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Sexual concurrency and its potential contribution to HIV transmission within racial/ethnic groups among men who have sex with men in the United States

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B.S., Cornell University, 2006

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An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Epidemiology
2012

Abstract

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By Eli S. Rosenberg

In the United States, the majority of HIV infections occur among men who have sex with men (MSM). MSM of color bear disproportionately higher levels of HIV prevalence and incidence.

Individual-level risk behaviors have failed to explain this disparity and network factors have been suggested. Sexual concurrency, or the overlapping on one's sexual partnerships in time, catalyzes HIV transmission in networks and remains little studied among MSM. In populations where concurrency has been studied, methodological limitations have resulted in inconsistent estimates of its prevalence and relationship to HIV transmission.

For this dissertation, three studies were conducted to understand the occurrence and potential impact of concurrency in an online cohort of MSM in the US. Simultaneously, three methodological issues were addressed: accurate measurement, inference at the appropriate levels of analysis, and the measurement of biologically relevant concurrency.

In the first study we evaluated existing methods and a novel partnership timing module for measuring concurrency. The module had strong concurrency detection ability and agreement with previous measures, at the individual-, dyad-, and triad-levels, suggesting it may be well-suited to quantifying concurrency among MSM.

In the second study we assessed concurrency and concurrent unprotected anal intercourse (UAI) at the individual and triad levels. Forty-five percent of individuals indicated concurrent partnerships and 16% indicated concurrent UAI in the previous 6 months, with no significant heterogeneity by race/ethnicity. Respondents had a two-fold odds of UAI with two partners when they were concurrent.

In the third study we implemented a new technique for quantifying the indirect exposure imparted to sex partners attributable to concurrency and concurrent UAI. Levels of indirect exposure to other partners were high among repeat sex-partners: 58% were exposed by concurrency and 37% of UAI partners were exposed by concurrent UAI. Black non-Hispanic and casual partners were more likely to be exposed.

Concurrency is highly prevalent among MSM, potentially contributing to high HIV incidence, and may place black and casual partners at greater risk. The methods developed may aid in the understanding of concurrency in other contexts where concurrency is thought to play a role in HIV transmission, such as sub-Saharan Africa.

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Chapter 1 Background and Significance

MSM, especially black MSM, are disproportionately affected by HIV/AIDS in the United States

Since the earliest reports of AIDS in the United States, men who have sex with men (MSM) have been, and continue to be, the most heavily affected risk group in the US HIV epidemic.[1] In 2009, men who have sex with men (MSM) were the group most represented among new HIV infections (61%) and prevalent diagnosed infection.[2,3] In 2008, MSM there were an estimated 341,414 individuals living with a diagnosis of HIV infection in the United States. [3] The death toll among HIV-infected MSM has been high. During the most current three-year period of 2006 – 2008, an estimated 20,728 MSM died with an HIV diagnosis, 18,299 of whom also had an AIDS diagnosis. Since the beginning of the epidemic in the early 1980s through 2008, an estimated 335,934 MSM have died with an AIDS diagnosis, representing 54% of all US deaths among people diagnosed with AIDS.[3]

Furthermore, since 2000, MSM have represented the only risk group in the United States for whom HIV incidence is rising.[4-6] The number of new HIV notifications among MSM reported to the national HIV surveillance system increased by 8.6% in the six-year period from 2001-2006 [7] and 5.8% in the 4-year period from 2006-2009,[2] or about 1.4% annually between 2001-2009. Although the causes for rising incidence among MSM are not yet fully known, existing evidence points to prevention fatigue, treatment optimism, generational differences, and the increase in sex-seeking via the internet.[8,9]

In addition to the disparities between MSM and other populations at risk for HIV infection, there are pronounced disparities in both prevalence and incidence within the United States' MSM HIV epidemic by race/ethnicity. In surveillance reports, black non-

Hispanic, white non-Hispanic, and Hispanic ethnicity of any race MSM are considered distinct demographic groups. We maintain this convention throughout this dissertation, but sometimes abbreviate the first two groups as ‘black MSM’ and ‘white MSM’, for brevity. In the second MSM cycle of CDC’s National HIV Behavioral Surveillance System (NHBS) surveillance study, conducted in 21 US metropolitan areas in 2008, black non-Hispanic MSM were significantly more likely to be infected with HIV than were white non-Hispanic MSM (28% vs 18%), and were also significantly more likely to be unaware of their HIV infection (59% vs 26%).[10] The prevalence rate-ratio in Georgia for black MSM, compared to white MSM, is estimated to be 5.5.[11] With respect to HIV incidence, from 2001-2005, black MSM accounted for 18% of all new HIV diagnoses,[12] yet during the same period, black men accounted for less than 7% of the US population [13] and black MSM represented an estimated <1% of the US population. From 2001-2006, new HIV diagnoses in black MSM increased by 1.9% per year, compared to a 0.7% annual increase for white MSM.[7]

Age is another important axis of disparity within the MSM epidemic. The increase in HIV incidence among MSM is largely driven by a marked increase among young MSM.[14] Further, the racial disparities in HIV incidence and prevalence are greatest among young MSM and black MSM have played a disproportionate role in the recent rise in new infections among young MSM. From 2006 to 2009, black MSM under age 30 experienced a 47% increase in new infections and in 2009, there were more new infections in Black MSM under age 30 than in white MSM under age 39 and more than all Hispanic MSM.[2]

<u>It is unknown why black non-Hispanic MSM are at greater risk:</u>

The reasons are unclear for the disproportionate levels of prevalence and incidence of HIV among black MSM, but simple examinations of individual risk behaviors have failed to explain the excess of HIV infections among black MSM. Data from the Young Mens' Surveys [15], from NHBS,[16-18] and from meta-analyses[19,20] suggest that the levels of individual-level behavioral risks, such as unprotected anal intercourse (UAI) and illicit drug use, are not greater, and may actually be less, among black MSM than among white MSM. Other data support the conclusion that black MSM tend to report fewer sex partners than do white MSM.[19,21-24]

The possible explanations for higher HIV prevalence in black MSM have been reviewed.[25] A critical review of the biomedical and social science literature documented support for the hypothesis that black MSM may be at greater risk of HIV because of increased prevalence of sexually transmitted diseases and lack of knowledge of serostatus, but no evidence that black MSM have more drug use, alcohol use, or unsafe sex.The review additionally found insufficient evidence to determine whether black men may be at increased risk because of choosing partners who are more likely to be HIV infected, higher genetic susceptibility, incarceration, differences in circumcision, or higher infectiousness.[25] The factors considered in this review were primarily individual-level factors, however the authors note that, from the scarce data available, the sexual network properties of black MSM are likely a contributing factor to higher HIV rates. A key network property that facilitates HIV/STI transmission, *sexual concurrency* was not addressed in this work.

Dyadic and network factors may help to explain the racial disparity among MSM

There has been a call to understand higher-order partnership (dyadic) and network-level properties among MSM, factors that may help to explain disparities seen among MSM.[26]

Recently published results from the 2008 MSM cycle of NHBS found that having partners of unknown HIV status was the only analyzed characteristic more prevalent among black participants [27]. Given that black men have a similar likelihood of lifetime testing compared to white men, this suggests that a lack of dyadic pre-sexual discussion of HIV status before first sex (‘serodiscussion’) may account for the higher prevalence of unknown serostatus partners among black men.[19,25] Several recent studies have reported lower serodiscussion among black MSM.[28,29] no study has examined serodiscussion by race/ethnicity in MSM stratified by HIV status and dyadic risk behavior. Using data from the Checking In study, an online study of MSM sexual behaviors that is the data source for this dissertation and described further in Chapter 2, we demonstrated that the lowest levels of serodiscussion occurred among black HIV-positive respondents and this group was the only one for whom serodiscussion with UAI partners was not more likely than with non-UAI partners.

A partnership and network factor that has been described as an important factor in the heterosexual spread of HIV is that of assortative mixing, or assortativity [30]. Assortative mixing may be understood as the extent to which individuals tend to interact with sex partners who share demographic or other characteristics. In sexual networks where high-risk/high-prevalence members have more frequent interactions with low-risk/low prevalence members (disassortative mixing), more transmission is expected to result.[31] Disassortative mixing can occur along several dimensions, including age, socioeconomic status, and risk behavior.

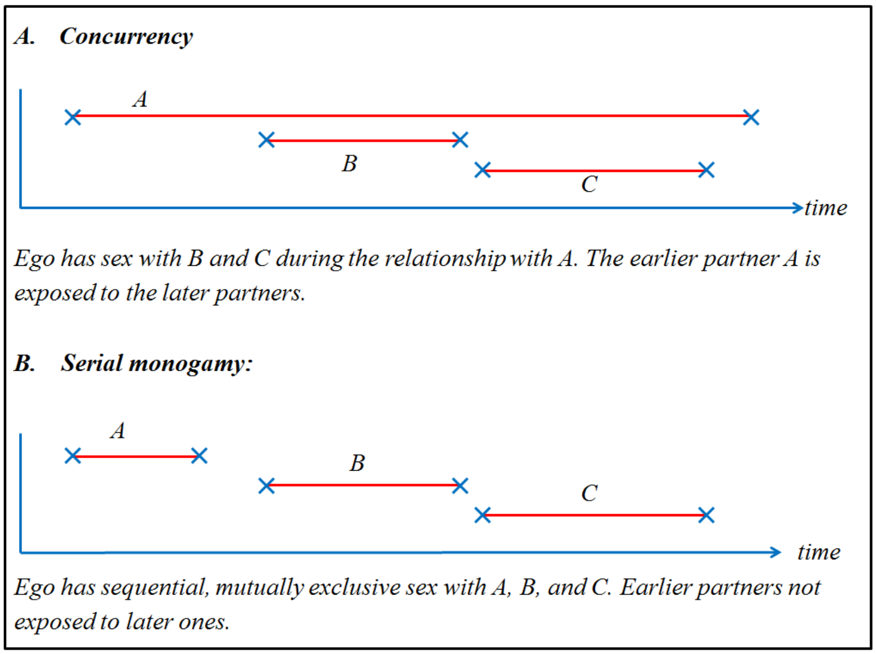
To measure assortative and disassortative mixing, researchers have characterized study participants and their sex partners by observable characteristics (e.g., age, race) that are known to be associated with higher HIV prevalence at the population level[32,33], and compared these traits among dyads using standard agreement statistics [28,29]. Occupation class (white collar, blue collar, marginal) has been used as a marker of socioeconomic status to describe disassortative mixing in black MSM.[22]

Our own analyses of the Checking In and BOPR (an online precursor to Checking In, conducted by Emory University) studies, have found high levels of racial disassortative mixing (~65% concordance) and age assortative mixing within racial groups (Lin's Concordance Correlation Coefficient [34] from 0.44 to 0.53) (*unpublished data.)* Simulations have shown that these high degrees of mixing yield enough epidemiologic 'bridging' between black and white populations to homogenous HIV prevalence over time, rather than sustain HIV disparities. *(Steve Goodreau - personal communication*).

<u>Sexual concurrency is potentially an important factor in understanding HIV epidemics</u>

Another important partnership-level phenomenon that is a determinant of HIV transmission in sexual networks and hypothesized to play a role in the US MSM epidemic is *sexual concurrency,* which may be concisely defined as having temporally overlapping sex partners (Figure 1.1.A). [35] A 2009 UNAIDS panel formally defined concurrency as "overlapping sexual partnerships where sexual intercourse with one partner occurs between two acts of intercourse with another partner" [36]. In the absence of concurrency, one's sexual partners are in a *serial monogamous* arrangement, where each of one's partnerships ends before the next begins (Figure 1.1.B)

Figure 1.1: Serially monogamous and concurrent partner arrangements



Serially monogamous relationships offer a protection of sequence, such that an individual's earlier partners are not placed at risk of acquiring a sexually transmitted infection from a later sex partner (transmitted through the individual having sex with both partners). The path of an infectious agent's transmission is therefore only from earlier partners to later ones. In contrast, concurrent relationships are thought to be an important catalyst of HIV/STI transmission via two mechanisms. The first is that concurrent relationships allow for bi-directional transmission of an infection between two partners, placing each at indirect risk from the other. Thus, at the network level, concurrency doubles the number of reachable paths for disease transmission [35,37]. Second, compared to serial monogamy, concurrency increases the likelihood that a newly infected individual would transmit HIV to an uninfected partner during the highly infectious acute period of HIV infection [35,38]. An important distinction is that the increased risk due to concurrency is imparted solely to one's partners, not to that individual. In other words, from the individual's (ego's) perspective, the temporal arrangement of one's partners does not matter. This point has been a source of analytical errors and methodological difficulties that are discussed below and that we propose to partially address in this work.

A number of simulation studies have established that concurrency has the potential to greatly accelerate HIV transmission in populations [31,39]. Morris et al [40] have recently demonstrated via simulation that minor differences in concurrency, in conjunction with a high degree of assortativity by race, have the potential to cause vastly deviating epidemics among heterosexuals in the United States. This confirms earlier modeling work[31] and suggests that concurrency may yet play a role in the United States' MSM epidemic.

<u>Limited data are available on concurrency among MSM</u>

Concurrency has been described with respect to the epidemiology of STIs and HIV in a variety of contexts such as African populations, [41-43] clinic-attending and general populations in the Seattle, Washington area, [44,45] and African-American communities in the southeast US.[46,47] Using data from the 2002 National Survey of Family Growth (NSFG), Adimora et al found that 11% of US heterosexual males had concurrent partnerships within the previous year, and among men who had any sexual partners within the previous year, 14% had concurrent partnerships.[48] They additionally reported that non-Hispanic black men (vs. non-Hispanic white men) had an adjusted odds-ratio of 2.6 (95% CI: 1.6, 4.1) for concurrent sex in the previous year, suggesting that a racial disparity in concurrency may also exist among MSM.

The understanding of concurrency among MSM is more limited. At the time this work was first proposed in December 2011, only one report of concurrency prevalence among MSM in the US had been published.[49] This analysis, by Bohl et al, used city-specific data from the second MSM cycle of NHBS. Among MSM in San Francisco, the authors showed a one-year concurrency period prevalence of 78%, using a variant of 'direct question' method (discussed in detail in *Methodological issues...*), which classified an individual as having had concurrent partners if sex was reported with a different partner during the most recent sexual relationship. Using this outcome, insufficient evidence of a racial/ethnic difference was observed. However, this concurrency outcome is highly dependent on the duration of and recentness of last sex in that most recent partnership.[36] If these relationship properties differed between racial groups, there could have been also been differential classification of and meanings of concurrency between these groups as well. The authors additionally reported that black men were 3 times as likely to report all pairs of their sexual relationships to start or stop within 3 weeks of one another (a type of 'complete concurrency'), compared to white men. This concurrency outcome is flawed in that it may classify bursts of serially monogamous partnerships that ended and began close in time as concurrent.[36] Perhaps most importantly, the racial comparison findings were also limited by the number of black MSM with multiple partners who provided complete data (n=18).

These first results suggest that levels of concurrency among MSM are far higher than reported among heterosexuals. Further, some differences in concurrent sexual relationships may exist between black and white MSM, but further studies are needed that involve more participants and that can more accurately measure concurrency by conditioning on a time interval and measuring the timing of all sexual relationships within it, rather than conditioning on the most recent relationship. Indeed, Bohl et al conclude their manuscript with a call for more expanded study of concurrency in MSM and validation of the multiple methods for measuring concurrency, a call echoed by others.[50]

Our own analyses of national NHBS data from 11,191 MSM have shown that black MSM have an adjusted estimate of 23% fewer casual male partners, compared to white MSM.[51] Coupled with Bohl et al's findings,[49] this suggests that black MSM may have fewer but longer, overlapping, or near overlapping, relationships rather than short-term concurrent relationships. Short-term concurrent relationships would have manifested in higher partner numbers unless the sexual encounters were few but concentrated in time.

In May 2012, Glick et al published a large (n = 2,889), comparative study of sexual behaviors of heterosexuals and MSM, using data from four multi-city and Seattle-based projects.[52] Using the month-resolution date-overlap approach, they reported a 10% 12-month cumulative prevalence of concurrency among heterosexual males, compared to 31% and 18% from 2 MSM samples. Although significant heterogeneity was observed by age, with men < 25 years being less likely to engage in concurrent sex, no findings were reported stratified by race/ethnicity. These findings confirm heterosexual estimates presented by others,[48] the likely disparity in concurrency levels between heterosexual males and MSM, and present more plausible concurrency estimates than those of Bohl et al.[49] Because concurrency was measured with a method that is subject to misclassification, race/ethnicity was not examined, and because the behaviors associated with and implications of concurrency are unknown for MSM, more studies on concurrency among MSM are needed.

Recent controversies have challenged the role of concurrency in HIV epidemics and reveal opportunities for methodological and empirical advancements

Despite the documentation of concurrency's occurrence in a variety of contexts, there is less conclusive empirical evidence documenting the causal relationship between concurrent sex and increased HIV transmission. Empirical evidence has also been insufficient to demonstrate concurrency's role in creating disparate epidemics between racial groups or countries. These shortcomings have generated at least three recent debates in *AIDS and Behavior*, *the Journal of the International AIDS Society (JIAS)*, and *The Lancet* about the role of concurrency in facilitating epidemics and creating disparities, primarily in the context of the sub-Saharan African HIV epidemic.[42,53-57]

The *JIAS* critique by Sawers and Stillwagon provides an excellent framework for understanding the state of concurrency research, as it intentionally and unintentionally highlights the historical difficulties, inconsistencies, and errors in the measurement and analysis of concurrency. Accordingly, the debate, initiated at the 2010 International AIDS conference,[58,59] and continued in a joint World Bank-USAID debate on concurrency in 2010, highlights the need for methodological advancements, parts of which are addressed in this dissertation. In June 2011, we provided an in-depth analysis and participated in a consultation on concurrency to Dr. Harold Jaffe, Associate Director Science for the Centers for Disease Control and Prevention (CDC) and other CDC leadership.[60]

In this section we summarize our analysis of the three most salient and relevant criticisms of Sawers and Stillwaggon's review. [54]

1. *Concurrency has been defined and measured inconsistently, yielding measures that are hard to compare across studies and regions, but cumulatively show weak support for high levels of concurrency in sub-Saharan Africa.*

Many studies have measured only whether relationships are proximal in time, but have not ascertained whether they truly overlap in time. Concurrency defined in this way is a relatively non-specific measure that would classify some serially monogamous partnerships as concurrent. Other inadequate concurrency measurement methods that result in similar misclassification are described in detail below, in *Methodological issues.* In general, these inadequacies are due to limitations of questionnaire design, technology, and recall. Sawyers and Stillwaggon erroneously used the mixed set of measures that resulted from these studies as evidence of inconsistent support for the existence of extraordinary levels of concurrency in sub-Saharan Africa, rather than ceasing at criticizing the methodological issue.

2. *The levels of concurrency and number of partners among sub-Saharan African heterosexuals are similar to the United States, yet the HIV prevalence is far higher in Africa. Therefore, concurrency is not important in explaining the different epidemics in*

Africa and elsewhere.

Sawers and Stillwaggon claim that there is no ecological evidence that shows an association between HIV prevalence and concurrency either within Africa or between African communities and those abroad; Epstein and Morris cite a number of studies to the contrary, while admitting that such studies are imperfect [55]. Yet conclusions drawn from these ecological studies are subject to ecological fallacy, and ecological findings alone do not preclude a role for concurrency, or other sexual network traits, in driving disparities in heterosexual epidemics. At least two mechanisms exist for such ecological fallacy, despite a true effect of concurrency on HIV epidemic propagation..

The first is that other sexual network factors like assortativity may be acting in concert with concurrency to cause different epidemics. At its heart, concurrency is primarily about the paths available for and speed of transmission, but other network factors like mixing patterns are required to guide the trajectory of transmission and to sustain the differentials that cause disparities. Assuming equivalent levels of concurrency in sub-Saharan Africa and the US, concurrency in sub-Saharan Africa might explain higher transmission rates if it were occurring in the context of mixing of high- and low-prevalence pools (i.e., geographic movement or the mixing of high and low age pools).

The second mechanism is that sexual concurrency is a situation that involves *three* individuals: a person and his/her two sex partners (aka: triads, Figure B2). The specific sexual practices with concurrent partners may extensively modify the effect of concurrency and have seldom been accounted for in previous research. For example, in order for concurrency to be biologically relevant, unprotected sex needs to occur with *both* of the concurrent partners. This is seldom measured, as it is difficult to collect the partner sexual data at this resolution. Only one paper has measured this phenomenon, finding that only about a third of concurrencies were biologically relevant [61]. To the extent that there are differential behaviors acting in concert with concurrency by region, differential effects of concurrency on HIV transmission may be seen.

3. *Beyond the societal level, there is no empirical evidence to demonstrate that concurrency increases HIV risk to individuals.*

The bulk of the studies used to assert that there is no individual-level relationship between concurrency and HIV risk have conducted their analyses incorrectly. This is because these studies have attempted to relate a person's level of concurrency to *that same person's* HIV risk.[62,63] The individually-focused studies (i.e., egocentric) that lead to these erroneous analyses are easier to conduct than the ones necessary to actually demonstrate increased HIV transmission due to concurrency.

In general, appropriate studies need to follow the partners of concurrent individuals either over time until infection develops, or, if the partner is already infected, conduct interviews or assays that establish the directionality of infection transmission. Contact-tracing studies of Chlamydia and syphilis in the US have provided some of the only examples of the latter technique [64,65]. Although these studies showed a strong association between concurrency and STI transmission to partners, they are not studies of HIV or of sub-Saharan Africa.

Epstein and Morris describe a set of longitudinal studies of HIV-incidence in African concordant-negative couples and studies of strain-similarity studies among concordant-positive ones have been conducted that allow estimation of HIV transmission into partnerships due to concurrency. They estimate that for stable couples, 60 to 84% of incident infections come from concurrency [55]. Yet a weakness of such results is that they are so narrowly focused on the unit of long-term couples and they cannot reliably give information about transmission risk for other individuals or at the community level.

