 months (n = 595)		
1	271	(45.6)
2	149	(25.0)
3	81	(13.6)
4+	94	(15.8)
At least 1 casual male sex partner reported in past 12 months (n = 642)		
No	299	(46.6)
Yes	343	(53.4)
Met at least 1 male sex partner online in past 12 months (n = 646)		
No	311	(48.1)
Yes	335	(51.9)

Numbers total less than 650 for some variables due to missing data

[a] Other includes 2 or more races

[b] Household income is only presented for women 25 years of age and older

[c] Unmarried includes divorced women

[d] Sexually Transmitted Diseases (STD's) included in variable are chlamydia, gonorrhea, syphilis, genital warts, genital herpes, and human papillomavirus

days since last sex with Partner 1 was 14 (interquartile range: 4–81). For women who reported Partner 1 as a casual partner the median number of months since first sex was 5.6, compared to a median of 19.6 months among women who reported Partner 1 as a regular partner ($p < .001$). The median partnership length (number of months between first and last sex) for Partner 1 was 10.6 (interquartile range: 2.0–36.5) months.

Missing Data

Missing responses were uncommon (<5 %) for both continuous and categorical variables capturing dates of first and last sex. Furthermore, the majority of continuous date responses included both a year and a month. However, 25.1 % of women did not report a day for date of first sex and 13.9 % were missing a day for date of last sex. When incomplete responses for continuous date variables (missing month and/or day) were compared across subgroups, differences were observed for two subgroups of women. Women who responded "yes" or "don't know" to whether they thought Partner 1 had a concurrent sex partner had higher percentages of incomplete responses for continuous date questions about first and last sex ($\chi^2 = 14.48, df = 2, p = .001$ for first sex; $\chi^2 = 9.3, df = 2, p = .010$ for last sex). For date of last sex with Partner 1, the percentage of incomplete responses increased with each increasing age group of women (Wilcoxon-type test for trend $p < .001$) (Cuzick, 1985) (Table 2).

Measures of Concurrent Sexual Partnerships

The point prevalence of concurrent sexual partnerships at 6 months prior to the questionnaire date was 10.9 % when using the continuous fill-in-the-blank date questions for first and last sex and 10.5 % when using the categorical questions (Table 3). While the maximum cumulative prevalence for the past 12 months was similar between the two question formats (28.6 % for continuous and 29.6 % for categorical), the minimum values were different (27.6 % for continuous and 17.0 % for categorical), resulting in a larger range between the minimum and maximum values of prevalence when using the categorical questions. Furthermore, when we excluded partnerships with incomplete dates instead of imputing dates, the point prevalence of concurrent sexual partnerships using the continuous questions was 6.8 % and the minimum and maximum cumulative prevalence were both equal to 20.5 %.

Agreement for Dates of Sex with Most Recent Partner

Thirty-seven women were missing either the categorical or continuous variable for date of first sex with Partner 1 (n = 613), and 70 were missing either the categorical or continuous variable for date of last sex with Partner 1 (n = 580) (missing and excluded data for these analyses are detailed in Table 4). When comparing the continuous and categorical questions, the weighted kappa statistic for date of first sex with Partner 1 was 0.56 (95 % CI 0.48–0.64), indicating moderate agreement (Landis & Koch, 1977). Very good agreement was observed for date of last sex with Partner 1 ($\kappa = 0.93$, 95 % CI 0.91–0.94) (Table 4). The sensitivity of the categorical question when compared to the continuous question for dates of first and last sex by reported time interval is shown in Fig. 2.

Predictors of Agreement

We found few significant associations between agreement of sex dates and the covariates selected a priori. Women who reported Partner 1 as a casual partner were more likely than women who reported Partner 1 as a regular partner to report categorical and continuous dates of first sex that agreed (OR = 1.61, 95 % CI 1.02–2.52). The opposite association was observed for agreement of date of last sex with the most recent partner. When Partner 1 was reported to be a casual partner, women were less likely to report dates of last sex that agreed when compared to women who reported Partner 1 as a regular partner (OR = 0.49, 95 % CI 0.30, 0.82). When asked if they thought Partner 1 had

Table 2 Missing data for survey questions about date of first and last sex with most recent partner among sexually active female online daters in the US, 2007–2012