Either egocentric studies employing enhanced methodologies or longitudinal studies of more broadly defined sexual networks may provide better assessments of individual-level risk due to concurrency. Even if studies can establish the individual-level transmission risk, it is less clear how to quantify the society-level attributable risk for transmissions due to concurrency, without ecological or simulation studies. Morris has suggested randomized community-level concurrency intervention studies that prospectively evaluate HIV incidence between intervention and control communities [66].

Despite generally astute criticisms, Sawers and Stillwaggon frame concurrency as a monolithic theory to explain why the sub-Saharan African HIV epidemics are different than those found in the rest of the world. They conclude that imperfect and slowly-progressing evidence to support a promising alternative hypothesis of the concurrency-increased transmission relationship means that it should be forever discarded in favor of the (also unproven) null hypothesis. A more prudent conclusion is that the methodology used to understand concurrency needs improvement and application to other populations experiencing generalized epidemics, such as MSM in the United States.

Indeed, all recent debates in the concurrency literature have focused on the sub-Saharan African HIV epidemics. Concurrency may be an important factor in the epidemics among MSM in the US, but remains little studied in that population. The controversies have nonetheless underscored key methodological issues that need to be resolved to understand concurrency among MSM.

Methodological issues in the measurement and analysis of concurrency

As described in the previous section, a portion of the controversy surrounding concurrency and its role in HIV epidemics is attributable to variations in and shortcomings of the methods used to measure and analyze this phenomenon. We frame the issues into three domains that have been inadequately addressed; that of accurate measurement of concurrency, inference at the appropriate levels of analysis, and the incorporation of risk behavior.

Measurement of concurrency

Participant concurrency response data have predominantly been collected using two techniques, 'date-overlap' and 'direct question', that are used to create a variety of individual-level concurrency cumulative prevalence outcomes. The techniques and outcomes have limitations and limited agreement with one another.[50,53,67]

The theoretically most precise method is the day-resolution variant of the date-overlap method, in which the dates of first and last sex for participants' named sex partners are collected and the resulting intervals are examined between each partner pair (‘triads’) for overlaps. Yet this is subject to errors in recall and logical inconsistencies [36,50,68]. More commonly, these data are collected at the month-level resolution, but this results in temporal ambiguities and misclassification of concurrency, particularly for short-term casual relationships.[24,48,50,69] Specifically, in the instances where a single-month overlap results in an ambiguity, the ‘tie’ partnerships must either be included as concurrent,[50,67] or conservatively excluded and assumed to be serially monogamous.[48,67]

In the ‘direct question’ method, one asks a participant, for each of his/her partners, about the existence of concurrent partners during that relationship. This precludes an understanding of partner sequencing as well as the other concurrent partners and associated behaviors involved [45,50]. Despite these limitations, this method is easiest to administer, may aid in participant recall, and was adopted in the second MSM cycle of NHBS in 2008.

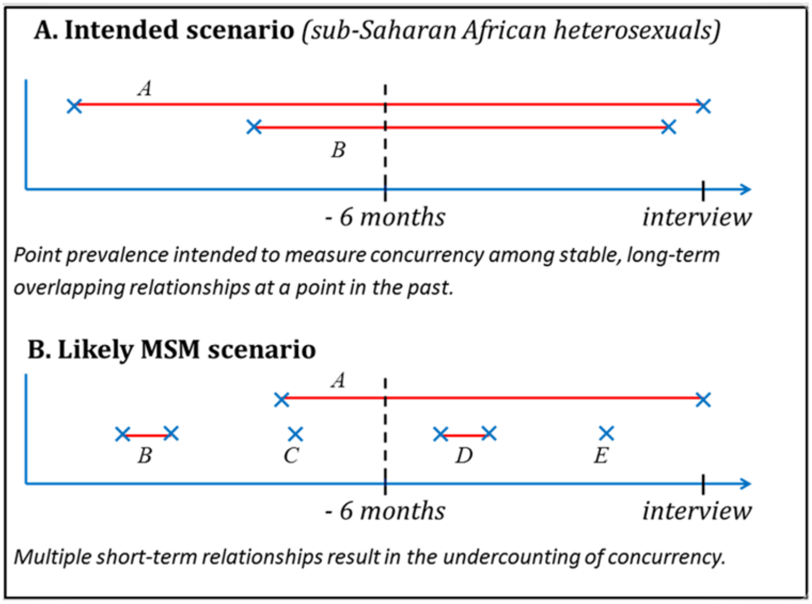
A lesser-used third technique is to inquire about temporally proximal (e.g. sex within 3 weeks) sex partners and assume them to be concurrent. [49] While this method detects the element of concurrency that is due to the increased transmission risk during acute HIV infection, it is flawed since it does not strictly measure the overlapping partnerships element and thus misclassifies proximate serially monogamous partners as concurrent. In the Checking In study, where 55% of reported partners in the previous six months were one-time sex partners, one would expect to observe substantial misclassification if using this measure and month-resolution date overlap measures, where assumptions are made about partnerships within the same month.

In response to the varied and limited measures of concurrency, a 2009 UNAIDS reference group recommended that the measure of the point-prevalence of concurrency at

6-months before interview, using one-month resolution date recall, be used in all future research [36,70]. The recommendation of a 6-month reference point, rather than the day of interview, is to avoid participant speculation about which partnerships are ongoing and to give a stable but easily recalled period in the past at which an overlap can be established.

Recent findings have both questioned [67,71,72] and supported [73] the utility of the UNAIDS recommendation. In any case, this metric faces at least three potential limitations in the measurement of concurrency among MSM in the United States, not described elsewhere. The first limitations involves the earlier described imperfections of date-recall and using a one-month date resolution, which the authors recognize [36]. Second, the UNAIDS group purposely chose a point-prevalence measure, rather than period-prevalence ones, to emphasize long-term overlaps and de-emphasize short-term ones. This is understandable, given the group's focus on the sub-Saharan African epidemic, where long-term overlaps are theorized to be the primary contributor to concurrent transmission. Yet, MSM have a greater number of partnerships,[24] a large proportion of which are short-term.[52] Together, this would decrease the probability that an individual was concurrently involved with two men at a particular point in time, despite having a substantial period prevalence of concurrency, ultimately yielding an undercount of concurrent sex among MSM. This potential misclassification is illustrated in Figure 1.2. Finally, although the data are gathered using the tie-exclusive month-resolution date overlap technique, the UNAIDS outcome is designed to only provide information about which individuals engage in concurrency, but limited information about the partners involved in the concurrency, a flaw partially shared with the direct question approach. This facilitates surveillance for individual-level concurrency but hinders nuanced understandings of the partnership and situational factors (triadic factors, discussed in *Levels of Analysis*) and the implied risk to partners (discussed in *Levels of Analysis*) that may be critical to understanding and/or modifying this behavior through prevention programs.

Figure 1.2: Point prevalence measures of concurrency underestimate the phenomenon among MSM



Given the limitations of the extant measures, there is a need to develop and validate an improved method for measuring sexual concurrency that is tailored to the sexual activity patterns of MSM. Drawing on both the strengths and weakness of the measures in use, such a tool should have all of these properties:

- Easy recall of the required information
- Truly measures overlaps between 2 partners, and ideally can establish the exact sequencing of all partners

- Can be linked with partner-specific behaviors and properties

In Chapter 2 we describe a technique that we have developed that satisfies all of these requirements. It is implemented in this dissertation and evaluated in Manuscript 1.

Levels of analysis

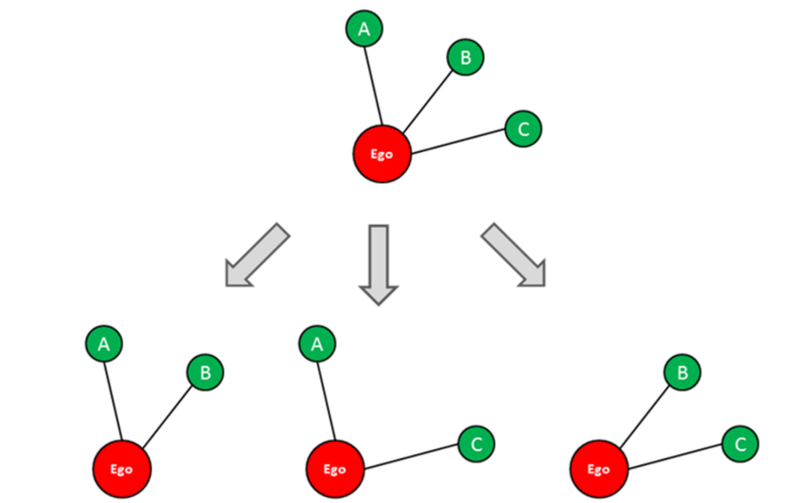
Egocentrically-collected data on sexual timing and concurrency may be conceptualized and analyzed at three levels of analysis, each of which provides unique information about concurrency.

The large majority of empirical studies of concurrency have presented their findings at the individual level, using individual study participants ('egos') as the observational units and reporting measures such as the period or point prevalence of concurrency. Analyses from this perspective are appropriate only to describe the distribution and correlates of individuals who engage in concurrent sex, and thus are most useful for behavioral surveillance. The analysis by Bohl et al of concurrency among MSM in San Francisco is from this perspective.[49]

But there is another level that is more relevant to understanding the population-wide prevalence and correlates of concurrent sexual arrangement: the triad.[74] Triads are the basic level at which concurrency's bidirectional transmission potential acts and represent the unit of an individual and two of his/her sex partners (aka: partnership pair, Figure 1.3). A given individual with p sex partners (p >1) may have up to $\binom{p}{2}$ concurrent triads of sex partners. Studies that have employed date-based concurrency measurement methods have explicitly assessed concurrency at this level before deriving individual-level prevalence measures. However, information may be lost when summarizing an individual's sexual history across triads, rendering individual-level concurrency an insufficient perspective for prevention applications. This is because individuals may be concurrent with only certain pairs of partners, and may differentially contribute to community transmission risk based on the number and types of concurrent triads they have. One may gain a better understanding of the features associated with concurrent partnerships (such as the individuals and risk behaviors involved) and their contribution to community risk, if concurrency is analyzed at the triadic level.[a] To support triadic analyses, sexual timing data must be collected using a method that measures concurrency with each of individuals' pairs of partners. The direct question and UNAIDS measures described fail to do this. Both support individual-level analyses and the direct question approach supports some dyadic analyses. Few reports of triadic concurrency have been published,[61] and none have been for MSM.

[a] In network-wide studies, the Morris and Kretzschmar *kappa* coefficient provides a measure that also summarizes instantaneous or cumulative concurrent connections in a way that does not reduce the available information.[37] However, this metric describes entire networks, rather than instances of concurrency, and is not available in egocentric study designs.

Figure 1.3: Triads, the fundamental unit of concurrency



An ego with p partners (p >1) has $\binom{p}{2}$ triads that may be concurrent or serial. Here, an ego has 3 partners and thus 3 triads of partners.

As cited, standard individual-level concurrency analyses are not appropriate for understanding individual HIV acquisition risk, yet a number of empirical studies have attempted to relate egos' levels of concurrent sex to those same egos' HIV risk. This has generated both misleading results and consternation from experts in the field, who have argued that risk due to concurrency cannot be understood from egocentrically collected data and that longitudinal dyadic or network study designs are required. [55] [b] Nonetheless, egocentric studies of concurrency are the most common and easiest to implement. There is a need to use such data to understand HIV acquisition risk to either egos or their partners, yet no methodology to do so exists. In Manuscript 3, we address this need by

[b] If one made the assumption that dyads are perfectly homogeneous with respect to sexual risk and concurrency, then an ego's level of concurrency could be used as a surrogate for that of his partners and relate that to the ego's HIV risk. This is unrealistic. Furthermore, in the context of comparisons across racial/ethnic groups, one might expect individual-level analyses of concurrency to approximately represent racial/ethnic differences in risk under the condition of high racial assortativity. However, MSM have a higher degree of racial mixing than do heterosexuals (65% concordance vs. 95%, [42] and unpublished data) and such an assumption would be a mistake.

implementing a new **partner-level** (dyadic) technique to understand the HIV acquisition risk imparted to partners of MSM that results from the egos' individual- and triadic-level concurrency.

Biologically relevant concurrency outcomes

An important limitation of the numerous empirical and simulation-based findings on concurrency, such as the racial disparities simulation by Morris et al,[40] is that investigators typically examine only the 'transmission potential' of concurrency. Any network connectivity is considered sufficient for transmission, irrespective of the dyadic risk behaviors and pathological properties that might modify the transmission effect of concurrency among concurrent triads. Yet the presence of concurrency is insufficient to cause the potential increase in disease transmission associated with concurrency since condoms may be used with one or both of the sex partners involved. In a triad, if condoms are used consistently and completely with either or both partner, then the potential chain of transmission is broken and the associated concurrency is irrelevant to network transmission dynamics. There is a need to understand *biologically relevant concurrency* – that is, triads in which anal sex with and incomplete condom use with both partners actually enables disease transmission.

However, biologically relevant concurrency has been seldom measured or described at either the participant or triad levels. This is likely due to the requirement of merging triadic-level concurrency findings with detailed dyadic behavioral data. Doherty et al have published the only findings on biologically relevant concurrency among triads from the US heterosexual data described above, and found that among these men, 28% of concurrent triads involved unprotected vaginal intercourse (UVI) with both partners.[61] To date, no data have been published on biologically relevant concurrency at any level among MSM.

Methodological improvements and an understanding of concurrency among MSM are needed

In this work we address the above three methodological gaps in the understanding of concurrency - those of measuring concurrency accurately, at the appropriate levels of analysis, and with the incorporation of risk behavior - towards the objective of a multifaceted understanding of concurrency among MSM.

This is accomplished across three aims. In the first, we apply and evaluate an enhanced method for measuring concurrency to data from a national sample of MSM. In the second aim, we quantify the amount of concurrency and concurrent UAI that MSM engage in, stratified by race/ethnicity, both at the individual and triadic levels, in a national online study of MSM. In the final aim, we explore the HIV acquisition risk conferred to partners, partially overcoming previous inabilities to understand risk from egocentric concurrency data.

These specific aims were formally proposed in January 2012:

1. To assess the ability of a novel partnership timing assessment module and algorithm to improve the classification of concurrency among MSM.

2. To describe the six-month period prevalence of concurrency and concurrent UAI at both the individual (ego) and triadic levels, and the triadic association between concurrency and UAI, among a national egocentric study of MSM, and to compare these findings by race/ethnicity.

3. To relate the findings of Aim 2 to HIV risk in the above egocentric study, by using a novel technique of describing the indirect exposure of participants' sex partners to other partners that is attributable to participants' concurrency and concurrent UAI. These findings will be compared by partner race/ethnicity and age.

The *a priori* implications for this work to the field of HIV prevention are potentially far-reaching. Findings of racially differential concurrency and concurrent UAI have the potential to provide a partial explanation for the disparate HIV epidemics among MSM in the US. Similarly, high but racially equivalent levels of concurrency may help to explain the incidence disparity seen between MSM and heterosexuals men. Either of these results could inform the development of interventions for MSM centered on monogamous agreements among men and/or the use of prophylactic measures when stepping out of monogamous relationships.

To date, no HIV/STI prevention intervention aimed at concurrency has been fully evaluated, although Uganda's "Zero Grazing" campaign of the early 1990's provides ecological evidence for the success of such a program.[75] A number of sources have suggested the exploration of a "one partner at a time" message,[40,76] which has begun in sub-Saharan Africa.[77] Although behavioral interventions to change detrimental sexual network characteristics would undoubtedly be challenging to design, test, and implement, having a solid evidence base that is MSM-specific and that incorporates more nuanced behavioral analyses on which to build intervention research would be critical to such an effort.

Irrespective of our findings among MSM in the United States, the enhanced methodologies employed in this work are anticipated to forward concurrency research in other contexts where it is thought to be a driver of HIV epidemics, such as Southeastern Asia and sub-Saharan Africa.

Structure of dissertation

In the next chapter (Chapter 2), we describe the Checking In study, which contributed the research structure and data of this dissertation, as well as the instruments developed for understanding concurrency in this research. This is followed by three chapters (Chapters 3-5), each containing an original scientific manuscript that addresses a specific aim of this research. In the final chapter (Chapter 6), we consider the *a posteriori* significance of this dissertation's findings and methods.

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Chapter 2 Research study and instruments

Study design

All data presented in this dissertation were collected by our Emory University-based research team as part of the *Checking In* study, a 12-month prospective online study of MSM in the United States, which began in August 2010. The primary objectives of Checking In are to assess the comparative utility of using web-based versus SMS data collection and retention methods among MSM in an online HIV prevention cohort and the feasibility of collecting biological endpoints among such a cohort, via at-home HIV testing. However, a secondary objective, implemented by this author (Rosenberg), is to obtain a detailed national sample of individual, dyadic, and network-level HIV risk behaviors. The principle behavior intended for study is sexual concurrency, although other phenomena such as serodiscussion, serosorting, and assortativity have been explored by Rosenberg and colleagues [1-3].

The participants were internet-using MSM who were recruited between August – December 2010 via selective placement of banner advertisements on social networking websites, including Facebook, MySpace, Black Gay Chat, and Adam4Adam. Men who clicked on the advertisements were taken to an online eligibility screening survey. Eligible individuals for the baseline questionnaire were male, at least 18 years of age, and reported a male sex partner in the past 12 months. Following the administration of an online consent document, participants completed a 60-minute SurveyGizmo-based Computer Assisted Self Interview (CASI) questionnaire. The study was reviewed and approved by the Institutional Review Board of Emory University (IRB #00031326).

While only a subset of men were eligible for and participated in the at-home HIV testing and longitudinal portion of the research study, a broader set of men enrolled in and completed the baseline questionnaire and form the sample of participants for the proposed research. Specifically, a total of 6,104 men consented to and began the online baseline behavioral questionnaire. Among them, 4,138 (68%) remained in the questionnaire and reported on having a male sex partner within the previous 6 months, with 3,768 (91%) having a sex partner within the previous 6 months. Of these MSM, 3,471 (92%) completed the partnership-timing module. This represents the largest and most geographically broad sample of MSM used in a detailed study of sexual concurrency, to date.

Study questionnaire

The data obtained for the dissertation research come from the CASI questionnaire administered at the online baseline visit, implemented in SurveyGizmo v2.6, a highly customizable and programmable online survey platform, and hosted on www.surveygizmo.com. The bulk of the responses utilized come from the Sexual Behavior Inventory portion of the questionnaire, which was developed by Rosenberg and Sullivan between Fall 2009 and Summer 2010. This is a modification of that used for the first MSM cycle of the CDC National HIV Behavioral Surveillance System (NHBS), conducted between 2003-2005 [4].

An outline of the inventory as implemented in Checking In is provided in Table 2.1, with the full inventory presented in Appendix 1. Section 1 collected aggregate partner counts and behaviors and is nearly identical to questions administered in the

NHBS, to enable comparisons of Checking In participants to national surveillance data. Section 2 allowed participants to enter nicknames for up to five sex partners in the previous six months and contains an implementation of the Partnership Timing Module, the primary concurrency data collection tool used for this research that is discussed in detail in the following portion of this chapter. Male sex partners were defined as anal and/or oral sex partners, and female sex partners were vaginal or anal sex partners. The next section, Section 3, contained a detailed dyadic behavioral inventory that collects demographic factors, partnership characteristics, and risk behaviors for each sex partner named. Responses from this section were merged with those from Section 2 to enable analyses of concurrency by partnership characteristics and behaviors in all three specific aims.

The data obtained from the Checking In questionnaire were downloaded from SurveyGizmo as an SPSS dataset, and were converted to the SAS7BDAT format and de-identified prior to data analysis.

Table 2.1. Page Layout of the Checking In Study Sexual Behavior Inventory

Section 1 - Partner metadata
- Partner genders, numbers, exchange sex
- Male partners: online partner number, and total sex acts
- Male partners: total UAI acts

Section 2 - Partnership timing module
- Partner name list *(up to 5)*
- Partner calendar
- Concurrency clarification questions *(if calendar indicates temporal ambiguities)*

Section 3 - Partner-specific section (*repeated for each recent sex partner named)*

3a. Partnership formation
- Partner demographics
- Partnership description
- Geography
- Disclosure of HIV status before first sex
- Serosorting intent

3b. Partnership timing
- Date of first sex
- Date of last sex
- Ongoing relationship

3c. Ongoing partnership questions
- Transgender partner anatomy
- Sexual frequency in the previous six months
- Sexual activity outside of this relationship *(Manhart et al direct questions (REF))*
- Group sex

3d. Last sex
- Sexual activities
- Circumstances (location, drugs, HIV status)
- Last sex – HIV status knowledge
- HIV status knowledge source
- Strategic positioning

Section 4 - Post partner-specific wrap up
- Relationships among partners *(transitivity)*
- Final screen

Partnership timing module

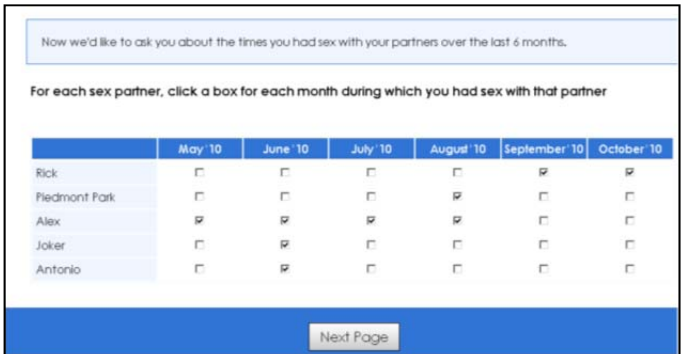
In order to conduct the dissertation work of understanding concurrency among MSM in the Checking In study as well as prepare for the launch of a cohort study of MSM in Atlanta, in Fall 2009 we began developing an improved method for measuring concurrency that improves on the methods described earlier, and is better suited to the partnering patterns of MSM.