		Date of first sex			Date of last sex		
	N	n	%		n	%	
Missing response for date of sex, categorical	650	3	0.5		28	4.3	
Missing response for date of sex, continuous	650	20	3.1		27	4.2	
Incomplete response for date of sex, continuous							
Wrote year only- missing values for month and day	650	32	4.9		4	0.6	
Wrote month and year- missing value for day	650	163	25.1		90	13.9	
				χ^{2a}			χ^{2a}
				p			*p*
Incomplete responses (missing values for either month or day), by subgroups	650	195	30.0		94	14.5	
Age (years)	650			ns			.004
18–24	179	40	22.4		17	9.5	
25–29	190	63	33.2		23	12.1	
30–39	160	52	32.5		25	15.6	
40–65	121	40	33.1		29	24.0	
Marital status	643			ns			ns
Unmarried	456	140	30.7		70	15.4	
Unmarried, living with a partner	98	26	26.5		9	9.2	
Married	65	21	32.3		7	10.8	
Separated	24	8	33.3		7	29.2	
Lifetime number of sex partners	631			ns			ns
1–4	124	31	25.0		14	11.3	
5–7	126	43	34.1		18	14.3	
8–12	132	41	31.1		22	16.7	
13–22	122	40	32.8		20	16.4	
23+	127	33	26.0		18	14.2	
Thought partner had other concurrent sex partners	629			.001			.01
No	340	80	23.5		36	10.6	
Yes	172	66	38.4		35	20.4	
Don't know	117	42	35.9		19	16.2	
Number of male sex partners in past 12 months	595			ns			ns
1	271	83	30.6		35	12.9	
2 or more	324	96	29.6		49	15.1	
Type of sex partner	635			ns			ns
Regular	474	148	31.2		64	13.5	
Casual	161	44	27.3		28	17.4	
Met sex partner online	646			ns			ns
Yes	238	61	25.6		31	13.0	
No	408	133	32.6		63	15.4	

[a] Pearson's χ^2 hypothesis test for independence between missing status (yes/no) and each subgroup of the characteristic

concurrent sex partners, women who selected yes were less likely to report dates of last sex with Partner 1 that agreed when compared to those who selected no (OR = 0.53, 95 % CI 0.31, 0.92). However, no statistically significant relationship was observed for agreement between date of first sex and Partner 1 having concurrent sexual partnerships (Table 5).

Agreement for Date of First Sex Between Two Consecutive Questionnaires

Of the 650 women in the study, 117 did not complete two questionnaires and 118 were excluded from this analysis for completing the second questionnaire more than 6 months after

Table 3 Prevalence of concurrent sexual partnerships among sexually active female online daters in the US, 2007–2012

	N	Prevalence (%)
By continuous date questions (n = 605)[a]		
Point prevalence at 6 months prior	66	10.9
Minimum cumulative prevalence over past 12 months	167	27.6
Maximum cumulative prevalence over past 12 months	173	28.6
By categorical questions (n = 636)[b]		
Point prevalence at 6 months prior	67	10.5
Minimum cumulative prevalence over past 12 months	108	17.0
Maximum cumulative prevalence over past 12 months	188	29.6

Point prevalence is the number of women having more than one ongoing sexual partnership six months before the survey date, divided by the total number of sexually active women who provided dates of partnerships. Cumulative prevalence is the proportion of participants who had overlapping sexual partnerships during the 12 months prior to the survey date. A minimum cumulative prevalence was estimated using discrete partnership dates and a maximum cumulative prevalence was obtained by allowing the end of one sexual partnership and the beginning of the next partnership to occur on the same day or during the same time period

[a] 45 women did not provide valid continuous date information within 12 months for any sexual partnerships

[b] 14 women did not provide categorical date information within 12 months for any sexual partnership

Table 4 Reliability of partnership date questions for most recent sex partner among sexually active female online daters in the US, 2007–2012

	N	Weighted kappa (κ)[a]	(95 % CI)[b]
Agreement between categorical and continuous date questions			
Date of first sex	613[c]	0.56	(0.48, 0.64)
Date of last sex	580[d]	0.93	(0.91, 0.94)
	N	Intraclass correlation coefficient (ICC)	(95 % CI)
Agreement between continuous date questions on 2 consecutive questionnaires within 6 months			
Date of first sex	199	0.89	(0.86, 0.92)

[a] Quadratic weights were assigned

[b] Bootstrap methods were used to obtain a bias corrected 95 % CI

[c] 3 women did not provide a response for the categorical variable. For the continuous date, 2 women provided implausible dates that were recoded to the nearest day (September 31st was changed to September 30th and February 29th was changed to February 28th), 20 women did not provide a response, and 14 women provided future dates that were excluded. No women were missing both the categorical and continuous date variables