Overview of measurement technique

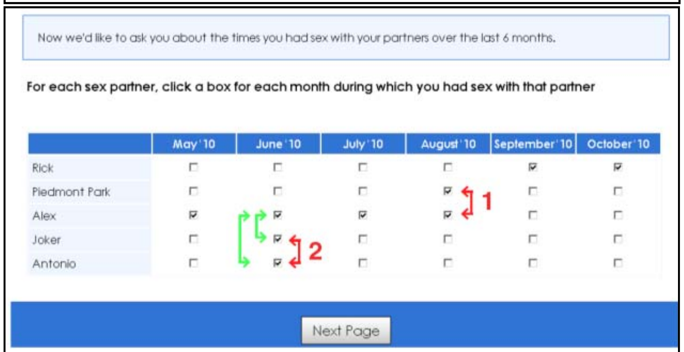
The partnership timing module was designed to measure concurrency in a manner that combines the strengths of the exact date recall and direct questioning methods described in Chapter 1, while circumventing their limitations. The module was designed to meet all criteria for an adequate concurrency measurement tool, also outlined in Chapter 1.

In the partnership timing module, individuals are given a calendar grid that displays the previous 6 months in columns and their partner names on the rows, with a prompt to indicate in which months they had sex with each partner by clicking the corresponding check-box (Figures 2.1 and 2.2).

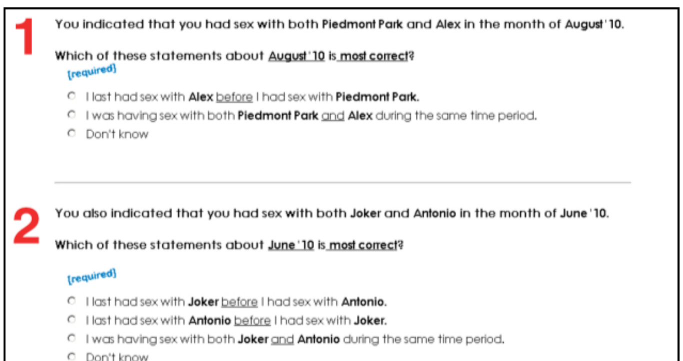
Figure 2.1. Implementation of calendar-based partnership timing module in SurveyGizmo ver 2.6, illustrating follow-up clarification questions



A.
The study participant indicates the months in which he had sex with each named partner.



B.
Partner pairs are examined at each month. Ambiguous overlaps between partners (red), are selected for further questioning. Obviously concurrent overlaps (green) are not selected.



C.
For each ambiguous month, the participant indicates the appropriate serial configuration of his partners, or that he was concurrently having sex with both.

Figure 2.2. Hypothetical partner calendar responses and concurrency determinations

Pattern A: During the last two months of sex with Partner A, the participant has sex with Partner B, satisfying concurrency Condition 1.

Partner	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
A						
B						

Pattern B: The participant has sex with Partner A in the month preceding and following the month of sex with Partner B (February). The relationship with Partner B is entirely contained within that of Partner A. This satisfies concurrency Condition 2.

Partner	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
A						
B						

Pattern C: The participant has sex with Partners A and B during the single month of March. It is unclear whether the partnership with Partner A ended before the participant began his relationship
with Partner B in March (serial monogamy) or whether he was with both concurrently, following the 'transitional' typology defined by Gorbach. A direct question asking about concurrency in March is required in order to determine whether concurrency Condition 3 is satisfied.

Partner	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
A						
B						

Pattern D: The participant has sex with all three partners A, B, and C during March. All may have been serial within that month, or any given pair of partners may have been concurrently with the participant. Three direct questions asking about concurrency with each pair of partners in March are required in order to determine whether concurrency Condition 3 is satisfied for each pair.

Partner	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
A						
B						
C						

The shaded months of Patterns C and D indicate 'opposing' non-sexual months that are used to detect ambiguous partner overlaps and trigger the administration of direct concurrency follow-up questions.

In the case where two or more overlapping months of sex between two partners, and one-month overlaps whereby one interval ‘contains’ a one-month interval entirely, are indicated, concurrency can be implicitly deduced from the calendar. But if the responses indicate a single overlapping month between two partners that is ambiguously concurrent or serial, direct follow-up questions are asked to establish whether the participant was with the two partners serially or concurrently during the indicated month. The responses to these direct questions can then be combined with the overall calendar responses to unambiguously reconstruct the participant’s partnership sequencing and make triadic conclusions about concurrency or serial monogamy while with each pair of partners.

This technique benefits from the easier recall afforded by month-level date-overlap and direct question approaches, while also incorporating a visual calendar aid. This is in congruence with recent calls for technology-enabled calendar methods for measuring concurrency [5,6]. Further, it gains the exact sequencing information provided by measuring dates of sex, without requiring participants to recall this hard to remember information. The gathering of exact sex sequence data allows for conclusive classification of concurrency and is superior to other common measures that make assumptions of no concurrency if two partners are named within the same month [6,7] or of concurrency from temporally proximate dates of sex (e.g. within 3 weeks of each other [8]. Furthermore, the direct questioning approach requires that concurrency questions be asked for each sex partner, whereas our novel technique only queries the participant in the event of an ambiguously concurrent response.

Concurrency determination algorithm: Definition

Participants reporting zero or one sex-partner by definition cannot have concurrent sex partners and are classified as having no concurrency. For participants indicating more than one sex-partner, triadic determinations of concurrency are made in the following manner. For each pair of partners (with an operational five-partner maximum of $\binom{5}{2} = 10$ pairs), the months that the participant indicates he had sex with each are compared. The pair is considered concurrent according to the following three conditions:

Condition 1

If the intervals defined by the months of first and last sex for each partner overlap by two or more months. (Figure 2.2, pattern A). This includes the 'transitional' and 'contained' concurrency typologies, as defined by Gorbach et al [7,9].

Condition 2

If the above intervals indicate a one-month overlap such that one partner with at least a 3-month long relationship entirely contains a one-month relationship with the other (Figure 2.2, pattern B). This pattern corresponds to both types of Gorbach's 'experimental' concurrency typologies [45].

Condition 3

Other one-month overlaps are ambiguously concurrent from the calendar alone (Figure 2.2, patterns C-D), and the participant is asked the following direct clarification question for each ambiguous month:

You indicated that you had sex with both **X** and **Y** in the month of **Z.**

Which of these statements about **Z** is most correct?

A. I last had sex with **X** before I had sex with **Y**.

B. I last had sex with **Y** before I had sex with **X**.

C. I was having sex with both **X** and **Y** during the same time period.

D. Don't know

The selection of Option C indicates that the participant was concurrent with the pair during the indicated month, while Options A and B indicate serial configurations. Since Gorbach's concurrency typologies were defined only at the one-month resolution, these more finely measured concurrency patterns may be realizations of any of the three defined typologies.

One-month overlaps that the participant indicates as serial in the given month are classified as concurrent if sex occurs with one of the partners in a later month such that an overlap exists. For example, if in the month of January, sex occurs with A and then B, and then sex occurs again with A in May, this configuration is concurrent.

Concurrency determination algorithm: Implementation

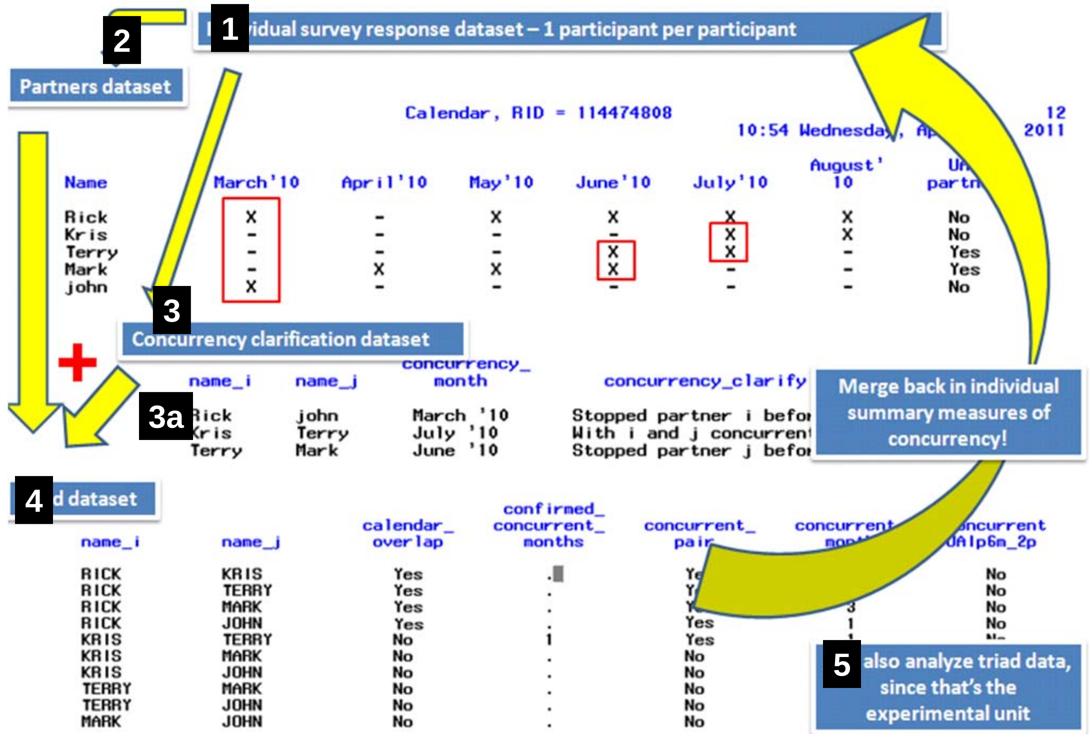
This algorithm is implemented piece-wise in two distinct stages, one at the time of data collection and the other at the time of data analysis.

Conditions 1 and 2 are both forms of unambiguous calendar overlap and may be evaluated from the processed calendar response data after the time of data collection. The processing of the response data is complex and both tasks have been implemented in SAS 9.2. This procedure is outlined in Figure 2.3, with code provided in Appendix 3.

Condition 3 is the only condition that requires calculation at the time of data collection, since determinations need to be made about offering the follow-up clarification questions. The real-time evaluation for Condition 3's ambiguous overlaps was implemented for each pair of partners for each calendar month, using SurveyGizmo's PHP-based scripting language. If for a given month, sex occurred with both partners of a pair, then the single months immediately preceding and following are also inspected. If these months indicate the current month was the month of last sex for one partner and first sex for the other (non-sexual 'opposing' corner months, indicated by shaded regions in Figure 2.1, patterns C and D), then the current month is deemed ambiguously overlapping and the follow-up clarification question are asked for the two partners in that month.

The choice of whether to display Options A and/or B is customized based on the temporal ordering of the two sex partners X and Y on the calendar. If the month of first sex with X is before that of first sex with Y, then Option A is presented. If the reverse is true, then Option B is presented. If first sex with both is in the same month (both are overlapping 1-month partnerships. Figure 2.1, pattern D), then both are presented. Options C and D are always presented. Other minor considerations, such as if the month inspected is the first or six on the calendar, are accounted for as well. The full PHP code for this script is provided in Appendix 2. Responses to the follow-up questions are processed to determine the satisfaction of Condition 3 in SAS 9.2 as part of the same code that evaluates Conditions 1 and 2 (See Figure 2.3 and Appendix 3).

Figure 2.3. Schematic of SAS processing of concurrency calendar data and implementation of concurrency determination algorithm



Explanation of datasets and steps

1. Calendar responses are stored on a cross-sectionally oriented dataset, with one row per participant. *Dataset N = n, the number of study participants*

2. Transposition of the responses pertaining to each partner of a participant yields a stacked partner dataset that allows for visualization of the original concurrency calendar and for dyadic analyses (ie: UAI, right-most column). *Dataset N =* $\sum_{i=1}^{n} p_i$*, where* p_i *is the number of partner reported by participant i*

3. Transposition of the responses to the concurrency clarification questions yields a stacked dataset of these responses, with observations for each pair of participants at each month with an ambiguous one-month overlap.

   Dataset N = $\sum_{i=1}^{m} \sum_{j=1}^{\binom{p_i}{2}} \sum_{g=1}^{6} a_g$*, where m is the number of participants with ≥ 2 partners,* p_i *= the total number of partners that participant i reports, and* a_g *= 1 if the partner pair j has an ambiguous one-month overlap in the month g and = 0 if not.*

   3a. The dataset from #3 is summarized for each unique pair of partners of a participant to determine whether concurrent sex was directly reported for a given pair in any month. Dataset n = sum of all partner pairs for whom a clarification question was asked.

   Dataset N = $\sum_{i=1}^{m} \sum_{j=1}^{\binom{p_i}{2}} b_j$*, where m is the number of participants with ≥ 2*

Continued on next page…

Figure 2.3 from previous page…

partners, p_i = the total number of partners that participant i reports, and b_j = 1 if the partner pair j had any ambiguous one-month overlap and = 0 if not.

4. For participants with ≥ 2 partners, a triadic dataset is created that has one row for each pair of a participant's partners and unique identifiers that are the partner pair names. The partner dataset in #2 is twice merged into the triadic dataset (once for each partner of the pair) and with the pair-oriented dataset of #3a. Each row contains enough information to evaluate the calendar overlap of Conditions 1 and 2 and the responses to direct questions that allow evaluation of Condition 3. Triadic concurrency outcomes, such as concurrency period prevalence, concurrency duration, and concurrent UAI are computed.
   Dataset N = $\sum_{i=1}^{m}\sum_{j=1}^{\binom{p_i}{2}} 1$, where m is the number of participants with ≥ 2 partners, p_i = the total number of partners that participant i reports. This is the total number of possible pairs of partners reported.
5. The triadic concurrency outcomes may be analyzed on the triadic dataset of #4, summarized by participant and merged in with the individual-level dataset of #1, or summarized by partner and merged in with the dyadic dataset of #2.

<u>Qualitative evaluation and pilot testing</u>

In November 2009 we recruited 13 MSM from Atlanta at venues frequented by MSM to participate in a computer-based pilot testing of the partnership timing module and a subsequent focus group about the user experience that was moderated by Rosenberg. All men were required to be at least age 18 and of black and white non-Hispanic race. An additional inclusion criterion was having at least 2 sex partners within the previous 6 months, so that concurrency in the timeframe was possible. The results from this formative work were presented in Spring 2010.[10]

Among those attending the focus group, the median age was 30, and 10 participants were white and 3 were black. The median number of sex partners reported in the previous 6 months was 4. At the conclusion of the CASI administration of the partnership timing module, participants completed a set of questions evaluating their experience, with results shown in Table 2.2. The responses reaffirmed that it was not easy to recall exact dates of sex. In contrast, recall associated with direct questioning about concurrency (typical direct question approach and clarification questions of the partnership timing module) was easier. The most positive distribution of responses pertained to the ease of use of the calendar method and in aiding recall of sexual partnership timing. In the focus group discussion, there was further general agreement that recalling the dates of sex with one's partners was difficult. There was support for the calendar-based module as a method to improve recall, with representative quotes in Table 2.3. Participants also provided feedback about the questionnaire's design, such as language suggestions and placing the calendar before the set of dyadic questions, that were used to modify the tool.

In July 2010, a revised version of the partnership timing module was included in an online pilot of the baseline questionnaire for Dr. Sullivan's Involvement cohort study. The questionnaire was administered to 1,077 men recruited using Facebook advertisements. The purpose of this pilot test was to evaluate the survey's programming logic to ensure that it functions correctly when administered to a large number of study participants. No errors that affected the timing module were identified and we felt comfortable integrating the section into subsequent study questionnaires.

Table 2.2: Summary of responses evaluating the partnership timing module

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I was able to recall the number of	0	2	4	5	2
I was able to recall the dates of sex with my partners …	0	7	3	3	0
When I could not recall an exact date, the questions that came after … were useful.	0	1	7	4	1
I was able to recall how many other many partners I had, while involved with the partner being discussed.	0	1	5	5	2
The partner calendar … was easy to use	0	0	1	9	3
The partner calendar helped me visualize my relationships.	0	1	1	9	2
If I were already part of a paid study that involved filling out a more general survey every 6 months for 2 years (5 times total), it would be reasonable to also include this survey's questions.	0	0	0	10	3

Table 2.3: Key themes and representative quotes from the qualitative evaluation of the partnership timing module

Preference for calendar method over other methods
"The grid at the end with the calendar, that sorta recapped everything… it was easier to think like that… it was easier to recall than one person at a time, with a date"
"… most of them I just remembered generally, but I did know who was before who, so I knew exactly that"
"… it's just hard for me to remember exact dates. I was pretty much estimating."
Acceptability of follow-up questions to resolve ambiguities
"I liked that at the end where it come back and said, … 'sex with these 2 people in October. If so, did you stop with him before you started with him'. That was so much easier for me. "

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Chapter 3 – Manuscript 1

For submission to JMIR: Journal of Medical Internet Research

Article Type
Original paper

Title
Assessment of a new web-based concurrency measurement tool among men who have sex with men in the United States

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Sources of Support:
National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and NIH P30AI050409 – the Emory Center for AIDS Research.

Abstract

Background

Men who have sex with men (MSM) are the most affected risk group in the United States' HIV/AIDS epidemic. Sexual concurrency, the overlapping of partnerships in time, accelerates HIV transmission in populations and has been documented at high levels among MSM. However, concurrency is challenging to measure empirically and variations in assessment techniques used (primarily the 'date-overlap' and 'direct question' approaches), and the outcomes derived from them, have led to heterogeneity and questionable validity of estimates among MSM and other populations.

Objective

To evaluate a novel, web-based, and interactive partnership timing module, designed for measuring concurrency among MSM, and to compare outcomes measured by the partnership timing module to those of typical approaches, in an online study of MSM.

Methods

In an online study of MSM aged ≥ 18 years, we assessed concurrency by using the direct question method and by gathering the dates of first and last sex, with enhanced programming logic, for each reported partner in the previous 6 months. From these methods, we computed multiple concurrency cumulative prevalence outcomes: direct question, day-resolution date-overlap, month-resolution date overlap including one-month ties and excluding ties. We additionally computed variants of the UNAIDS point-prevalence outcome. The partnership timing module, which uses an interactive month-resolution calendar to improve recall and follow-up questions to resolve temporal ambiguities, combines elements of the direct question and date-overlap approaches and was also administered. The agreement between partnership timing module and other concurrency outcomes was assessed with the percent agreement, kappa statistic (κ), and matched odds-ratio, at the individual, dyad, and triad levels of analysis.

Results

Among 2,737 MSM who completed the partnership section, 41% of individuals had concurrent partners in the previous 6 months, using the partnership timing module. The partnership timing module had the highest degree of agreement with the direct question. Agreement was lower with date-overlap outcomes (agreement range: 79%-81%, κ range: 0.55 – 0.59) and lowest with the UNAIDS outcome at 5 months before interview (65% agreement, κ = 0.14 [95% CI: 0.12, 0.16]). All agreements declined after excluding individuals with 1 sex partner, who are always classified as not engaging in concurrency, although the highest agreement was still observed with the direct question technique (81% agreement, κ = 0.59 [95% CI: 0.55, 0.63]). Similar patterns in agreement were observed with dyad- and triad-level outcomes.

Conclusions

The partnership timing module showed strong concurrency detection ability and agreement with previous measures. These levels of agreement were greater than others have reported among previous measures. The partnership timing module may be well-suited to quantifying concurrency among MSM at multiple levels of analysis.

Keywords: concurrency, MSM, sexual-network measurement, online questionnaire, HIV transmission, STD transmission

Introduction

Men who have sex with men (MSM) have long been the most heavily impacted risk group in the United States' HIV epidemic.[1] In 2009, MSM accounted for 61% of new HIV infections in the US and since 2000, MSM have been the only transmission group for whom incidence has been increasing.[2,3] Emerging evidence suggests that the biological realities of differential transmission probabilities for anal and vaginal sex and heterosexual role segregation play a larger role in the HIV disparities between MSM and heterosexuals than differences in individual-level risk behavior.[4-6] Yet the role of differential network-level factors may also be important and these factors remain insufficiently explored.[6,7]

On such factor is sexual concurrency, defined as "overlapping sexual partnerships where sexual intercourse with one partner occurs between two acts of intercourse with another partner".[8] Concurrency has the potential to catalyze transmission in populations by increasing both sexual network connectivity and the likelihood of transmission during acute HIV infection.[9,10] Simulation- , couples-based, and ecological studies have provided theoretical and empirical evidence of concurrency's causal role in amplifying HIV epidemics.[11-14]

Differences in the level and patterns of sexual concurrency between MSM and heterosexuals in the US remain little understood. High levels of concurrent sex have been recently documented among MSM in the United States (18% - 78% prevalence in the previous year),[7,15,16] substantially greater than among heterosexual men (10% - 11% in the previous year).[7,17] These reports all used differing methods of measuring concurrency, an issue found throughout concurrency research.[18,19] To properly describe the role concurrency might play among MSM, an understanding of the appropriateness of concurrency measures for this at-risk population is needed.

It is important to differentiate between the tools used to elucidate sexual timing information and the concurrency measures derived from these tools, as these two notions are subject to different types of limitations that have been conflated in critical examinations of concurrency measurement.[8,20,21] Two approaches, 'date-overlap' and 'direct question', have primarily been utilized to gather concurrency responses, both of which involve assessment on a partner-by-partner basis for a given number of recent sex partners. On the other hand, a variety of individual-level concurrency measures have been calculated using data from these approaches.

In the date-overlap method, the dates of first and last sex with each partner are gathered with the purpose of combining this information to examine overlapping partner intervals. Although seemingly powerful and precise if exact dates are used, this approach is subject to poor date recall and missing or illogical responses.[20,22,23] Variants of this measurement technique intended to alleviate these issues have been to gather date information at the month/year resolution only and as the number of days/weeks/month/years preceding interview.[8,17] The easements these alternatives provide come at the expense of potential temporal ambiguities for single-month interval overlaps ('ties'), which may be more common in populations with more short-term partnerships.

From these date collection techniques, multiple individual-level concurrency cumulative prevalence measures have been employed: having any exact date-overlaps,[24] any month-resolution overlaps and including ties as concurrent,[20,21,23] and most commonly, any date-overlaps but conservatively excluding ties.[8,17,21] These have been typically computed for a 12-month recall period.

A UNAIDS working group recently introduced a measure of concurrency, the point-prevalence of concurrency at 6 months before interview, to be calculated as a month-resolution overlap during this month and excluding ties.[8,19] This measure was specifically chosen to emphasize longer term relationships and overlaps, which are expected to more greatly contribute to the risk of concurrency in the sub-Saharan African context for which the measure was developed.[8,19] Yet this also creates the potential to drastically under-count the occurrence of concurrency in a population with frequent short-term sexual contacts.

The direct question data collection method assesses, for each partnership, how many other sex partners were had during that partnership in the recall period. An individual-level period prevalence measure is then derived from inspection for any partnership with 1 or more outside partner.[23] This method is simple to administer, may be easier for recall, typically yields fewer missing data, and is less limited by the total partners able to be described in the survey.[20,25] Yet it is potentially more impacted by biases related to social-desirability and in the perception of concurrency.[21]

The few published comparisons have shown varied performance of these measures, partly due to the differences and limitations discussed. Nelson et al found similar levels of concurrency among US heterosexuals, but only fair agreement, using month-resolution date-overlap (inclusive of ties) and direct question measures.[20] Glynn et al found lower agreement across a broader set of the above measures, and the most concurrency using direct question in Malawian heterosexuals.[21] Maughan-Brown and Venkataramani have reported similar findings in a South African comparison of the direct question and UNAIDS measures.[25] Because no gold-standard method exists, it is unclear if the highest levels of concurrency measured by the direct method correspond to best detection.

Absent from previous discussions of concurrency measurement techniques are considerations of which levels of analysis they enable. Individual-level concurrency is important for the surveillance of those who engage in concurrent sex. Yet it is a limited analytical perspective for the research purposes of empirically understanding the types, correlates, and implications of concurrency. This is because the fundamental unit at which concurrency operates is the triad, composed of an individual and two sex partners.[26] Individuals may contribute multiple triads, and summarizing triads to form individual-level measures discards information about the partnership-level factors associated with concurrency. Recently published triadic results have described the prevalence of unprotected sex with both members among concurrent triads and the association between triadic concurrency and unprotected sex.[15,27] Of the above measurement approaches, only measures based on cumulative date-overlap data would permit triadic analysis.

The dyadic, or partner, perspective is another important level for understanding concurrency.[28] An individual's concurrency does not impact one's own risk of infection acquisition, but rather that of one's partners, a distinction that has long stymied empirical analyses of concurrency.[26,29] Ideally, empirical analyses of infection risk due to concurrency would examine which types of partners are involved in concurrent relationships and would quantify partners' increased exposure and/or infection due to concurrent sex. One analysis has assessed such increased dyadic exposure among MSM (Rosenberg et al. - unpublished). Both date-overlap and direct question approaches can be used to measure dyadic concurrency, although the latter is limited by the absence of data on other partners with whom the respondent was concurrent. UNAIDS-type point prevalence measures are insufficient for triadic and dyadic analyses, since only a particular subset of concurrent partnerships are detected.

The majority of empirical concurrency measurement work has been conducted in in sub-Saharan African [21,30-32] and US heterosexual [23,30,31] settings, rather than MSM, whose partnership patterns are distinct from these populations.[7] Compared to heterosexuals, MSM on average report more, shorter term casual partners.[7,32] This presents several challenges to concurrency measurement among MSM. First, to the extent that these partnerships are one-time or are contained within a single month, substantial misclassification would be likely if month-resolution date-overlap measures are used, with disparate results seen depending on the inclusion of ties. Because MSM are more likely to report more than one sex partner, and thus have more opportunity for concurrency, fewer individuals would be automatically classified as non-concurrent by all measures, compared to heterosexuals. This would be expected to result in higher estimated prevalence of concurrency among MSM, and a decline in the agreement between concurrency measures.

In this paper, we describe a novel, web-based concurrency measurement tool, used in two recent analyses.[15] (Rosenberg et al. unpublished) It is designed to remedy reporting biases, enables triadic and dyadic analyses, and is tailored to the sexual activity patterns of MSM. This tool employs a compromise between date-overlap and direct question methods, and is consistent with calls for improved, computer and calendar-aided concurrency measurement techniques.[8,20] At multiple analysis levels, we assess the agreement of concurrency prevalence measures from this technique with those computed based on the other methods.

Methods

Study design

Data are from participants' baseline responses in a 12-month prospective online study of HIV behavioral risks among MSM in the United States, described previously.[15,33,34] Internet-using MSM were recruited from August – December 2010 through selective placement of banner advertisements on social networking websites. Eligibility criteria for participation in the baseline questionnaire were being male, being at least 18 years old, and having a male sex partner in the past 12 months. Following online screening and consent, participants completed a 60-minute questionnaire, developed in SurveyGizmo 2.6 and hosted on www.surveygizmo.com. The study was reviewed and approved by the Institutional Review Board of Emory University (IRB #00031326).

<u>Partnership-level data collection</u>

As part of the online questionnaire, participants who had ≥1 sex partner in the 6 months before interview were asked to provide nicknames for up to 5 most recent anal, oral, or vaginal sex partners within the previous 6 months. This was followed by a novel partnership timing module, described elsewhere,[15,35] in which participants were provided a calendar-like grid of check-boxes that displayed the previous 6 months in columns, and partner nicknames on the rows. Participants were asked to indicate the months in which they had sex with each partner (Figure 1a). A response pattern that showed two or more common months of sex between a given two partners resulted in the triad being later classified as concurrent, consistent all date-overlap techniques. In the case where responses indicated a tie, follow-up direct questions (Figure 1b) were asked to clarify whether the participant was with the two partners serially or concurrently during the indicated month. This method inherits the easier recall afforded by month-resolution dates and direct questioning approaches, but gains the unambiguous sequencing information provided by day-resolution dates.[35] Recall is further aided by the ability to visualize all partnerships simultaneously on a calendar, rather than report timing per partnership.[8,20] The partnership timing module additionally enables concurrency measurement at the individual, dyad, and triad levels. A demonstration of the partnership timing module is available at *https://s-t1yp3-325535.sgizmo.com*.

Following the partnership timing module, participants completed an in-depth demographic and behavioral inventory for each partner. For repeat, rather than one-time (one-off), sex partners, standard direct concurrency questions were asked,[23] along with the partnership's first and last dates of sex. To help alleviate common problems with missing or invalid dates,[19,20] a flexible series of date questions were asked, with tight logical controls applied. Initially, month/year-resolution dates were requested, but participants could opt-in to provide the exact date, if known. If the month was unknown, participants were prompted to select quarters of the year and shown reminders of familiar events during those seasons, in order to aid recall. If the year was unknown, ranges of years in the past were provided. Out of sequence or invalid (ie: future dates or last sex > 6 months prior to interview) first and last sex dates (or approximate dates/quarters) were detected in real-time. Participants were then shown their logical error and prompted for correction. Due to the multiple allowances for indicating partial/unknown responses, the date questions could collectively be set as required, further reducing the potential for missing data.

<u>Focus group & Facebook pilot</u> –

In December 2009, a focus group with 13 MSM was conduct to evaluate the partnership timing module, in comparison to the direct question and date-based data collection methods. A high degree of acceptability was indicated for the partnership timing module, which participants felt facilitated recall more than the date collection. Focus group feedback resulted in refinements to the partnership timing module placement and follow-up question wording. An additional online pilot study was conducted with 1,077 Facebook-recruited MSM, with the purpose of testing and refining the questionnaire's logic.

<u>Concurrency measures</u>

Measures of concurrency were calculated at the triadic, dyadic, and participant levels.

Each unique combination of a respondent and two reported sex partners comprised a triad; each respondent could contribute 0-10 triads, based on the number of sex partners in the past 6 months about whom he reported information. Triads were considered concurrent using partnership timing module responses if the months of sex with both partners overlapped by >= 2 months (criterion A), if they overlapped by 1 month and one partner's interval entirely contained the 1 month relationship of the other partner (criterion B), or based on a response to the clarification questions that affirmed concurrency for a 1-month tie (criterion C). Using the date information for each partner described, triadic date-overlap was evaluated by the 3 methods described above: exact date-overlap, month-resolution date-overlap and excluding ties (using criteria A and B),[17,19,21] and including ties.[20,21,23]

At the dyad level, concurrency was classified using direct question responses, dichotomized at ≥ 1 other sex partners during the relationship being queried.[23]

These triadic and dyadic measures were summarized by participant to yield individual-level binary measures of the cumulative occurrence of any concurrency in the previous 6 months.

Lastly, we computed UNAIDS measures of the point-prevalence of concurrency prior to interview.[8,19] The questionnaire's six-month recall period precluded its calculation at 6 months before interview, and instead 5 and 3 months were chosen to represent the closest time to 6 months and the mid-point of the recall period, respectively.

Analytical methods

We previously described concurrency among 3,471 participants who completed the partnership timing module [15] and in this report we included the 2,737 who completed the partner inventory for all partners (79%), consistent with recommendations for concurrency outcome computation.[8] For this restricted sample, we computed the distribution of demographic characteristics. Next, the prevalence of individual-level concurrency was computed for all concurrency measures. The percent agreement of concurrency classifications was computed pair-wise between the partnership timing module and the other methods (direct question, all three date-overlap, and both UNAIDS outcomes). Agreement in excess of chance was assessed the kappa statistic (κ) and its 95% confidence interval (CI).,The degree to which discordant concurrency classifications favored the partnership timing module was quantified by the matched odds-ratio (mOR) and its 95% CI.

Several participant subsets were examined to further resolve the partnership timing module's ability to accurately classify concurrency. To understand whether limiting the partnership inventory to 5 partners constrained concurrency measured by the partnership timing module, relative to the direct method (which has no upper bound), we compared these two methods after excluding participants who reported more than 5 total partners in the previous 6 months. Because participants with only 1 sex partner are automatically classified as not concurrent by all measures, thereby inflating their agreement, we performed the above computations restricted to participants with multiple sex partners. Next, because dates of sex were not collected for one-time sex partners, potentially lowering date-based prevalence and agreement estimates, we additionally conducted an analysis restricted to participants who reported multiple and exclusively repeat sex partners.

We additionally assessed the prevalence and agreement of these measures at the dyad and triad levels of analysis. This is because these levels are the ones at which concurrency data are primarily collected (dyadic by direct question; triadic by date methods) and these levels contribute to understanding different aspects of concurrency,

Results

Among the 2,737 participants who completed the partnership inventory, 53% (1,843) identified as white non-Hispanic, 17% (604) as black non-Hispanic, 14% (493) as Hispanic, and 15% (531) as other race/ethnicity. The median age was 27 years and a median of 3 sex partners was reported in the previous 6 months.

Table 1 displays individual-level prevalence measures of concurrency in the previous 6 months. Using the partnership timing module, 41% of participants reported at least one concurrent triad and thus had concurrent partners. More individual concurrency was identified using the direction question (49%) and lower levels were classified using the date-based measures. The pair-wise agreement between the partnership timing module and the other concurrency measures is shown in the right pane of Table 1. Overall, a large degree of agreement was observed (agreement range: 65% - 86%), although substantial variation was seen in the amount in excess of chance association (κ range: 0.14 – 0.71).

The most agreement was observed with the direct question technique, with 86% and a κ of 0.71, although the direct question method significantly classified more concurrency (mOR = 0.27, $p < .0001$). The exclusion of 388 participants with more than 5 total partners reduced both methods' concurrency prevalences by 7%, but resulted in a negligible change in their agreement (87% agreement, $\kappa = 0.72$).

Concurrency prevalences were 28% and 26% using overlapping day- and month-resolution (excluding ties) date measures, respectively. Although these levels were less than that detected with the partnership timing module, these dates measures had nearly identical and moderate agreement with the module (79% agreement, κ: 0.55). Where the methods differed, the partnership timing module was over 4 times more likely to classify individual concurrency (mOR: 4.8, 6.8, compared to day- and month-level dates methods, respectively). A 33% concurrency prevalence was measured by overlapping month-level dates that included ties. Levels of agreement with the partnership timing module were similar to those of the other date measures, although a lower mOR of 2.6 was observed.

The lowest levels of concurrency were detected using the two modified UNAIDS point-prevalence measures. Five percent of participants reported concurrent partnerships at 5 months before interview, and 7% did so at 3 months beforehand. Similarly, the agreements between these measures and the partnership timing module were lowest (κ = 0.14 and 0.17 at 5 and 3 months, respectively). Additionally, the two modified UNAIDS measures had high agreement with one another (97% agreement, $\kappa = 0.73$). To assess to the degree to which the use of month-level dates with the exclusion of ties might diminish UNAIDS-measure estimates, we calculated these point prevalences using day-resolution date information and found prevalences of 16% and 17%, at 5 and 3 months respectively.

Table 2a displays these same metrics for those participants who reported ≥ 1 sex partner. Among these participants, the prevalence of concurrency as measured by the partnership timing module was 60%. As anticipated, this restriction also caused all other prevalence measures to increase (range: direct question 70% - UNAIDS 5 months 8%) and their agreement with the partnership timing module to decrease (κ range: direct question 0.59 - UNAIDS 5 months 0.09). For this subgroup, the agreement between the direct question and the tie-inclusive overlapping dates methods were fair (κ = 0.44), similar to that reported among US heterosexuals (κ = 0.40),[20] and higher than that among Malawian heterosexuals (κ ≈ 0.23).[21]

A further restriction to participants with exclusively repeat partners is shown in Table 2b. A 74% concurrency prevalence was observed, using the partnership timing module. High and similar levels of agreement were observed for the direct question and date-overlap methods, compared to the partnership timing module (agreement range: 87 – 90%, κ range: 0.65 – 0.72). Despite high agreement, very low mOR were seen for the direct question (mOR = 0.07) and tie-inclusive date-overlap methods (mOR = 0.03). In contrast, poor agreement was seen between the UNAIDS and partnership timing module measures (% agreement: 49%, 51%, κ range: 0.17, 0.20 for 5 and 3 months).

The measurement of concurrency at each method's primary unit of measurement is shown in Table 3. Participants indicated concurrent partners during 57% percent of partnerships involving repeat partners, using the partnership timing module. Using the direct question, this was 67%, with a substantial level of agreement (84%, κ = 0.66). Discordantly classified partners were 5 times as likely to considered concurrent by the direct question method (mOR = 0.2). Among triads involving two repeat partners, 64% of those involving two repeat partners were concurrent. Agreement was consistent and moderate with the three overlapping dates measures (agreement range: 79 – 81%, κ range: 0.48 – 0.59). By the tie-inclusive overlapping dates method, triadic concurrency prevalence was high (82%), with high tendency to classify discrepant triads as concurrent, compared to the partnership timing module (mOR = 0.08).

Discussion

In this comparison of extant concurrency measures and measures derived from a new partnership timing module, a wide range was seen in the overall prevalence of concurrency among our sample of MSM, which may help to explain the sizeable variability seen in published estimates of concurrency prevalence among MSM.[7,16] Overall, the observed levels of agreement between the partnership timing module with date-overlap and direct question cumulative prevalence measures are higher than we and others have found among these latter two types of measures.[20,21] Further, the prevalences of concurrency measured by the partnership timing module were between those resulting from these two measurement types. This is consistent with our expectations, as aspects of the partnership timing module are borrowed from these techniques.

The greatest degree of agreement was seen with the direct question measures, which consistently yielded the highest frequency of concurrency, consistent with what others have reported.[21] That this highest prevalence was seen despite restricting to individuals with less than 5 partners corresponds to either better concurrency detection abilities of the direct question method or its inadequate validity. Because direct question concurrency was seen among 3-7% of those with 1 partner, this approach likely has limited specificity. Others have attributed this to under-reporting in partner histories and priming effects of the direct questions,[21,25,36] however we observed this phenomenon even more frequently when using 6-month partner counts provided earlier in the questionnaire. Due to potential over-classification and the earlier analytical limitations for the direct question measures, the high levels of agreement between the techniques, and that the partnership timing module retains direct questioning where critical, we feel the partnership timing module seems like an appropriate alternative to the direct question approach.

More individuals were classified as having concurrent partners using the partnership timing module than with all date-overlap methods. Examining those with exclusively repeat partners, agreement was markedly improved. Some of this is likely explained by the limitation of not asking dates of one-time partners, who represented almost half of partners described in this sample (45%), and may be involved in a substantial proportion of concurrent triads among MSM. This pattern is less common and has been generally disregarded as unimportant for concurrency-related HIV transmission in other contexts.[8] However, the role of one-time partnerships in MSM concurrency transmission is yet to be determined and may be broader, given the greater per-sexual act HIV transmission risks and the documentation of transmission bursts among MSM.[4,37] The inclusion of sex date for one-time partners would increase date-overlap measure prevalence, yet it is unclear whether the agreement of these measures would be substantially improved, compared to the partnership timing module, for several reasons. Poor recall for ongoing partnerships has led to the seldom use of day-resolution concurrency measures. Although the enhanced date collection methods used may have improved date recall and quality, data quality would likely be worse for one-time partners. The more commonly used month-resolution measures showed a greater disparity in the degree of concurrency detected, owing to differential classification of repeat ‘tie’ partnerships of short duration but within one calendar month. The influx of one-time partners would necessarily inflate the number of one-month partnerships and cause the agreement of the two month-resolution measures to diverge further, representing upper and lower bounds of the true date-based concurrency estimate. Indeed, the partnership timing module was designed precisely to alleviate this ambiguity among MSM partnerships.

Relatively low levels of concurrency were detected by the UNAIDS-style point-prevalence measures at 5 and 3 months. The two prevalence measures were consistently similar, implying that the precise time-point may be arbitrary, and suggesting a plausible range for the 6-month indicator, if it were computable. A portion of the low detection may be explained by the exclusion of one-time partners. However, the UNAIDS method always excludes ties and many one-time partnerships would manifest as single-month ties, rather than being fully ‘contained’ within another multi-month partnership. The degree to which classification was impeded by excluding ties was quantified by substituting day-resolution point-prevalence (a non-standard measure), which resulted in modestly increased classification. This method by definition excludes all one-time partners, except for those on the exact day being assessed, and the inclusion of one-time partner dates would not change the estimates of 16% and 17%. Nonetheless, the month-resolution measures we found are in the range of those reported among sub-Saharan

African heterosexual men.[21,38] This implies a false equality in concurrency patterns between these two populations, given the documentation of substantially different concurrency cumulative prevalence,[7,15] that is likely partially due to differences in partner duration among MSM. The UNAIDS measure accordingly appears to be ill-suited for studying concurrency among MSM in either surveillance or research contexts.

In addition to measure-specific limitations discussed, this report is subject to several broad limitations. Participant drop-out in the partnership inventory may have biased observed results, specifically lowering concurrency estimates since those with more partners were likely to not complete the questionnaire. We earlier reported 45% individual-level concurrency among the 3,519 men who began, but did not necessarily complete this section.[15] This is similar to the 41% observed in this report and partly allays these concerns. We also recognize that concurrency measured on subsets, such as those with multiple partners, do not necessarily make valid population-wide estimates because their validity is tied to the occurrence of those subsets. These subsets should be used only to weigh the relative merits of measurement approaches. Last, we have only considered the performance of these concurrency tools and measures among MSM. In other at-risk populations, particularly those with more longer-term concurrently overlapping relationships, fewer differences between measures are expected. Nonetheless, the desire to conduct analysis at other levels should be considered in selecting the appropriate concurrency measure. Compared to other measurement approaches, the partnership timing module requires that more complex computer-programming logic be executed in real-time, in order to be implemented. This may impede its application in some surveillance contexts. Yet as technologically-enhanced data collection modalities become sophisticated and normative, this limitation will become less prominent.

Across a range of comparisons, the partnership timing module showed strong concurrency detection ability and agreement with extant measures among an online sample of MSM. The technique overcomes known limitations of other concurrency collection approaches and measures, and may be well-suited to MSM partnership patterns. Furthermore, its placement before detailed partnership questions may help to avoid priming participants for socially-desired responses,[25] while providing the benefit of generally reorienting participants to their sexual histories. Further research of concurrency among MSM should consider the incorporation of this new measurement technique.

Acknowledgements

We wish to acknowledge Christine Khosropour for her coordination of the Checking In study, Nicole Luisi for her data management support, as well as the following National Institutes of Health grants: National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and P30AI050409 – the Emory Center for AIDS Research.