[d] 28 women did not provide a response for the categorical variable. For the continuous date, 27 women did not provide a response, 12 women were excluded for providing future dates, and 16 were excluded for listing a continuous date that was more than one year ago and therefore did not match the categorical response options. Thirteen women were missing both the categorical and continuous date variables

the first. Additionally, four women were excluded for not providing initials for Partner 1 on the first questionnaire and 19 were excluded for not answering the continuous question about date of first sex with Partner 1 on the first questionnaire. Among the 392 women remaining, we included 199 who listed a sex partner on the second questionnaire with initials matching Partner 1 on the first questionnaire and also provided a complete date of first sex on both questionnaires. The median time between the two consecutive questionnaires was 4.5 months and agreement was high for the continuous date of first sex with Partner 1 (ICC = 0.89, 95 % CI 0.86–0.92) (Table 4).

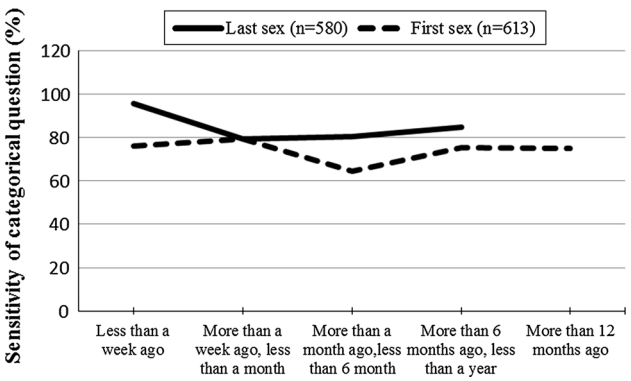

Fig. 2 Sensitivity of categorical question to capture the same time interval as continuous question for dates of sex with most recent partner among sexually active female online daters in the US, 2007–2012

Discussion

Although the observed reliability between the continuous and categorical date questions ranged from moderate to almost perfect, precision was lost when estimating concurrent sexual partnerships with the categorical format. Our study found only minimal variation in the point prevalence of concurrent sexual partnerships at 6 months prior to the survey date when using either the continuous or categorical date format. However, the range between the minimum and maximum values for cumulative prevalence over the past 12 months increased from 1 to 12.6 % when using the categorical dates compared to continuous dates. When one sexual partnership ends and another one begins during the same date range (using the categorical date variables), or on the same day (using the continuous date variables), the conservative minimum value does not consider these partnerships as concurrent, while the maximum value assumes that they were. When continuous dates were used, fewer partnerships were excluded in determining the minimum cumulative prevalence since the date range is only 1 day, resulting in a smaller range between the minimum and maximum values.

Table 5 Predictors of agreement between categorical and continuous questions about first and last sex with most recent partner (Partner 1) among sexually active female online daters in the US, 2007–2012

	First sex with most recent partner			Last sex with most recent partner		
	N	Odds ratio	(95 % CI)	N	Odds ratio	(95 % CI)
Age (years)	613			580		
18–24		Ref			Ref	
25–29		1.07	(0.65, 1.75)		1.07	(0.58, 1.97)
30–39		0.84	(0.51, 1.39)		1.53	(0.77, 3.04)
40–65		0.61	(0.36, 1.04)		1.07	(0.53, 2.15)
Marital status	607			574		
Unmarried		Ref			Ref	
Unmarried, living with a partner		0.90	(0.54, 1.49)		1.73	(0.80, 3.76)
Married		0.63	(0.36, 1.10)		1.96	(0.76, 5.10)
Separated		0.71	(0.28, 1.78)		0.57	(0.18, 1.81)
Lifetime sex partners	599			567		
1–4		Ref			Ref	
5–7		0.82	(0.46, 1.45)		0.76	(0.35, 1.66)
8–12		1.42	(0.78, 2.60)		0.99	(0.45, 2.20)
13–22		0.95	(0.53, 1.70)		1.02	(0.45, 2.32)
23+		0.74	(0.42, 1.31)		0.72	(0.34, 1.56)
Thought partner had other concurrent sex partners	594			562		
No		Ref			Ref	
Yes		0.96	(0.62, 1.49)		0.53	(0.31, 0.92)
Don't know		0.70	(0.44, 1.12)		0.54	(0.28, 1.02)
Number of male sex partners in past 12 months	561			535		
1		Ref			Ref	
2 or more		1.12	(0.77, 1.64)		0.68	(0.41, 1.14)
Type of sex partner	600			570		
Regular		Ref			Ref	
Casual		1.61	(1.02, 2.52)		0.49	(0.30, 0.82)
Met partner online	611			578		
No		Ref			Ref	
Yes		0.74	(0.51, 1.07)		0.75	(0.46, 1.22)

Previous research has found conflicting results about the impact of error in reported dates on the estimated concurrency of sexual partnerships. Morris and O'Gorman (2000) found the influence of reporting error to be modest, with a slight positive bias in the prevalence estimates. The potential for falsely classifying a relationship as concurrent was greater when the time between partnerships was small. Brewer, Rothenberg, Muth, Roberts, and Potterat (2006) obtained similar results when evaluating the effect of date discrepancies reported by partner dyads on measurement of concurrent sexual partnerships. Despite good reliability among dates of sex reported by both partners during public health contact tracing interviews, the estimate of concurrency was subject to some error during simulation models. A study that used sociocentric self-reported survey data to assess interpartner reliability found that biases in the measurement of concurrent sexual partnerships were potentially large and of an unknown direction (Helleringer, Kohler, Kalilani-Phiri, Mkandawire, & Armbruster, 2011). Researchers used a question about whether or not a sexual relationship was ongoing to measure the point prevalence of concurrent sexual partnerships at the time of the survey. The resulting prevalence varied substantially depending on whether or not the partnership was reported as ongoing by only the participant, the participant and their partner, or either partner. Helleringer et al. (2011) disagreed with the assumptions by Morris and O'Gorman (2000) that estimates of partnership history are reliable and that reporting errors occur at random. Our findings provide further evidence that dates of sexual partnerships are moderately to very reliable, but that the precision of those dates is important when estimating concurrent sexual partnerships. Although use of the categorical questions did not result in an

upward bias in prevalence measures in our study, they may not be able to precisely reflect the time between sexual partnerships, increasing the likelihood of misclassification.

Women reported the date of last sex with more precision and reliability than date of first sex with the most recent partner. Agreement between the two question formats for the date of last sex with the most recent partner was extremely high. We observed only moderate agreement when measuring the date of first sex with the most recent partner, which is not unusual considering the median time since first sex with that partner was 1.1 years. Studies of event recall have demonstrated that recall becomes more difficult as time lapses and that a longer recall period can lead to errors (Pierret, 2001). The kappa value was slightly higher when we restricted the analysis to women who reported first sex with Partner 1 within the last year using the continuous date question ($\kappa = 0.62$; 95 % CI 0.52–0.72), demonstrating substantial agreement (Landis & Koch, 1977) between the two question formats. One unique finding from our study was the ability to measure reliability across time. When reliability for the continuous date of first sex with Partner 1 was assessed across two consecutive questionnaires, we observed high reliability.

We found few meaningful differences in agreement between the two date formats among subgroups of women with different demographic or behavioral variables. Women who reported their partner as a casual sex partner instead of a regular sex partner were more likely to have agreement for date of first sex, but less likely to have the two formats agree for date of last sex. This is likely due to recall bias since first sex with Partner 1 was more recent for women reporting a casual sex partner (median, 5.6 months) in comparison to those who reported Partner 1 as a regular partner (median, 19.6 months).

Studies about recall ability suggest that self-reported sexual behavior may not be reliable past a 3-month recall period (Schroder et al., 2003). While we did find reliability to be substantially lower for date of first sex when compared to date of last sex, we found high agreement for date of first sex across two questionnaires completed a median of 4.5 months apart. We limited the time between the two questionnaires to no more than 6 months in order to minimize differences in length of recall among participants. However, compared to women who completed the second questionnaire within 6 months of the first, those who completed it beyond 6 months were more likely to report a new sex partner between questionnaires. To investigate the effect of new partner acquisition on longitudinal recall of sex dates with a previous partner, we conducted a post hoc analysis restricted to those women who reported a new sex partner on the second questionnaire. The reliability for the date of first sex with the partner originally identified as Partner 1 on the first survey was slightly lower among the 25 women reporting a new recent sex partner on the second questionnaire (ICC = 0.78; 95 % CI 0.63–0.94).

We did not observe a linear trend across time periods when evaluating the sensitivity of the categorical question to capture the same time frame as the continuous date question. For date of first sex, we observed a u-shaped trend, implying that the categorical question may be less accurate for the time period between 1 and 6 months when compared to the continuous question. Sensitivity increased for the final response choice of first sex more than 12 months ago although this could be due to the wider time interval in this response option. A similar trend was observed for the sensitivity of the categorical question for date of last sex, implying that large time intervals, although less precise, are likely to be more accurate when recalling events that occurred more than a month ago.