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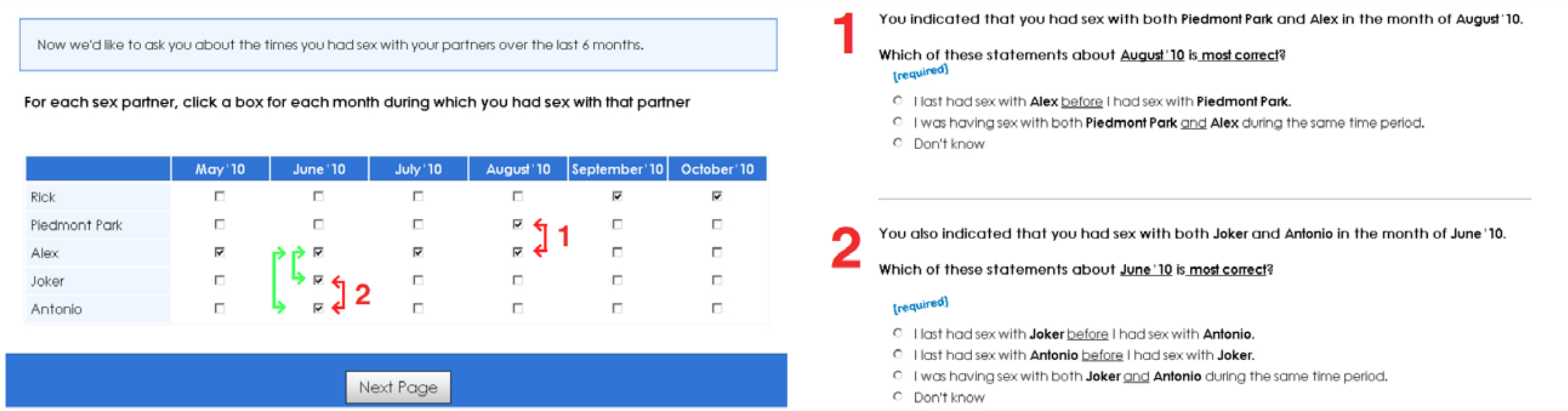
Figure 1



A.
The study participant indicates the months in which he had sex with each named partner. Partner pairs are examined at each month. Ambiguous overlaps between partners (red), are selected for further questioning. Obviously concurrent overlaps (green) are not selected.

B.
For each ambiguous month, the participant indicates the appropriate serial configuration of his partners, or that he was concurrently having sex with both.

Table 1 **Individual-level concurrency, by partnership timing module and alternative measures of concurrency, among 2,737 men who have sex with men**

	Concurrency prevalence		Agreement with partnership timing module					
	%	*(n concur,; n miss.)*[1]	*%*	*(n agree; n concur.)*[2]	*kappa*	*(95% CI)*	*mOR*	*(95% CI)*
Partnership timing module	41.1	(1,124; 0)	--	-- --	--	--	--	--
Direct question	49.3	(1,333; 35)	85.6	(2,313; 1,026)	0.71	(0.69, 0.74)	0.27	(0.21, 0.34)
Date overlap, *day-resolution*[3]	27.5	(753; 1)	79.4	(2,171; 656)	0.55	(0.52, 0.58)	4.8	(3.9, 6.0)
Date overlap, *month-resolution, excluding ties*	25.7	(704; 1)	79.4	(2,172; 632)	0.55	(0.52, 0.58)	6.8	(5.4, 8.8)
Date overlap, *month-resolution, including ties*	32.6	(893; 1)	80.7	(2,209; 745)	0.59	(0.56, 0.62)	2.6	(2.1, 3.1)
UNAIDS, *5 months before interview*[4]	5.3	(146; 1)	64.8	(1,746; 140)	0.14	(0.12, 0.16)	164.0	(78.6, 405.5)
UNAIDS, *3 months before interview*	6.8	(185; 1)	65.1	(1,781; 177)	0.17	(0.15, 0.20)	118.4	(62.1, 255.6)

1. *n concur* = number concurrent, *n miss* = number missing
2. *n agree* = number that agree, *n concur* = number that both agree are concurrent
3. Date overlaps measures exclude one-time partners, for whom dates of sex were not asked.
4. UNAIDS point prevalence measures modified to 5 and 3 months from typical 6 months

Table 2 **Individual-level concurrency, by partnership timing module and alternative measures of concurrency, among subsets of men who have sex with men**

	Concurrency prevalence		Agreement with partnership timing module					
	%	*(n concur.; miss.)*[1]	*%*	*(n agree; n concur.)*[2]	*kappa*	*(95% CI)*	*mOR*	*(95% CI)*
a. Participants with multiple partners *(n = 1,864)*								
Partnership timing module	60.3	(1,124; 0)	--	-- --	--	--	--	--
Direct question[3]	70.1	(1,291; 22)	81.2	(1,495; 1026)	0.59	(0.55, 0.63)	0.31	(0.24, 0.40)
Date overlap, *day-resolution*[4]	40.4	(753; 1)	69.7	(1,298; 656)	0.42	(0.38, 0.45)	4.8	(3.9, 6.0)
Date overlap, *month-resolution, excluding ties*	37.8	(704; 1)	69.7	(1,299; 632)	0.42	(0.39, 0.46)	6.8	(5.4, 8.8)
Date overlap, *month-resolution, including ties*	47.9	(893; 1)	71.2	(1,326; 745)	0.44	(0.40, 0.48)	2.6	(2.1, 3.1)
UNAIDS, *5 months before interview*[5]	7.8	(146; 1)	46.9	(873; 140)	0.09	(0.08, 0.11)	164.0	(78.6, 405.5)
UNAIDS, *3 months before interview*	9.9	(177; 1)	48.7	(908l 177)	0.12	(0.10, 0.14)	118.4	(62.1, 255.6)
b. Participants with multiple and exclusively repeat partners *(n = 307)*								
Partnership timing module	73.9	(227; 0)	--	-- --	--	--	--	--
Direct question[3]	82.2	(250; 3)	90.1	(274; 222)	0.72	(0.62, 0.81)	0.07	(0.01, 0.26)
Date overlap, *day-resolution*[4]	75.5	(231; 1)	87.6	(268; 210)	0.67	(0.57, 0.77)	0.81	(0.42, 1.5)
Date overlap, *month-resolution, excluding ties*	73.2	(224; 1)	86.6	(265; 205)	0.65	(0.56, 0.75)	1.2	(0.62, 2.2)
Date overlap, *month-resolution, including ties*	85.0	(260; 1)	88.6	(271; 226)	0.65	(0.55, 0.76)	0.03	(0.00, 0.15)
UNAIDS, *5 months before interview*[5]	24.8	(76; 1)	48.7	(149; 73)	0.17	(0.12, 0.23)	51.3	(18.6, 203.8)
UNAIDS, *3 months before interview*	27.1	(83; 1)	51.0	(156; 80)	0.20	(0.14, 0.26)	49.0	(17.7, 194.6)

1. *n concur* = number concurrent, *n miss* = number missing
2. *n agree* = number that agree, *n concur* = number that both agree are concurrent
3. 3% (n=42) of those who indicated concurrency by the direct question also named only 1 sex partner.[20, 24] Accordingly, the 42 individuals are included in Table 1, but are excluded from the subsets of participants with multiple partners in Table 2.
4. Date overlaps measures exclude one-time partners, for whom dates of sex were not asked.
5. UNAIDS point prevalence measures modified to 5 and 3 months from typical 6 months

<u>Table 3</u> Dyad- and triad-level concurrency, by partnership timing module and alternative measures of concurrency, among subsets of men who have sex with men

	Concurrency prevalence		Agreement with partnership timing module					
	%	*(n concur; miss.)* [1]	*%*	*(n agree; n concur.)* [2]	*kappa*	*(95% CI)*	*mOR*	*(95% CI)*
Dyad level, repeat partners *(n = 2,962)*								
Partnership timing module	56.7	(2,667; 0)	--	-- --	--	--	--	--
Direct question	67.3	(2,927; 353)	83.7	(3,639; 2,334)	0.66	(0.64, 0.68)	0.20	(0.16, 0.24)
Triad level , repeat partners *(n = 4,703)*								
Partnership timing module	63.7	(1,879; 10)	--	-- --	--	--	--	--
Date overlap, *day-resolution*	68.3	(1,986; 54)	78.8	(2,291; 1.608)	0.53	(0.50, 0.56)	0.63	(0.54, 0.74)
Date overlap, *month-resolution, excluding ties*	63.3	(1,842; 54)	81.0	(2,355; 1.568)	0.59	(0.56, 0.62)	1.0	(0.86, 1.2)
Date overlap, *month-resolution, including ties*	81.8	(2,378; 54)	78.6	(2,287; 1,802)	0.48	(0.45, 0.52)	0.08	(0.06, 0.10)

1. *n concur* = number concurrent, *n miss* = number missing
2. *n agree* = number that agree, *n concur* = number that both agree are concurrent

Chapter 4 – Manuscript 2

In *Sexually Transmitted Diseases*, October 2012 39(10)

Title

High prevalence of sexual concurrency and concurrent unprotected anal intercourse across racial/ethnic groups among a national, web-based study of men who have sex with men in the United States

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Word counts

Summary:	30
Abstract:	231
Text:	3,339
Figures:	2
Tables:	2 in text, 2 as Supplementary Digital Content

Sources of Support:
National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and P30AI050409 – the Emory Center for AIDS Research.

Conflicts of Interest:
The authors have no conflicts of interest to declare.

Short summary

An online study of MSM in the United States utilized new methodology to measure and demonstrate a high degree of sexual concurrency among MSM that was consistent across racial/ethnic groups.

Abstract

Background

Men who have sex with men (MSM) are the largest HIV risk-group in the United States. Sexual concurrency may contribute to high HIV incidence, or to racial/ethnic HIV disparities among MSM. Limited information is available on concurrency and racial/ethnic differences among MSM, or on the extent to which MSM engage in concurrent unprotected anal intercourse (UAI).

Methods

Data are from baseline responses in a prospective online study of MSM aged ≥ 18 years, having ≥ 1 male sex partner in the past 12 months, and recruited from social networking websites. Pair-wise sexual concurrency and UAI in the previous 6 months among up to 5 recent partners was measured, using an interactive questionnaire. Period prevalences of concurrency and concurrent UAI were computed and compared across racial/ethnic groups at the individual and triad (a respondent and 2 sex partners) levels.

Results

2,940 MSM reported on 8,911 partnerships; 45% indicated concurrent partnerships and 16% indicated concurrent UAI in the previous 6 months. Respondents were more likely to have UAI with two partners when they were concurrent, compared to serially monogamous (OR [95% CI] = 1.93 [1.75, 2.14]). No significant differences in levels of individual concurrency or concurrency among triads were found between non-Hispanic white, non-Hispanic black, and Hispanic men.

Conclusions

Concurrency and concurrent UAI in the previous 6 months was common. Although there were no differences by race/ethnicity, the high levels of concurrency and concurrent UAI may be catalyzing the transmission of HIV among MSM in general.

Key Words

Concurrency, MSM, sexual networks, UAI, racial disparities

Introduction

In 2009, men who have sex with men (MSM) were the group most represented among new HIV infections (61%) and individuals living with HIV (55%) in the United States [1,2]. Furthermore, since 2000, MSM have been the only transmission group in which incident HIV cases have increased [1,3,4].

In addition to the disparities between MSM and other HIV risk-groups, there are substantial disparities among MSM. Estimates of both prevalence and incidence are consistently higher among black and Hispanic MSM, compared to white MSM, with young black MSM facing the greatest disparity in HIV incidence [2,5].

The reasons that MSM of color are more at risk for HIV infection are unclear. Studies of individual-level risk factors have consistently revealed equivalent or lower levels of such behaviors among men of color [6,7] . Differential sexual network properties have been hypothesized as a contributor to this disparity, although the published data are limited. Sexual concurrency, defined as "overlapping sexual partnerships where sexual intercourse with one partner occurs between two acts of intercourse with another partner" [8], is thought to be an important catalyst of HIV transmission. This is because concurrency increases the exposure of one's partners to each other and increases the likelihood that a newly infected individual would transmit HIV to an uninfected partner during the highly infectious acute period of HIV infection [9,10]. Concurrency has been demonstrated in simulations of US heterosexuals to accelerate HIV/STI transmission and drive racial disparities [11,12], and networks factors such as concurrency have been suggested possible determinants of the racial disparity among MSM in the US [6].

Concurrency may contribute to the disparities seen in the US HIV epidemics yet remains little studied empirically among MSM [13]. Among predominantly heterosexual men in the US sampled from 2002-2003, Adimora et al found a 12-month period prevalence of concurrency of 11% and 14% among those reporting at least one sex partner [14]. Only one report has been published on the prevalence of concurrency among MSM, by race/ethnicity [15]. In that study of MSM in San Francisco, among those with multiple sex partners, 65% of white men reported concurrency, compared to 56% of black men. These results are limited by the measure of concurrency used, which considered partnerships close in time but not necessarily overlapping to be concurrent and thus may have misclassified serial monogamy as concurrency. They are further limited by the small number of black MSM (n = 18), and the restriction to one US city.

Three key methodological gaps have traditionally precluded accurate empirical understandings of concurrency: those of measuring concurrency accurately, at the appropriate levels of analysis, and with the incorporation of risk behavior.

Participant concurrency response data have traditionally been collected in several ways, all of which have limitations and limited agreement with one another [16,17]. The theoretically most precise method is to gather dates of first and last sex for participants' named sex partners and examine the resulting intervals for overlaps. Yet this is subject to errors in recall and logical inconsistencies. Others have asked for these dates at the one-month level of detail, but this results in temporal ambiguities and misclassification of concurrency, particularly for short-term casual relationships [14,16,18]. Another method is to directly ask a participant, for each of his/her partners, about the existence of concurrent partners, but this precludes an understanding of partner sequencing and of the other concurrent partners involved [16,19] and ultimately limits the understanding of concurrency.

The level of analysis of concurrency may be important to understanding the possible impact of concurrency within sexual networks. Concurrency is most often described at the individual study participant level, but there is another level which is more relevant to understanding HIV transmission dynamics: the triad. Triads are the level at which concurrency's bidirectional transmission potential acts and represent the unit of an individual and two of his/her sex partners (aka: partnership pair). Yet information may be lost when summarizing an individual's sexual history across triads, rendering this an insufficient measure for prevention applications. This is because individuals may be concurrent with only certain pairs of partners, and may differentially contribute to community transmission risk based on the number and types of concurrent triads they have. One may gain a better understanding of the features associated with concurrent partnerships and their contribution to community risk, if concurrency is analyzed at the triadic level.

Further, most reports have focused on quantifying the prevalence of concurrency, irrespective of dyadic risk behaviors. This alone is insufficient to describe the potential increase in disease transmission associated with concurrency since condoms may be used with one or both of the sex partners involved. In a triad, if condoms are used consistently and completely with either or both partners, then the attendant concurrency is irrelevant to network transmission dynamics. There is a need to understand biologically relevant concurrency – that is, triads in which incomplete condom use with both partners actually enables disease transmission.

However, biologically relevant concurrency has been seldom measured or described at either the participant or triad levels. Descriptions of concurrency at the triadic level or that incorporate condom use are scant. Doherty et al [20] have published the only findings on biologically relevant concurrency among triads from the US heterosexual data described above, and found that among these men, 28% of concurrent triads involved unprotected vaginal intercourse with both partners. To date, no data have been published on biologically relevant concurrency or concurrency at the triadic level among MSM.

In this work, we seek to quantify the prevalence of concurrency among MSM, by race/ethnicity, in a national online study of MSM in the United States. To do so accurately and robustly, we address the above methodological gaps by using an improved concurrency measurement tool [21], quantify both concurrency and concurrent UAI, and conduct analyses at both at the individual and triadic levels.

Materials and Methods

Study design

Data come from the baseline responses of a 12-month prospective online study of HIV behavioral risks among MSM in the United States, being conducted by Emory University. Internet-using MSM were recruited from August – December 2010 through selective placement of banner advertisements on websites [22]. In order to attain the broadest sample of online MSM, the majority of respondents were recruited from social networking websites (eg: Facebook, MySpace, although limited recruitment occurred on one dating website. No other dating or hook-up sites were included, in order to avoid over-sampling higher-risk MSM. Men who clicked on the advertisements were taken to an online eligibility screening survey. Eligible individuals for the baseline questionnaire were male, at least 18 years of age, and had a male sex partner in the past 12 months. Following the administration of an online consent document, participants completed a 60-minute questionnaire. The study was reviewed and approved by the Institutional Review Board of Emory University.

To allow testing of race/ethnicity-related hypotheses with adequate power, this analysis includes only white non-Hispanic, black non-Hispanic, and Hispanic respondents. The questionnaire's dyadic sexual behaviors module was oriented about a 6-month recall period and thus we further restricted our analysis to the 91% of respondents who additionally had sex within the previous 6 months.

Sexual concurrency and partnership data collection

Participants who had a sex partner within 6 months were asked to provide nicknames for up to 5 most recent anal, oral, or vaginal sex partners within the previous 6 months, followed by a partnership timing module, and behavioral inventory for each partner.

A brief description of the partnership timing module follows. Participants were provided a calendar grid that displayed the previous 6 months in columns, and partner nicknames on the rows and asked to indicate in which months they had sex with each partner (Figure 1). Two or more common months of sex between two partners classified the triad as concurrent. If the responses indicated a single overlapping month between two partners, and was thus ambiguously concurrent or serial, follow-up questions (Figure

1b) were asked to establish whether the participant was with the two partners serially or concurrently during the indicated month. This technique benefits from the easier recall afforded by month-level calendar and direct questioning approaches, but gains the exact sequencing information provided by measuring dates of sex [21]. The questionnaire was designed in SurveyGizmo 2.6 and hosted on www.surveygizmo.com.

Concurrency outcomes

Based on the calendar responses, measures of concurrency were calculated at the triadic and participant levels. For each triad, the duration of overlap in months was calculated (range: 1-6). Triads were considered concurrent if the months of sex with both partners overlapped by >= 2 months, if they overlapped by 1 month and one partner's interval entirely contained the 1 month relationship of the other partner, or based on responses to the clarification questions. Each concurrent and serially monogamous triad of partners was classified according to whether UAI occurred with both partners in the previous 6 months.

From the triadic data, we calculated at the participant-level: cumulative occurrence of concurrency and concurrent UAI in the previous 6 months, the number of concurrent triads, UAI triads, unique concurrent partners, and the total months of concurrent overlap ('concurrency-months').

Partners of all genders were counted in concurrency determinations (female and transgender partners represented < 3% of partnerships). Though we collected UAI for partners of all genders, we chose to only include male partnerships in our outcome of concurrent UAI.

Analysis

Participant-level demographics and concurrency outcomes were summarized descriptively, stratified by participant race/ethnicity, and compared using χ^2 and Kruskal-Wallis tests. The concurrency outcomes were summarized overall and for those who had concurrent partnerships. Categorical measures were compared across racial/ethnic groups using χ^2 tests and continuous ones using one-way ANOVA. Racial/ethnic group comparisons were done both overall and pair-wise, with white non-Hispanic MSM as the referent group.

Data were next examined at the triad level, using all possible pairs of partners reported by each participant with more than one partner (up to ${}_5C_2 = 10$ triads per participant). The association between a triad being concurrent and involving UAI with both partners was calculated using odds-ratios (OR) and compared by race/ethnicity using the χ^2 and Breslow-Day tests. This was done both overall and for just triads in which anal intercourse occurred with both partners. We additionally adjusted our OR estimates for repeated measures on participants using a repeated measures GEE logistic regression model with an exchangeable ln(OR) correlation structure [23].

The post-processing of the response data and all analyses were conducted in SAS ver 9.2.

Results

A total of 6,104 men reporting a male sex partner in the previous 12 months began the online behavioral questionnaire. Among them, 4,138 (68%) remained in the questionnaire and answered questions about male sex within the previous 6 months, with 3,768 (91%) having a partner within the previous 6 months. Of these MSM, 3,471 (92%) completed the partnership timing module. The 2,940/3,471 (85%) MSM who self-reported white, black, or Hispanic race/ethnicity form the basis for this analysis.

The analytic sample was 63% white non-Hispanic, 21% black non-Hispanic, and 17% Hispanic. The overall median age of 27 years (IQR: 22 – 39, range: 18 – 79) and white participants were on average older than their black and Hispanic (median 29, 26, 25 years respectively, $p < .0001$). Nine percent of white, 18% of black, and 7% of Hispanic MSM self-reported being HIV-positive ($p < .0001$). White participants were more likely to hold a college degree compared to black and Hispanic participants (44% vs 34%, 33% respectively, $p < .0001$) and less likely to identify as bisexual (12% vs 30%, 19% respectively, $p < .0001$). These participants provided data on 8,911 partners. Seventy-three percent of participants (2,144/2,940) reported more than one sex partner in the previous 6 months, allowing for concurrency to be determined among 12,812 triads.

The participant-level concurrency findings are presented by race/ethnicity in Table 1. Among all participants, 45% of white, 45% of black, and 46% of Hispanic participants indicated at least one pair of concurrent partnerships (concurrent triad) in the previous 6 months ($p = 0.84$). No other concurrency metric was found to be racially differential at the participant unit of analysis (Table 1). Overall, 16% of participants indicated a concurrent UAI triad. The 1,326 MSM with at least one concurrent triad in the previous 6 months had a mean of 3.6 concurrent triads, involving a mean of 3.5 unique partners and 8.6 concurrency-months, while 39% engaged in UAI with both partners of a concurrent triad.

Table 2 displays findings at the triad level. Among the 12,812 triads involving participants with more than one partner, 38% were concurrent (rather than serially monogamous). These findings did not significantly vary by race/ethnicity (adjusted p = 0.21). The duration of concurrent overlap was significantly shorter for white MSM compared to black and Hispanic MSM (51% had ≤ 1 month overlap vs. 48% and 49%, respectively. Table-wide p = .02), but this modest difference is likely not practically important. UAI occurred with both partners among 31% of concurrent triads and was also not different by race/ethnicity (adjusted p = 0.09).

Additionally, there was a positive association between triadic concurrency and UAI: triads were more likely to involve UAI with both partners if they were concurrent (unadj. OR [95% CI] = 1.93 [1.75, 2.14], adj. OR = 1.57 [1.41 1.75]). This association was consistent across levels of by participant race/ethnicity (adjusted p = 0.95).

Individual and triadic level concurrency results are also provided stratified by categories of participant age in Supplementary Digital Content Tables 1 and 2.

Discussion

In this largest study of concurrency among MSM to date, the six-month period prevalence of concurrency was high, with the prevalence at least four times that reported among their heterosexual counterparts in a nationally representative survey and involving more partners [14], but consistent with the limited reports on MSM [15].

Although the level of condom use among concurrent MSM triads was similar to that reported for heterosexuals [20], the overall levels of concurrent unprotected sex were higher due to the greater prevalence of concurrency. MSM who had a concurrent partnership were also concurrent with more partners than are concurrent heterosexuals. Combining these concurrency findings with the greater per-episode transmission risk of UAI compared to unprotected vaginal intercourse [24], MSM may face a far higher transmission burden due to biologically relevant concurrency and concurrency may be an important factor in the disproportionately high incidence seen among MSM.

At the individual level, we observed comparable levels of concurrency and concurrent UAI across race/ethnic groups, furthering our existing understanding that MSM of color do not engage in riskier sexual behaviors with the knowledge that MSM of color also do not have riskier patterns of concurrency at this level. Nonetheless, the implications of this finding for explaining differential HIV incidence are not conclusive. Similar but high levels of concurrent UAI, in conjunction with racial/ethnic differences in HIV prevalence and potentially in assortativity and network size between the sexual networks of black, white, and Hispanic MSM may still help explain disparities in HIV transmission and highlight a significant role for concurrency. Further, although we describe the prevalence of individual patterns of engaging in concurrent sex, this cannot be directly related to individual HIV acquisition risk, because this risk is imparted onto one's partners, not oneself. Our data revealed substantial racial/ethnic mixing (partnership racial concordance of 66% for white, 65% for black, and 37% for Hispanic participants). To the extent that racial mixing is occurring, a participant's race/ethnicity is not a reliable marker of his partner's race/ethnicity and it is difficult to make conclusions about racial/ethnic differences in HIV risk. Further analyses are needed.

Among our sample, concurrent partners were more like likely to be ones with whom unprotected sex occurred, compared to serial partners. This association of two transmission risk factors is a newly documented compound risk that was enabled through the use of triad-level analyses and further characterization of the circumstances underlying concurrency is needed.

This work is strengthened by the use of an improved measurement technique that gathered precise partner sequence data and was enabled by the programming of advanced online tools. Many of the partnerships reported by participants were short-term, with half being one-time encounters. The use of the typical approaches that classify concurrency at the one-month level of detail would have led to substantial undercounting of concurrency, since many partnership overlaps involving one-time encounters would be counted as single-month overlaps and thus assumed to be serial. Furthermore, by quantifying concurrency at the level at which it occurs, that of triads, and at the level of biological relevance, concurrent UAI, we have been able provide a fuller picture of concurrency among this sample of MSM, by race/ethnicity.

We recognize that our findings may be affected by the selection biases inherent in online behavioral research, which take the form of sampling, click-through, and questionnaire dropout biases. While it is difficult to quantify how these potential biases may have skewed our results, compared to the first (2003-2005) and second (2008) MSM cycles of NHBS, our data show comparable racial diversity as well as patterns of behavioral risk [25,26]. For example, the median number of casual sex partners in the previous 12 months in both NHBS cycles was 3, whereas our sample had a median of 4 partners, and participants in both studies had a median of 1 main sex partner. Though our data are not nationally representative, this comparability to NHBS and the large sample size, coupled with the demographic and geographic diversity of this study, provide for robust estimates of concurrency among MSM. It is still possible that MSM sampled online or using the venue-based time-space sampling methods of NHBS do not represent the true distribution of risk behaviors among the general population of MSM. If online respondents of all racial/ethnic groups are more likely to engage in high-risk sexual behaviors, comparisons of concurrency between these groups could be biased toward the null hypothesis of equality. Caution should thus be exercised with generalizing these results to the general US population of MSM.

A few decisions may have limited our measurement of concurrency. In allowing participants to provide data on only up to 5 most recent sex partners, other partners earlier in the interval may not have been reported. Also, by using a six month recall period for sexual timing, concurrencies involving intermittent partnerships in which sex occurs less than twice during the recall period are missed. Both of these limitations would lower estimates of concurrency and thus our findings may be conservative. Although the concurrent triads involving a serodiscordant partnership most directly impact HIV transmission, we chose to not consider participant-reported partner HIV serostatuses in our analyses. Other results from these data demonstrated only a moderate level of dyadic pre-sexual discussion of HIV status (50-70%) [27]. Considering the high proportion of HIV-infected MSM who are unaware that they are infected [2] and the potential for partners to misrepresent their statuses, these participant-reported data would be an unreliable marker for this purpose. Future studies should quantify the subset of concurrent UAI triads that could actually increase HIV propagation, by ascertaining the true infection statuses of both participants and partners.

We observed very high prevalences of engaging in concurrent sex and concurrent UAI in the previous six months among MSM, and these concurrencies may contribute to current high rates of HIV transmission among MSM. Although these prevalences were not different by participant race/ethnicity, further analyses need to be conducted to understand the risk conferred to sex partners of different race/ethnicities as a result of concurrency. Our findings of high levels of concurrency and an association between concurrency and UAI highlight the need for further research to both understand the factors associated with concurrency and the degree of transmission among MSM that is attributable to this phenomenon. If subsequent works demonstrate concurrency to be a significant contributor to HIV transmission and modifiable behavioral determinants are identified, then the development of concurrency-related prevention interventions may be highly impactful for MSM in the United States. Consideration should be given to the addition of brief concurrency assessments in healthcare provider settings, and to the incorporation of concurrency messaging into risk reduction counseling.

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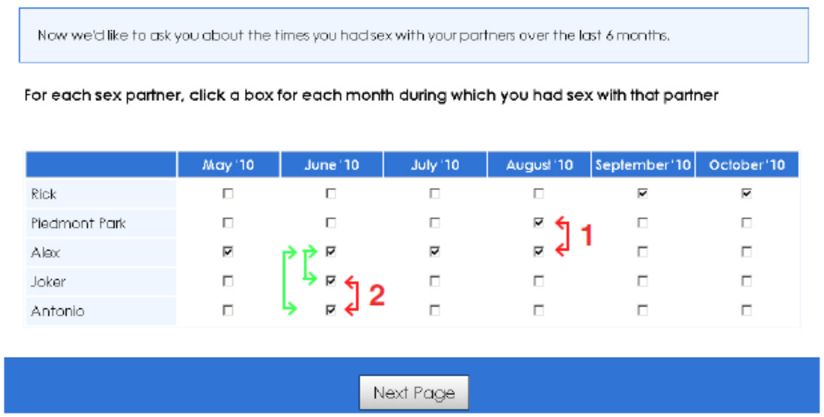
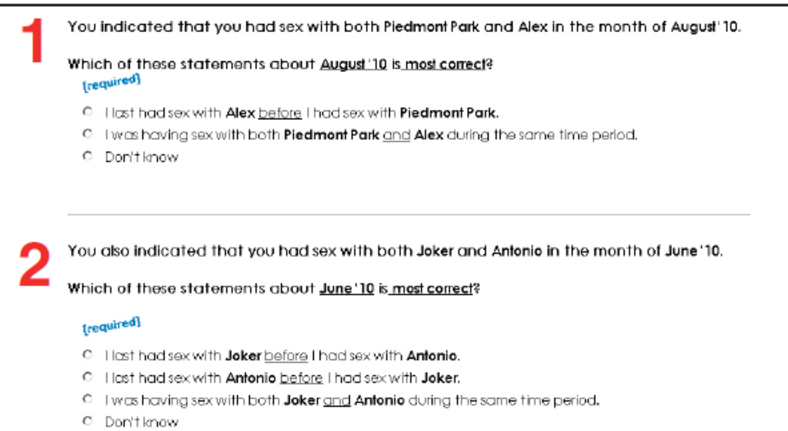
Figure 1



A.
The study participant indicates the months in which he had sex with each named partner. Partner pairs are examined at each month. Ambiguous overlaps between partners (red), are selected for further questioning. Obviously concurrent overlaps (green) are not selected.



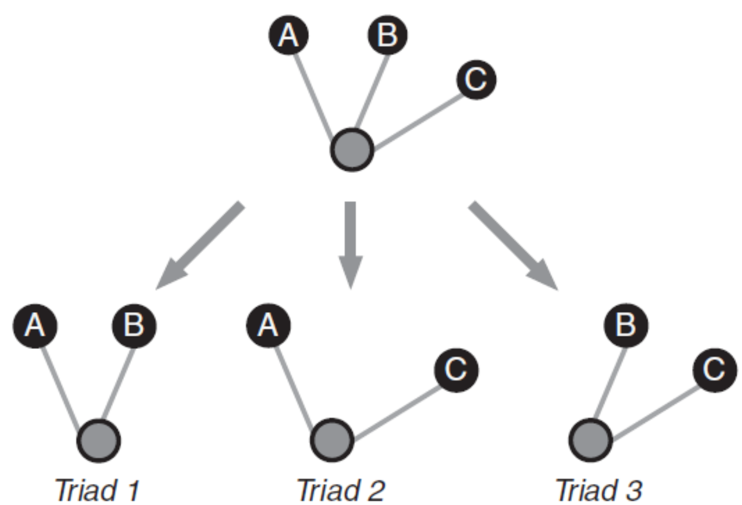
B.
For each ambiguous month, the participant indicates the appropriate serial configuration of his partners, or that he was concurrently having sex with both.

Figure 2

Triads

An individual with p partners ($p > 1$) has ${}_{p}C_{2}$ triads, or partner pairs, that may be concurrently or serially arranged.

Below, an individual (grey circle) with 3 partners (A, B, C) yields 3 triads.



<u>**Table 1**</u>

Participant-level concurrency and concurrent UAI in the previous 6 months among 2,940 MSM, by participant race/ethnicity

	White, non-Hispanic *(n = 1,843)*		**Black, non-Hispanic** *(n = 604)*		**Hispanic** *(n = 493)*		*p*
	n	*(%)*	*n*	*(%)*	*n*	*(%)*	
Overall							
Any concurrent triad [#]	829	(45.0)	269	(44.5)	228	(46.3)	0.84
Any concurrent UAI triad *	269/1574	(17.1)	70/454	(15.4)	56/396	(14.1)	0.31
Mean number of concurrent UAI triads *(S.D., n)* *	0.42	(1.38, 1574)	0.38	(1.21, 454)	0.28	(0.91, 442)	0.13 [a]
Participants with concurrent partnerships	*(n = 829)*		*(n = 269)*		*(n = 228)*		
Any concurrent UAI triad *(%)* *	269/663	(40.6)	70/190	(36.8)	56/164	(34.2)	0.26
Mean number of concurrent UAI triads *(S.D., n)* *	1.01	(1,98, 663)	0.92	(1.74, 190)	0.67	(1.33, 164)	0.11 [a]
Mean number of concurrent triads *(S.D.)*	3.70	(2.91)	3.57	(2.93)	3.53	(2.74)	0.67
Mean unique concurrent partners *(S.D.)*	3.49	(1.24)	3.38	(1.26)	3.42	(1.22)	0.44
Total concurrency-months *(S.D.)*	8.65	(12.06)	8.72	(12.51)	8.22	(8.22)	0.88

Triads (partnership pairs) are comprised of a participant and two sex partners, and are the fundamental unit of concurrency

* Alternate sample sizes indicated where there are missing UAI response data

[a] White non-Hispanic vs. Hispanic, p = 0.04

Table 2

Triad-level concurrency and concurrent UAI in the previous 6 months among 12,812 partner triads, involving 2,114 MSM participants with multiple partners in the previous 6 months, by participant race/ethnicity [#]

	White, non-Hispanic *(n = 7,907)* *n (%)*	Black, non-Hispanic *(n = 2,728)* *n (%)*	Hispanic *(n = 2,177)* *n (%)*	*Unadj. P*	*Adj. P* [1]
Concurrent triad	3064 (38.8)	960 (35.2)	805 (37.0)	0.0032	0.21
Duration of concurrent overlap (months)				0.02	--
≤1	1557 (50.8)	458 (47.7)	398 (49.4)		
2	424 (13.8)	149 (15.5)	145 (18.0)		
3	376 (12.3)	108 (11.3)	85 (10.6)		
4	207 (6.8)	77 (8.0)	45 (5.6)		
5	195 (6.4)	54 (5.6)	40 (5.0)		
≥ 6	305 (10.0)	114 (11.9)	92 (11.4)		
UAI in previous 6 months, overall				***P interaction***	
Among concurrent triads	667/2039 (32.7)	174/563 (30.9)	110/486 (22.6)	***Unadj.***	***Adj.*** [1]
Among non-concurrent triads	739/3719 (19.9)	200/1095 (18.3)	161/1062 (15.2)		
Prevalence OR (95% CI):	*1.96 (1.73, 2.22)*	*2.00 (1.58, 2.53)*	*1.64 (1.25, 2.15)*	0.46	0.95
UAI in previous 6 months, among AI triads					
Among concurrent triads	667/1290 (51.7)	174/398 (43.7)	110/319 (34.5)		
Among non-concurrent triads	739/1856 (39.8)	200/652 (30.7)	161/553 (29.1)		
Prevalence OR (95% CI):	*1.62 (1.40, 1.87)*	*1.76 (1.36, 2.27)*	*1.28 (0.95, 1.72)*	0.26	0.57

\# Triads (partnership pairs) are comprised of a participant and two sex partners, and are the fundamental unit of concurrency

1. Adjusted for repeated measures on respondents

Supplementary Digital Content Table 1

Participant-level concurrency and concurrent UAI in the previous 6 months among 2,940 MSM, by participant age

	18 – 24 *(n = 1,146)*		**24 – 29** *(n = 525)*		**30 – 39** *(n = 579)*		**40+** *(n = 690)*		*p*
Overall									
Any concurrent triad [#]	466	(40.7)	230	(43.8)	269	(46.5)	361	(52.3)	< .0001
Any concurrent UAI triad *	135/932	(14.5)	61/449	(13.6)	82/474	(17.3)	117/569	(20.6)	0.006
Mean number of concurrent UAI triads *(S.D., n)* *	0.30	(1.06, 932)	0.32	(1.22, 449)	0.38	(1.13, 474)	0.62	(1.69, 569)	< .0001
Participants with concurrent partnerships	*(n = 466)*		*(n = 230)*		*(n = 269)*		*(n = 361)*		
Any concurrent UAI triad *(%)* *	135/348	(38.8)	61/180	(33.9)	82/206	(39.8)	117/283	(41.3)	0.44
Mean number of concurrent UAI triads *(S.D., n)* *	0.79	(1.62, 348)	0.81	(1.83, 180)	0.86	(1.59, 206)	1.25	(2.23, 283)	.001
Mean number of concurrent triads *(S.D.)*	3.27	(2.82)	3.36	(2.69)	3.99	(2.86)	4.04	(3.04)	0.0001
Mean unique concurrent partners *(S.D.)*	3.26	(1.22)	3.35	(1.19)	3.70	(1.23)	3.58	(1.25)	< .0001
Total concurrency-months *(S.D.)*	8.12	(12.59)	7.01	(9.69)	9.28	(12.98)	9.69	(11.73)	0.03

Triads (partnership pairs) are comprised of a participant and two sex partners, and are the fundamental unit of concurrency

* Alternate sample sizes indicated where there are missing UAI response data

Supplementary Digital Content Table 2

Triad-level concurrency and concurrent UAI in the previous 6 months among 12,812 partner triads, involving 2,114 MSM participants with multiple partners in the previous 6 months, by participant age #

	18 – 24 *(n = 4,536)* *n (%)*	**24 – 29** *(n =2,120)* *n (%)*	**30 – 39** *(n =2,802)* *n (%)*	**40+** *(n = 3,354)* *n (%)*	***Unadj. P***	***Adj. P*** [1]
Concurrent triad	1526 (33.6)	772 (36.4)	1074 (38.3)	1457 (43.4)	< .0001	< .0001
Duration of concurrent overlap (months)					< .0001	--
≤1	704 (46.1)	438 (56.7)	574 (53.5)	697 (47.8)		
2	259 (17.0)	114 (14.8)	136 (12.7)	209 (14.3)		
3	181 (11.9)	71 (9.2)	14 (10.6)	203 (13.9)		
4	103 (6.8)	56 (7.3)	67 (6.2)	103 (7.1)		
5	71 (4.7)	49 (6.4)	60 (5.6)	109 (7.5)		
≥ 6	208 (13.6)	44 (5.7)	123 (11.5)	136 (9.3)		
UAI in previous 6 months, overall					***P interaction***	
					Unadj.	***Adj.*** [1]
Among concurrent triads	275/929 (29.6)	145/512 (28.3)	178/685 (26.0)	353/962 (36.7)		
Among non-concurrent triads	379/2156 (17.6)	165/1013 (16.3)	245/1298 (18.9)	311/1409 (22.1)		
Prevalence OR (95% CI):	*1.97 (1.65, 2.36)*	*2.03 (1.57, 2.62)*	*1.51 (1.21, 1.88)*	2.05 (1.71, 2.45)	0.15	0.24
UAI in previous 6 months, among AI triads						
Among concurrent triads	275/654 (42.1)	145/309 (46.9)	178/427 (41.7)	353/617 (57.2)		
Among non-concurrent triads	836/1215 (31.2)	165/493 (33.5)	245/690 (35.5)	311/663 (46.9)		
Prevalence OR (95% CI):	*1.60 (1.31 1.95)*	*1.76 (1.31, 2.35)*	*1.30 (1.01, 1.66)*	*1.51 (1.21, 1.89)*	0.43	0.49

\# Triads (partnership pairs) are comprised of a participant and two sex partners, and are the fundamental unit of concurrency

2. Adjusted for repeated measures on respondents

Chapter 5 – Manuscript 3

For submission to JAIDS: Journal of Acquired Immune Deficiency Syndromes

Article Type
Original article

Title
The implications of respondent concurrency on sex partner risk in a national, web-based study of men who have with men in the United States

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Sources of Support:
National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and NIH P30AI050409 – the Emory Center for AIDS Research.

Running head:
Concurrency and partner risk among MSM

Abstract

Background

Men who have sex with men (MSM) represent the largest HIV risk-group in the US. Substantial HIV prevalence and incidence racial/ethnic disparities exist among MSM. Sexual concurrency catalyzes HIV transmission in populations and has been documented at high levels among MSM in individual-level (egocentric) designs. Methods are lacking for understanding the risk implications of concurrency in egocentric studies and among MSM.

Methods

We developed a new technique for transposing egocentrically-collected sexual partnership data to quantify the prevalence of indirect exposure of partners to any other partners as a result of concurrency and serial monogamy, and incorporating unprotected anal intercourse (UAI). This method was applied to an online study of MSM aged ≥ 18 years, with comparisons made by partner race-ethnicity, age, type, and meeting location.

Results

Among 4,060 repeat partners of 2,449 MSM, 73% were serially or concurrently exposed to other partners and 58% were exposed by concurrency, in the previous 6 months. Examining UAI partners, 37% were exposed by concurrency. Among UAI partners, black partners were more likely than white ones to be concurrently exposed (unadj. OR [95% CI] = 1.34 [1.05, 1.70]), as were casual UAI partners relative to main partners (unadj. OR [95% CI] = 4.37 [3.58, 5.35]). In adjusted models, black UAI partners retained significantly elevated exposure due to serial monogamy or concurrency, but not due to only concurrency, and casual UAI partners remained significantly more exposed.

Conclusions

Sex partners of MSM, particularly casual and black non-Hispanic partners, may face a high burden of exposure to other partners.

Introduction

Since the earliest reports of AIDS in the United States, men who have sex with men (MSM) have been the most affected risk group in the US HIV/AIDS epidemic.[1] In 2009, MSM accounted for 61% of new HIV infections, and from 2006-2008 an estimated 18,299 MSM died with an AIDS diagnosis.[2,3] In addition to the HIV disparities between MSM and other groups, substantial racial/ethnic disparities among MSM, with black non-Hispanic MSM facing the greatest burden of both HIV prevalence [4] and incident infections.[5] In addition to recognized transmission probability differences between anal and vaginal intercourse,[6,7] differences in partnership and sexual network factors are emerging that may additionally explain the disparity in HIV incidence between MSM and heterosexuals.[8] It is less understood which factors are driving racial/ethnic differences among MSM, because insufficient evidence of elevated individual-level risk behaviors has been found among MSM of color.[9,10] Sexual network differences have been hypothesized but remain inadequately documented.[9,10]

Thus, HIV epidemics among MSM are an ideal setting in which to examine which sexual network properties may drive disparities, and the best ways to measure those properties. Sexual concurrency is considered a potentially important network determinant of HIV/STI transmission, and is defined as "*overlapping sexual partnerships where sexual intercourse with one partner occurs between two acts of intercourse with another partner*".[11] Concurrency has the potential to foster propagation in populations by increasing both the indirect exposure of partners to one another (e.g. network connectivity) and the likelihood of transmission during acute infection.[12,13] Three recent reports have indicated high levels of concurrent sex among MSM in the United States, using various measures, with estimates ranging from 18% - 78% in the previous year,[8,14,15] all of which are substantially higher than reported among heterosexual men.[8,16] We have in addition reported a 16% six-month prevalence of concurrent UAI with two partners, which is a biologically relevant metric for concurrency among MSM, and have described the prevalence of concurrency among triads, the basic unit of concurrency formed by an individual and two partners.[14]

Simulation- and couples-based studies have respectively lent strong theoretical and empirical support for concurrency's causal role in facilitating HIV transmission.[17-19] However, a greater number of concurrency investigations have been individual-level (egocentric) studies. Considerable controversy has developed over the use of egocentric studies to provide empirical evidence in support of or against the transmission effects of concurrency, because of the inconsistent evidence these studies have provided and fundamental flaws in their designs and analyses.[20,21] A common analytical fallacy underlying many egocentric concurrency studies [22-24] is relating a person's concurrent sex to that same person's HIV acquisition risk.[21,25] In reality, one's concurrency affects the risk of HIV acquisition for one's partners, a phenomenon not directly assessed in egocentric designs. Conversely, an individual's HIV risk is affected by the concurrency of his partners; concurrency of partners is inherently challenging to accurately ascertain in an egocentric design.