The main limitation of this study was that reliability studies provide information about the reproducibility of a measure, but do not result in a "correct answer" about the methods used. However, quantifying the reliability of a measure is often the first step in establishing its validity (Weinhardt et al., 1998). In order to measure the validity of an instrument, a perfect measure or "gold standard" is needed. No perfect measure exists for capturing dates of sexual partnerships. A diary that captures frequent measures is sometimes considered the gold standard in sexual behavior measurement due to its minimal reliance on recall (Leigh, Gillmore, & Morrison, 1998; Schroder et al., 2003), but participant burden is high and the act of recording in the diary may influence behavior (Glick, Winer, & Golden, 2012). When a validity study is not possible, it is common for an intermethod reliability study to compare a proposed measure to another measure that may be a larger burden to participants and researchers, but is considered more accurate. Although these studies cannot measure accuracy against a gold standard, they are still considered important to the design and implementation of research studies.

Other limitations include the potential for differential recall bias based on the duration of the sexual partnership. Considering the age distribution of the women in our study, and that nearly half of participants reported only 1 male sex partner in the past year, the date being recalled for first sex with most recent partner may have occurred several decades ago. The mean number of years since first sex with Partner 1 increased with each age group (1.7 among 18–24 year olds; 5.8 among 40–65 year olds). Although age was not a statistically significant predictor of agreement for date of first or last sex with the most recent partner, the difference in partnership duration likely contributed to the lower kappa value observed for first sex in comparison to last sex.

Our study was limited in its generalizability in three ways. First, we derived our data from previously conducted studies in women only, which did not allow us to assess reliability of sex date history in men. Second, these studies recruited online and enrolled women if they stated that they had used an internet dating website in the past year. Although online dating has grown in popularity, this requirement could limit our ability to obtain a representative sample from all age groups. Third, the time intervals in the categorical date question included intervals

with varying widths and were designed based on biological relevance for assessment of risk factors for HPV infection, limiting our ability to compare our results to other studies. Categorical questions designed to measure partnership histories for measurement of concurrent sexual partnership may ask about narrower or more uniform widths of time. However, we sought to determine the reliability of survey methods that are commonly used in the measure of sexual behaviors regardless of the original study motivation.

Overall, we observed less than 5 % of missing data for the date questions with little difference in the percentages of missing data between the categorical and continuous formats. However, the fill-in-the blank structure of the continuous question did result in incomplete dates for 30 % of first sex and 15 % of last sex responses. For the continuous date questions, only two socio-obehavorial variables were found to have significant differences in percentages of incomplete data. The amount of missing data increased with age for the date of first and last sex. Women who were either unsure or agreed that their most recent partner had concurrent sex partners were also more likely to provide incomplete dates. We conducted post hoc sensitivity analyses in order to investigate the importance of complete month/day/year dates for the measurement of concurrent sexual partnerships. Excluding all incomplete date values for the continuous questions had minimal impact on the reliability of the dates reported (data not shown), suggesting that imputing values for the day or month is a reasonable approach to handling incomplete sexual partnership dates. Furthermore, excluding partnerships with incomplete date values decreased the prevalence of concurrent sexual partnerships, suggesting that imputing may be preferable to excluding dates, given the observed minimal impact of imputation on reliability.

The reliability and validity of sexual behavior measures continues to be an important research priority (DiClemente, Swartzendruber, & Brown, 2013). Our findings provide reliability results that are important to consider in the design of survey instruments for measurement of concurrent sexual partnerships, but also contribute to a larger body of research related to self-reported survey data of sex partner history. Reliability for the date of last sex with the most recent partner was very strong between the two categorical and continuous date formats, but only moderate for the date of first sex across the two formats. The format of date questions has implications for measuring concurrent sexual partnerships. Use of categorical questions results in a wider range of uncertainty about the cumulative prevalence. Compared to the categorical format, continuous date questions allow for collection of richer, more precise, and possibly more accurate information about dates of sexual encounters. High frequencies of incomplete dates could deflate this advantage and construction of concurrent sexual partnerships using only month and year can result in misclassification (Manhart et al., 2002; Nelson et al., 2007). Our data suggest this can be minimized by imputing missing values for dates and therefore maintaining the precision of continuous dates compared to categorical dates in the measurement of concurrent sexual partnerships.

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