Other than the consideration of more complex study designs, few solutions have been proposed to address these limitations in egocentric studies. As a result, such studies can only appropriately report the prevalence and correlates of concurrent sex among study participants and inference to HIV transmission risk cannot be directly made. Our previous report of individual concurrency found equivalent prevalence in white, black, and Hispanic MSM, but this is inadequate for inference about race-specific HIV acquisition risks due to concurrency.[14] This is because it was the partners of these study participants (here called respondents) who were put at risk by indirect exposure (that is, exposure through the respondent) to other partners and it is the partners' race/ethnicities that are relevant. Unlike heterosexual dyads,[26] MSM dyads demonstrate substantial dissasortive mixing by race.,[27-29] and therefore respondents' race/ethnicities are not good markers for partners' race/ethnicities. Analyses of these data that consider the partners' perspectives (and race/ethnicities) are required to appropriately to understand racial/ethnic differences in risk.

In our previous study we demonstrated a method for accurately assessing the timing of sexual partnerships (and thus concurrency) and merged this information with risk behaviors to measure biologically relevant concurrency.[14] We extend these tools in this report, introducing a new method for using egocentric data to assess the increased exposure of respondents' partners to each other due to both concurrency and serial monogamy that respondents report. We use this method to assess the potential risk for HIV acquisition that male sex partners face due to these temporal arrangements, and the implications for understanding racial/ethnic disparities in HIV infection among MSM.

Materials and Methods

Study design

Data are from baseline responses of participants in a 12-month prospective online study of HIV behavioral risks among MSM in the United described elsewhere.[14,28,30] Briefly, MSM were recruited from August – December 2010 through selective placement of banner advertisements on social networking websites. Eligibility requirements for the baseline questionnaire were male sex, 18 years of age or older, and having had a male sex partner in the past 12 months. Following online consent, respondents completed a 60-minute questionnaire. The study was reviewed and approved by the Institutional Review Board of Emory University (IRB #00031326).

Sexual concurrency and partnership data collection

Respondents who had ≥1 sex partner in the 6 months before interview were asked to provide nicknames for up to 5 most recent sex partners (anal, oral, or vaginal sex) within the previous 6 months. They then completed a partnership timing module and behavioral inventory for each partner. The partnership timing module used a month-level calendar grid and clarifying questions to accurately inventory the sequence and overlap of sex partners.[14,31]

Triadic and individual level concurrency outcomes

Based on the calendar responses, measures of concurrency were calculated at the triadic and participant levels. Each unique combination of a respondent and two reported sex partners composed a triad; each respondent could contribute 0-10 triads based on the number of sex partners in the past 6 months about whom he reported information. Triads were considered concurrent if the months of sexual activity with both partners overlapped by ≥2 months; if they overlapped by 1 month and one partner's interval entirely contained the 1- month relationship of the other partner; or the respondent confirmed concurrency in answer to the clarification questions. Each triad of partners was also classified according to whether UAI occurred with both partners in the previous 6 months. From the triadic data, we calculated participant-level binary measures of any concurrency and of any concurrent UAI in the previous 6 months.

<u>Indirect exposure</u>

We defined indirect exposure for a partner as the risk posed by the respondent's other partners through concurrency, serial monogamy, or both (see Figure 1). In a given triad involving an Ego, Partner A and another of Ego's partners B, there are three possible relationship configuration that can arise: (1) Partner A and another partner may both be serially monogamous with the Ego, and Partner A's relationship concludes earlier (Serial; A before B); (2) Partner A and another partner may both be serially monogamous with the Ego, and Partner A's relationship concludes later (Serial; B before A); (3) Partners A and B overlap in accordance with the definition above (Concurrent). In the first configuration, the partnership sequence protects Partner A from exposure to B, while in the latter two configurations Partner A may be considered to be indirectly exposed to B by serial monogamy and concurrency, respectively.

For a respondent who describes a total of p partners, each partner is involved in a total of $p - 1$ triads. Where 3 or more partners are indicated ($p \geq 3$), a partner X may be indirectly exposed to multiple partners through serial monogamy and/or concurrency (#2 and/or #3). For example, Partner A may be serially exposed to Partner B (#2) but also concurrent with another Partner C (#3).

By evaluating all $p - 1$ triads involving a given partner X, we computed two dichotomous partner-level indirect exposure outcomes: any serial or concurrent exposure to another partner (at least one triad satisfying scenario #2, #3, or both), or not; any concurrent exposure (at least one triad satisfying #3), or not. These two outcomes provide complimentary information about indirect exposure: the first may be used to understand the general exposure and connectivity among partners and the second quantifies that which is attributable to concurrency. These outcomes are not mutually exclusive since all partners with concurrent exposure are necessarily also exposed by serial monogamy or concurrency.

Since indirect exposure is most biologically relevant for HIV transmission unprotected anal intercourse occurs with both partners of a triad, two additional outcomes were constructed that incorporated reported UAI with partners in the previous 6 months. These were also computed by evaluating all $p - 1$ triads involving a given partner X: UAI with X *and* any serial or concurrent exposure to another UAI partner, or not; UAI with X any concurrent exposure (at least one triad satisfying #3) to another UAI partner, or not. By restricting analysis of these two outcomes to partners X who are UAI partners, biologically relevant indirect risk is described among the subset of partners considered at behavioral risk.

Thus, four total outcomes were used in this analysis: 1) any serial or concurrent exposure, 2) any concurrent exposure, 3) any serial or concurrent UAI exposure, and 4) any concurrent UAI exposure.

Analytic sample

Of the original 6,104 men in the study, 3,768 had at least one male contact in the preceding 6 months, and 3,471 completed the partnership timing module (see Figure 2). Several modifications were made to the original ample of respondents and spartners to permit meaningful inference. Only respondents who did not self-report being HIV-positive were included (n = 3,118 respondents; 9,263 dyads) since HIV-positive men who have concurrent partners pose no additional HIV-transmission risk to their partners above that of direct contact.[25] An exception is the case of recently infected individuals who are in the process of concurrent transmission of HIV from one partner to another. Although pertinent, it is unlikely that more than a negligible proportion of those self-reporting being HIV-positive would be recently infected.

Partners with whom sex occurred only once were excluded (n=3,118 dyads; 38% of reported partners) since they cannot be put at risk by the respondent's concurrency. For one-time casual sex partners, all risk to the one-time partner is by definition from serially preceding partners. One-time partners may, however, contribute to risk to other partners imparted by the respondent's concurrency and they were therefore counted as the potential purveyor, but not potential recipient, of concurrency risk.

Because our analysis was primarily focused on understanding racial/ethnic disparities in HIV risk, we examined only partners reported to be white non-Hispanic, black non-Hispanic, and Hispanic race/ethnicity, analogous to our previous report,[14] irrespective of the race/ethnicity of the study participant (n=2,449 respondents; 4,060 dyads).

Statistical Analysis

Respondent-level demographics characteristics, previous six-month concurrency prevalence and concurrent UAI prevalence were tallied. At the dyad level, we summarized partner race/ethnicity, partner age, main/casual partner type, whether the partner was met online, and previous six-month sexual repertoire (categorized as: UAI; protected AI/oral sex, oral sex only). The 4 partner-level indirect exposure outcomes was computed for partners in all their possible triads, and was characterized by partner race/ethnicity, age, main or casual partner, online meeting status, and sexual repertoire. Summarization of the two UAI exposure outcomes was restricted to partners with whom UAI occurred in the recall period, as explained above. The prevalence of each exposure outcome was compared between the levels of each factor using bivariate odds-ratios (OR) with 95% confidence intervals (CI) and the χ^2 test.

Logistic regression models were fit for each outcome that included all partner factors as well as interactions of race/ethnicity with age and main/casual partner type. Models of UAI outcomes excluded sexual repertoire as a predictor. Adjusted ORs and 95% confidence intervals for race/ethnicity and partner type were computed. Since the exposure outcomes of partners from the same respondents are correlated, we adjusted the OR estimates in four corresponding repeated measures GEE logistic regression models with exchangeable ln(OR) correlation structures.[32] All models' interaction terms in the non-repeated and repeated models were retained if they respectively had a Wald or Score Test $p < .05$. All analyses were conducted in SAS ver 9.3.

Results

Of the 6,104 MSM who began the survey, 3,471 provided sufficient data on sexual partnerships in the previous 6 months and their timing (see Figure 2). Among these, 3,118 (90%) completed the HIV testing questions and did not report an HIV-positive test result, forming the base respondent sample who contributed sex partners to this analysis. This sample of respondents was 54% white non-Hispanic, 16% Black non-Hispanic, 15% Hispanic, and 15% of other race/ethnicity. The median age was 26 (IQR: 21-36) years. Seventy-nine percent self-identified as homosexual or gay, 18% as bisexual, 1% as straight, and 2% used another other term. These respondents reported a total of 9,263 sex partners from the previous 6 months, yielding a median partner count of 3 (IQR: 1, 5). Based on the timing of sexual contacts provided for the 14,322 triads formed between respondents and their partners, 44% (1,362/3,118) of the respondents reported at least one concurrent triad and 14% reported at least one concurrent UAI triad (379/2651) in the previous 6 months, with no significant differences by respondent race/ethnicity.

Among the 9,263 partners, 5,184 (56%) had repeated sexual contact with the respondent. Of these partners with repeated contact, 4,060 (78%) were white non-Hispanic, Black non-Hispanic, or Hispanic and made up the set of partners included in analyses of indirect exposure attributable to the partnership timing of respondents (Figure

2). The 4,060 partners were named by 2,449 different respondents.. By race/ethnicity, the partners were 60% white non-Hispanic, 21% Black non-Hispanic, and 19% Hispanic. The median age was 27 (IQR: 22-36) years, 59% were casual partners, 48% were met online, and 54% were partners with whom UAI occurred in the previous 6 months (Table 1a).

Overall, 73% of partners were serially or concurrently exposed to other partners, while 58% were exposed by concurrency (Table 1B). Black and Hispanic partners were more likely than white partners to have serial or concurrent exposure (crude. OR [95% CI] = 1.34 [1.11, 1.60] and 1.3 [1.1, 1.5], respectively), but no differences by race/ethnicity in concurrent exposure were observed. Serial or concurrent exposure did not significantly vary by age group; however, compared to partners under 25 years of age, those above 40 years of age were more likely to be concurrently exposed to other partners (crude. OR [95% CI] = 1.7 [1.3, 2.2]). Being a casual partner substantially increased the odds of both exposure outcomes (crude. OR [95% CI] = 5.1 [4.4, 6.0] and 3.3 [2.9, 3.8] for serial or concurrent and concurrent exposure, respectively) and 69% of casual partners were concurrently exposed.

Forty-eight percent of UAI partners were serially or concurrently exposed by UAI to other partners, and 37% were exposed by concurrent UAI (Table 2b). Black UAI partners were more likely to be exposed by UAI (crude OR [95% CI] = 1.5 [1.2, 1.9] and 1.3 [1.1, 1.7], serially or concurrent exposure and concurrent exposure, respectively) relative to white UAI partners, but no significant difference was seen between Hispanic and white partners. No significant associations were observed by age group. Relative to main UAI partners, casual UAI partners were far more exposed to other partners by UAI, either by either outcome (crude OR [95% CI] = 5.3 [4.4, 6.5] and 4.37 [3.6, 5.4], respectively). Sixty-eight percent of casual UAI partners were indirectly exposed to other partners by UAI in the previous six months.

In all multivariable models (either adjusted for or not adjusted for repeated measures), the interaction terms with race and age and partner type were not significant, yielding main-effects only models that controlled for race, age, partner type, and location of meeting place. In each model, casual partners were significantly more likely to be exposed to other partners through UAI, but the associations were diminished after accounting for repeated observations on respondents (Table 3). After adjustment, black partners and black UAI partners still had significantly elevated odds for being exposed serially or concurrently to other partners (Table 3, models 1a, 1b, 3a, 3b). Yet when examining exposure due to concurrency and concurrent UAI between black and white partners, no significant differences were observed (Table 3, models 2a, 2b, 4a, 4b).

Discussion

Using a new approach for inferring indirect exposure among repeat sex partners, we found high levels of concurrent indirect exposure to other recent sex partners in an online sample of MSM. Further, the extent to which men are indirectly exposed to other men via concurrent sex is greater than the extent to which MSM report individual-level concurrency.[8,14] This result is expected because individual-level prevalence measures include men who report exclusively one-time partners. Nearly half of respondents' UAI partners were indirectly linked to another partner by UAI in the previous six months (Table 2), a large proportion of which was attributable to concurrent UAI. These results suggest substantial connectivity and opportunities for HIV/STI transmission in the networks of MSM who have UAI, and each act of UAI may impose risks for exposure to HIV that transcend the partnership. Although no comparable heterosexual estimates are available, the prevalence of concurrency and partner numbers among US heterosexual males are substantially lower than for MSM.[8,16,33] Female partners of heterosexual males would thus be expected to be at less indirect risk than male partners of MSM.

Racial/ethnic heterogeneity was observed in partner risk. Black partners were more likely than white partners to be exposed to other partners, and black UAI partners were more likely to be exposed to other partners by UAI overall and because of concurrency. This finding indicates that black partners were placed at greater behavioral risk than were white partners by study respondents. That the concurrent UAI association was removed after controlling for repeated participant measures suggests that particular higher-risk individuals who had black partners may have contributed to this result. The racially-equivalent prevalence of concurrency among respondents also supports the notion that a combination of possibly unmeasured respondent, relationship, or situational factors put black partners at greater indirect exposure risk. Future analyses should identify and explore these factors.

Casual sex partners were far more likely than main partners to be exposed to other partners. This may indicate a stronger role for HIV transmission among casual partners than suggested by previous analyses that did not account for concurrency.[34] A reason for this difference may be our restriction to only repeat casual partners (50% of casual partners described). Furthermore, our exposure outcome was dichotomous and did not consider coital frequency,[35-37] which is substantially less with casual partners.[34,38]

Adjusting for the frequency of sex would be expected to increase the risk for main partners, and frequency of sex was a significant driver in the previous analysis that suggested a more prominent role for transmission from main partners.[34] Further studies should incorporate coital frequency to help determine the true relative risk that casual partners face and their contribution to transmission overall.

Further investigation of respondent risk factors is needed to examine both individual-level and situational factors that put partners at risk. Respondent attributes, particularly relating to partner choice and configuration, are relevant for intervention development, because the greatest level of agency lies with these individuals and not their sex partners. The division between who is in control of and affected by concurrent partnering presents a unique challenge in the development of concurrency interventions.

The UAI outcomes chosen for this study are basic, dichotomous measures of the existence of a biologically plausible route of HIV transmission between sex partners. In addition to considering coital frequency, as discussed, future work should incorporate more detailed partnership information, including the exact sequencing of UAI acts, rather than partnerships, and factors that modify the probability of HIV transmission such as sexual positioning, circumcision, and the HIV infection, viral load, and treatment status of sex partners.[39]

Inference from this presentation is limited by the absence of actual transmission outcomes for partners. Though our approach may add to an understanding of the partner and network exposure configurations that result from concurrency, it adds no empirical evidence to prove or disprove concurrency's role in HIV transmission, a subject of much debate that requires alternative study designs.[21]

Because all data on partners were provided by study respondents, all partner attributes were assigned by the respondents, allowing for the misclassification of partner race/ethnicity. While we know of no studies of the agreement of intra-partnership racial classification among MSM, other work suggests that such misclassification would be low for the racial/ethnic categories used.[40,41]

Evidence is emerging for the important role of concurrency in HIV epidemics, and for the high prevalence of concurrency among MSM. We extended existing methods for understanding concurrency in egocentric studies and demonstrated that sex partners of MSM, particularly casual and black non-Hispanic partners, face a high burden of exposure to other partners, due to both concurrency and serial monogamy. This potentially puts these partners at high levels of HIV/STI acquisition risk and may help to explain HIV transmission disparities both between MSM and heterosexuals and among MSM.

Acknowledgements

We wish to acknowledge Christine Khosropour for her coordination of the Checking In study, Nicole Luisi for her data management support, as well as the following National Institutes of Health grants: National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and P30AI050409 – the Emory Center for AIDS Research.

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Figure 1.
Contribution of triadic partnership configurations to indirect exposure outcomes for a Partner *A*

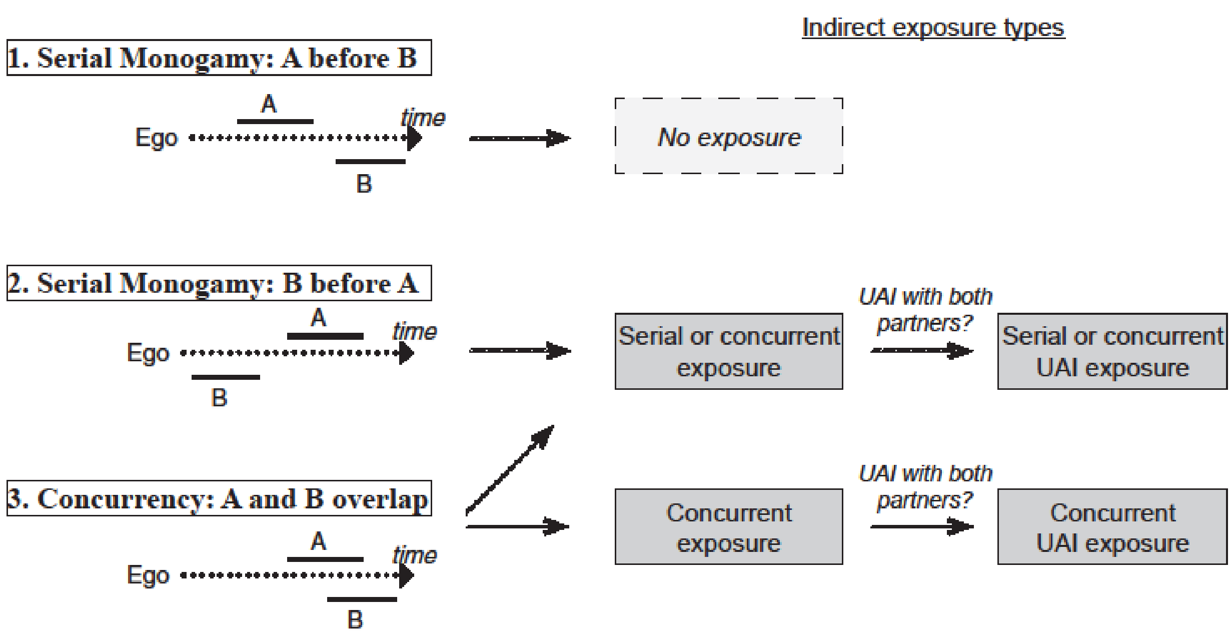
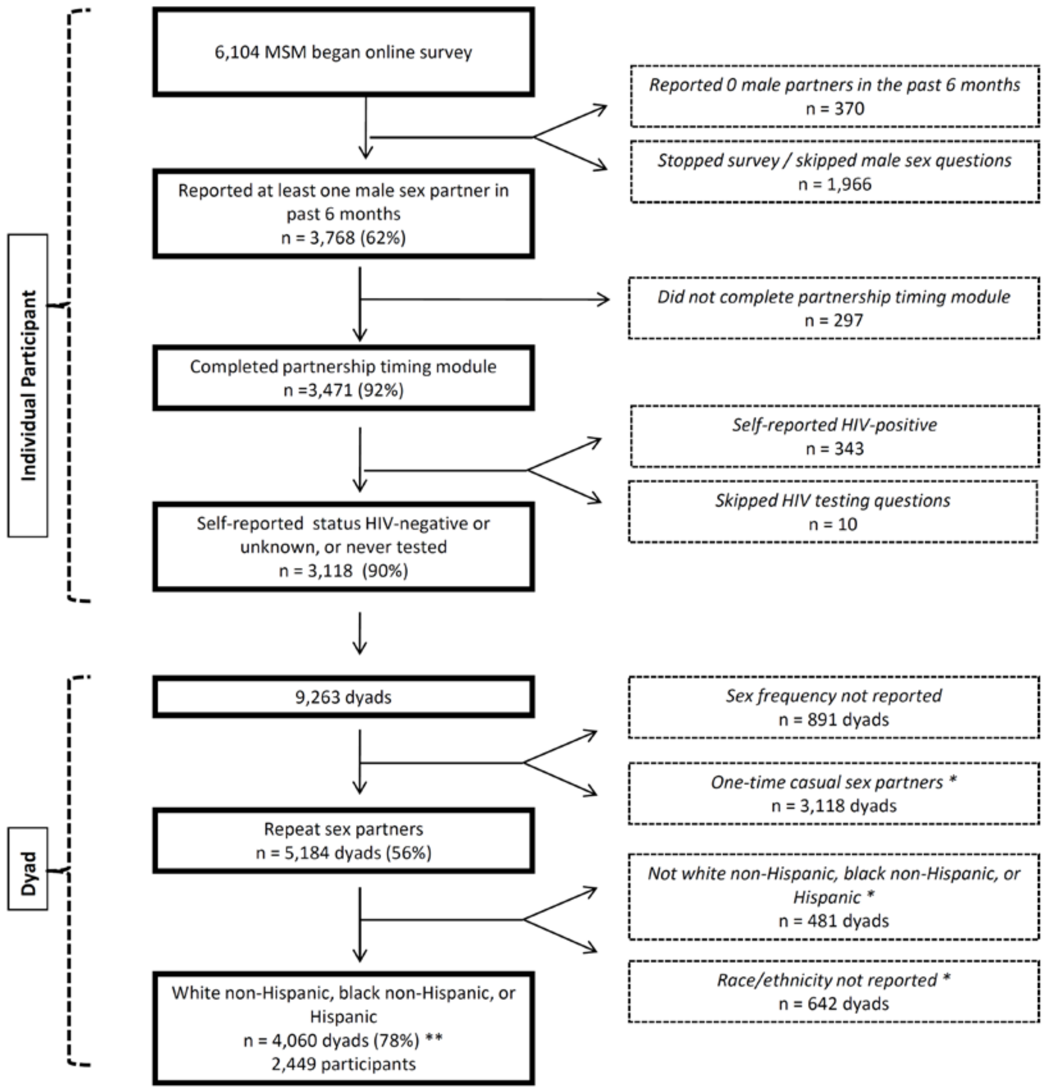


Figure 2: Flowchart for the inclusion of individuals and their reported partners (dyads) in an analysis of partner-perspective concurrency in a national online study of men who have sex with men



** These excluded partners (dyads) were still utilized in indirect exposure determinations for partners who met sex frequency and racial/ethnic analytic inclusion criteria.*

*** 1 partner was excluded due to insufficient partnership timing data*

Table 1. Characteristics of and indirect exposure among 4,060 sex partners with repeated contact to HIV-negative/unknown study participants

A. Partner characteristics	**Total**		**B. Type of partner indirect exposure: Serial or concurrent exposure**				**Concurrent Exposure**			
	col %	*(n)*	*row %*	*(n)*	*OR*	*(95% CI)*	*row %*	*(n)*	*OR*	*(95% CI)*
Overall		(4,060)	73.4	(2,980)	--	--	57.7	(2,343)	--	--
<u>Partner factors</u>										
Race/ethnicity										
White non-Hispanic	60.1	(2,439)	71.4	(1741)	*ref.*		56.9	(1388)	*ref.*	
Black non-Hispanic	21.0	(853)	76.9	(656)	1.34	(1.11, 1.60)	58.9	(502)	1.08	(0.92, 1.27)
Hispanic	18.9	(768)	75.9	(583)	1.26	(1.05, 1.52)	59.0	(453)	1.09	(0.92, 1.28)
Age										
< 25	38.3	(1,529)	72.1	(1103)	*ref.*		52.7	(805)	*ref.*	
25 – 29	20.3	(811)	75.0	(608)	0.91	(0.71, 1.17)	58.9	(478)	1.21	(0.95, 1.52)
30 – 39	22.9	(912)	71.8	(655)	1.11	(0.86, 1.44)	58.3	(532)	1.20	(0.95, 1.53)
40+	18.5	(737)	75.2	(554)	1.19	(0.90, 1.57)	64.6	(476)	1.70	(1.31, 2.21)
Partner type										
Main	41.3	(1,654)	55.0	(909)	*ref.*		40.6	(671)	*ref.*	
Casual	58.7	(2,352)	86.2	(2027)	5.11	(4.39, 5.95)	69.4	(1632)	3.32	(2.91, 3.79)
Location met										
Offline	52.1	(2,079)	71.6	(1488)	*ref.*		57.8	(1202)	*ref.*	
Online	47.9	(1,914)	75.2	(1438)	1.20	(1.04, 1.38)	57.1	(1092)	0.97	(0.86, 1.10)
Sexual repertoire										
Unprotected anal intercourse	53.7	(2,004)	68.5	(1373)	0.71	(0.58, 0.86)	54.4	(1091)	1.00	(0.84, 1.19)
Protected anal intercourse / Oral sex	28.4	(1,060)	80.0	(848)	1.30	(1.03, 1.64)	63.1	(669)	1.43	(1.18, 1.74)
Oral sex only	17.8	(665)	75.5	(502)	*ref.*		54.4	(362)	*ref.*	

Table 2. Characteristics of and indirect unprotected anal intercourse (UAI) exposure among 1,885 UAI partners with repeated contact to HIV-negative/unknown study participants

A. Partner characteristics	Total [1]		B. Type of partner indirect exposure: Serial or Concurrent UAI Exposure				Concurrent UAI Exposure			
	col %	*(n)*	*row %*	*(n)*	*OR*	*(95% CI)*	*row %*	*(n)*	*OR*	*(95% CI)*
Overall		(1,885)	47.5	(896)	--	--	37.1	(699)	--	--
Partner factors										
Race/ethnicity										
White non-Hispanic	61.1	(1152)	45.0	(518)	*ref.*		35.0	(403)	*ref.*	
Black non-Hispanic	19.8	(373)	55.0	(205)	1.49	(1.18, 1.89)	41.8	(156)	1.34	(1.05, 1.70)
Hispanic	19.1	(360)	48.1	(173)	1.13	(0.89, 1.44)	38.9	(140)	1.18	(0.93, 1.51)
Age										
< 25	38.5	(718)	47.6	(342)	*ref.*		35.4	(254)	*ref.*	
25 – 29	21.7	(405)	48.6	(197)	0.86	(0.68, 1.10)	37.0	(150)	1.08	(0.84, 1.38)
30 – 39	22.6	(421)	43.9	(185)	1.04	(0.82, 1.33)	37.1	(156)	1.08	(0.83, 1.38)
40+	17.3	(322)	50.0	(161)	1.10	(0.85, 1.43)	40.4	(130)	1.24	(0.94, 1.62)
Partner type										
Main	52.4	(985)	28.9	(285)	*ref.*		21.5	(212)	*ref.*	
Casual	47.6	(893)	68.3	(610)	5.29	(4.35, 6.45)	54.5	(487)	4.37	(3.58, 5.35)
Location met										
Offline	50.8	(957)	44.5	(426)	*ref.*		36.4	(348)	*ref.*	
Online	49.2	(927)	50.7	(470)	1.28	(1.07, 1.54)	37.9	(351)	1.07	(0.88, 1.29)

[1]Excludes 121 of 2,004 UAI partners for whom UAI data on other partnerships of the same participant are insufficient for indirect exposure calculations.

Table 3 **Multivariable models of the relationships between partner race/ethnicity and type with indirect exposure**

#	Model exposure outcome	Adjusted for repeated measures	Partner race/ethnicity: Black vs. White adj.OR	(95% CI)	p	Partner race/ethnicity: Hispanic vs. White adj.OR	(95% CI)	p	Partner Type: Casual vs. Main adj.OR	(95% CI)	p
1a	Serial or concurrent	N	1.34	(1.09, 1.65)	0.005	1.26	(1.02, 1.56)	0.03	5.34	(4.52, 6.30)	< .0001
1b	Serial or concurrent	Y	1.34	(1.11, 1.61)	0.002	1.28	(1.07, 1.53)	0.007	3.62	(3.14, 4.18)	< .0001
2a	Concurrent	N	1.07	(0.90, 1.28)	0.43	1.14	(0.95, 1.37)	0.17	3.73	(3.23, 4.32)	< .0001
2b	Concurrent	Y	1.03	(0.90, 1.18)	0.68	1.08	(0.96, 1.22)	0.18	1.97	(1.76, 2.20)	< .0001
3a	Serial or concurrent UAI	N	1.42	(1.10, 1.84)	0.008	1.14	(0.87, 1.48)	0.92	5.32	(4.35, 6.49)	< .0001
3b	Serial or concurrent UAI	Y	1.37	(1.10, 1.72)	0.006	1.02	(0.81, 1.29)	0.87	3.04	(2.52, 3.67)	< .0001
4a	Concurrent UAI	N	1.28	(0.99, 1.66)	0.06	1.22	(0.93, 1.58)	0.15	4.37	(3.57, 5.36)	< .0001
4b	Concurrent UAI	Y	0.99	(0.78, 1.27)	0.96	1.18	(0.99, 1.40)	0.06	1.99	(1.68, 2.35)	< .0001

Chapter 6 Conclusions

In this final section, we summarize the findings of the three analytical studies and consider their broader place in the fields of concurrency and HIV prevention research. We then consider the local impact of this work in improving HIV research at Emory University. These cumulatively inform potential directions for future research.

Review of major findings

In the first manuscript, we assessed concurrency among MSM participants in the Checking In study using our new partnership timing module and the two other predominant data collection methods, 'direct question' and 'date-overlap'. Individual-level concurrency prevalence was compared between the partnership timing module and 6 common outcomes derived from the other two. A high degree of agreement was found between the partnership timing module and other cumulative concurrency prevalence outcomes (% agreement range: 79 - 86%, κ range: 0.55 - 0.71), which represents better agreement than has been reported among these other outcomes, in other populations.[1,2] Comparative examinations at the dyad and triad levels of analysis corroborated these findings. UNAIDS point-prevalence concurrency outcomes were shown to have poor classificatory performance for MSM. These agreement results, and findings that demonstrated weaknesses in the other measurement methods, combined with the design enhancements of the partnership timing module and in the levels of analysis that it facilitates, cumulatively support the use of the partnership timing module for quantifying concurrency among MSM. This article is presently being prepared for submission to the *Journal of Medical Internet Research.*

In the second paper, we applied this new instrument to measuring the prevalence of concurrency and concurrent UAI with two partners among MSM in the Checking In study. A high prevalence of individual-level concurrency and concurrent UAI was found (45% and 16%, respectively). No differences were seen by race/ethnicity among MSM, yet the levels of concurrency observed were substantially higher than has been reported among heterosexual men. Triadic-level analyses revealed that having two partners concurrently was positively associated with engaging in UAI with both (OR: 1.9). These results suggest that biologically relevant concurrency may play a substantial role in facilitating HIV transmission among MSM, compared to heterosexuals. This manuscript was published in the October 2012 issue of *Sexually Transmitted Diseases*, and received favorable comments from peer-reviewers relating to its contributions to the field.

The third paper sought to overcome a major limitation of empirical concurrency research, by demonstrating a method for quantifying the risk sex partners face due to participants' concurrent and serially monogamous partnership configurations. By this method, profound connectivity and exposure was seen among repeat sex-partners of HIV-negative participants, with 58% concurrently exposed to another partner in the previous 6 months. Among UAI partners, 48% were exposed by UAI to another partner and 37% were exposed by concurrent UAI. Black non-Hispanic partners had modestly increased odds of concurrent UAI exposure (OR: 1.3). In combination with the results of the second paper, this suggests that black men engage in similar levels of concurrency compared to white men, but that partnership and mixing patterns might underlie a differential impact of concurrency on black partners. Concurrent UAI exposure odds were substantially increased for casual UAI partners (OR: 4.4), highlighting an important and potentially high-impact target for future work. This article is being prepared for submission to the *Journal of Acquired Immune Deficiency Syndromes.*

The dissertation and its contributions in context

During the course of my four years investigating the topic of sexual concurrency among MSM (2009 to 2012), the volume of research on concurrency has dramatically expanded. A Pubmed search for "concurrency AND (HIV *or* STI *or* STD)" shows that of 145 matches, 108 (74%) were published in 2009 or later.

Some of these recent publications provide important context to this work and are covered in the introductory and results chapters of this dissertation. Bohl et al's 2009 study provided the first, if flawed, estimates of concurrency among MSM in San Francisco.[3] In the same year, Morris et al's simulation of STI racial disparities due to concurrency and Doherty et al's analysis of condom use in concurrent triads were both published.[4,5] A 2009 UNAIDS meeting led to the 2010 introduction of a new 'consensus' measure for concurrency.[6,7] In 2010 and 2011, three contentious debates in the literature helped to underscore both what is known and remains unanswered in the field.[8-10] Evaluations in support [11] and against [1,12] the UNAIDS measure were published in 2011 and 2012. Finally, the first comparative analysis of concurrency between US heterosexuals and MSM was published in 2012,[13] while the second manuscript from this dissertation was in press.

Yet despite this growth in the field, two gaps that originally motivated this dissertation are still evident. The first is that little has been published on concurrency among MSM in the United States, the group most affected by the HIV/AIDS epidemic.

The work of Bohl et al, was available when we began this work, and the analysis by Glick et al. is the only new research that has since been added on this group. Notably, this paper did not provide race-specific estimates and thus no new results have been available for the sub-groups of MSM most affected by HIV.

The second gap is in the sophistication of methods for collecting, analyzing, and making inference on sexual concurrency data. As the debates referenced above have made clear, the available body of empirical concurrency studies is limited in its contribution to the understanding of concurrency. Yet, most of the empirical publications since then have used the same limited measurement tools and individual-level outcomes, with few employing novel methods. A notable exception is Tanser et al's innovative examination of spatial, ecological concurrency data and prospective HIV incidence.[9]

Against this backdrop, the contributions of this dissertation are clarified. Whereas only a few, inconsistently ascertained prevalence estimates had previously been available, we have added a robust compendium on the measurement, occurrence, correlates, and potential impact of sexual concurrency among MSM in the United States. This includes a new set of concurrency prevalence estimates among MSM, among the largest sample to-date, with values between those of Bohl et al and Glick et al.[3,13] Further, we have provided the first estimates of biologically relevant concurrency among MSM, and demonstrated associations between concurrent and unprotected sex. We observed no racial/ethnic differences in individual-level concurrency, a result that has already been incorporated in a recent, updated meta-analysis of racial-ethnic differences among MSM.[14] It was also demonstrated that black partners and casual partners were more likely to be put at risk due to concurrency. Together our results reveal a developing picture of alarming levels of connectivity due to sexual timing among MSM, particularly among those men who have UAI.

These results were enabled by the development of new methods for measuring and analyzing sexual timing data, which may benefit empirical concurrency research more broadly. We created and extensively evaluated a new, interactive tool for measuring concurrency among MSM. The partnership timing module was found to have high levels of agreement with extant tools. We developed new techniques of using triad and dyad level data in order to better understand concurrency's determinants and exposure patterns. The utility of these tools is not restricted to MSM and they may be used for future empirical research of concurrency research in both this and other populations, particularly those where progress has been stymied by the sole use of individual-level concurrency measures.

<u>Impact of this work at Emory University</u>

In addition to these contributions to the broader fields of HIV and concurrency research, this dissertation work has strengthened the HIV prevention research program at Emory University.

The questionnaire instruments (partnership timing module and inventory) and analytical code created for this dissertation research were adapted and extensively used in three NIH-sponsored studies of MSM. These include the Checking In study (NIH# RC1-MD004370), the data source for this work described earlier, and also the Atlanta-based Involvement (NIH# R01-MH085600) and MAN Project studies (NIH# R01HD067111).

For Involvement, a prospective cohort study of MSM in Atlanta, we adapted the survey instruments to accommodate 5 study visits and to allow both the carryover of sex partners between visits and the introduction of new partners. This version also saw the inclusion of more detailed partnership questions, such as those regarding relationship agreements.[15]

In the MAN Project, a cross-sectional study of MSM sexual networks and concurrency in Atlanta, we modified the research tools to accommodate up to 10 partners within the previous 12 months. Combined with the study's design of recruiting contemporaneous sex partners, we expect a far more detailed understanding of concurrency using this instrumentation. The partnership questions in the MAN Project are the most detailed and inherit those of Involve[men]t, with new questions related to partner identity and typologies (Pamina Gorbach, unpublished).

For the above 3 studies, these tools have to-date facilitated a wide variety of dyad-level analyses, pertaining to serosorting, assortative mixing, and identity among MSM as reviewed in Chapter 1, and contributed preliminary data to several NIH grant proposals under review in 2012.

Recently, the MAN Project's implementation of the partnership timing module was adapted for a study of adolescent African-African women, led by Teaniese Davis and Dr. Ralph DiClemente of the Behavioral Sciences and Health Education Department at Emory University. We are currently developing a reduced version of Involve[men]t's partnership timing module and inventory for the Sibanye study, one of the first prospective studies of MSM in sub-Saharan Africa (NIH #R01-AI094575).

Future research

Based on the results of this dissertation and their implications, we see opportunities for future research along 3 avenues:

1. *Role of concurrency in racial/ethnic disparities among MSM*

   As reviewed above, our individual-level analysis failed to find evidence for racial/ethnic differences in concurrency. This should not signal the end of concurrency as a potential explanation for disparate HIV transmission rates among subgroups MSM, for several reasons.

   First, our results originate from a national convenience sample of MSM. To the extent that geographic or other biases might impact the racial/ethnic composition of our sample, true differences might be obscured. It would be prudent to replicate our findings in different study designs and in more geographically-controlled analyses. As discussed in the previous section, the partnership timing module has been incorporated into two Atlanta-based studies of racial/ethnic HIV/STI differences that employed venue-based and chain-link referral sampling. These studies can serve as an excellent platform for future research on racial/ethnic patterns of concurrency among MSM.

   A significant, if not high-magnitude, association between black partners and increased exposure due to concurrency was found. This suggests a partnering pattern whereby black partners are preferentially put at behavioral risk. This phenomenon can be explored in analyses that seek to characterize the triads where black partners are put at risk. Such analyses would examine the demographic features of the participant (ie: race/ethnicity) and other partner (ie: main/casual type) involved, as well as partnership-level factors, such as where each partner was originally met and the circumstances of last sex with each. For these analyses, multi-level models would be most appropriate, since individual study participant, dyad, and triad level variables would be simultaneously included as predictors of the partner-specific outcome.[16,17] Overall, the Involvement study is better suited for such multi-level modeling than Checking In, which featured more limited data collection on individual study participants. HIV risk among black and white MSM is being assessed in Involvement at multiple levels, including the individual, dyadic, community, spatial, and societal levels, comprising more potentially meaningful covariates to such models than was available in Checking In. Additionally, this study conducts HIV testing on participants, which allows for a more accurate assessment of partner risk than self-reported HIV status as collected in Checking In. While Involvement was not available as a data source for this dissertation, baseline enrollment for Involvement will be ending in December 2012, and baseline visit data be available for planned multi-level analyses of concurrency in Spring 2013.

Finally, as postulated in the Discussion section of the second manuscript, it may be that similar levels of engaging in concurrent sex among two different groups may result in different ‘velocity’ epidemics because of underlying differences in sexual network size. One might reasonably expect higher degrees of connectivity in black MSM networks, which are likely smaller, than white MSM networks, given equivalent levels of concurrency. This hypothesis was evaluated and confirmed in a very recent simulation study of heterosexuals.[18] Future research might seek to replicate this simulation among MSM networks, given higher but equivalent levels of concurrency, sexual role versatility, and network sizes hypothesized for communities of MSM. If such work confirms racially-differential meanings to equivalent levels of concurrency, it will be important to quantify the degree of decrease in concurrency among black MSM that would be required to achieve health equity. This would determine the feasibility of intervening in concurrency to impact racial disparities among MSM.

2. *Role of concurrency in facilitating the HIV epidemic among MSM and relative to heterosexuals*

This research has provided documentation of the high prevalence and *potential* impact of concurrency among MSM. Yet this work alone is insufficient to demonstrate the degree of HIV transmission that results from these levels of concurrency among MSM. Agent-based simulations can be used to model concurrency's effects in populations, yet have been sparsely applied to MSM.[4,19,20] Simulation models of MSM can be parameterized according to observed concurrency patterns and might create counterfactual scenarios, whereby heterosexual levels of concurrency are assumed, in order to demonstrate the transmission risk attributable to excess concurrency among MSM.

A second opportunity for improved understanding of concurrency's implications among MSM stems from the recognition that our partner-perspective approach uses information on only one study participant to describe the exposure that his partner is subjected to. In reality, this partner might have other recent sex partners who might additionally be placing him at increased risk, and thus our partner-perspective outcomes represent a minimum exposure. This concept has been dubbed "overlapping concurrency" by Dr. Rich Rothenberg and its exploration is a primary aim of the MAN Project. To properly quantify this phenomenon, three sexually linked study participants must be enrolled and interviewed, as is done in the MAN Project.

3. *Targets of concurrency for intervention*

In the absence of specific modeling findings that quantify the degree to which concurrency accelerates HIV transmission in communities of MSM, given the extensive modeling literature in heterosexuals it can be held in near certainty that the high levels of concurrency among MSM present an important HIV risk. Accordingly, the possibility of modifying concurrency through behavioral interventions should be explored. Concurrency interventions are presently being evaluated among heterosexuals in Kenya and Seattle, WA by the University of Washington.[21]

As a pre-requisite to intervention development, there is an initial need for quantitative and qualitative work that explores the motivations, contexts, and perceptions of concurrency among MSM. Quantitative analyses might use data from the Involve[men]t and MAN Project studies to examine the partnership typologies and relationship agreements (eg: monogamous, open, no agreement) that are involved in both concurrent and non-concurrent partnership arrangements. Preliminary versions of such analyses were conducted in support of an R21 application with PI: Dr. Rob Stephenson that seeks to apply mixed qualitative methods towards understanding concurrency motivations among MSM in Atlanta, submitted in May 2012.

In conclusion, this dissertation has furthered the understanding of concurrency among men who have sex with men and contributed methods to the field that will support other research endeavors. The findings of this work depict substantial concurrency among MSM, support further research on this topic, and highlight a number of future directions of inquiry that will be pursued in the coming years.

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Appendix 1: Checking In Study, Sexual Behavior Inventory

Page Layout

Section 1 - Partner metadata

- Partner genders, numbers, exchange sex
- Male partners: online partner number, and total sex acts
- Male partners: total UAI acts

Section 2 - Partnership timing module

- Partner name list *(up to 5)*
- Partner calendar
- Concurrency clarification questions *(if calendar indicates temporal ambiguities)*

Section 3 - Partner-specific section (*repeated for each recent sex partner named)*

3a. Partnership formation

- Partner demographics
- Partnership description
- Geography
- Disclosure of HIV status before first sex
- Serosorting intent

3b. Partnership timing

- Date of first sex
- Date of last sex
- Ongoing relationship

3c. Ongoing partnership questions

- Transgender partner anatomy
- Sexual frequency in the previous six months
- Sexual activity outside of this relationship *(Manhart et al direct questions (REF))*
- Group sex

3d. Last sex

- Sexual activities
- Circumstances (location, drugs, HIV status)
- Last sex – HIV status knowledge
- HIV status knowledge source
- Strategic positioning

Section 4 - Post partner-specific wrap up

- Relationships among partners *(transitivity)*
- Final screen

==
Partner genders and numbers – p12m *(Baseline only)*
==

Thank you for all that you have told us so far. These next questions ask about people you've had sex with during the last 12 months, **since the beginning of [%%1742:month_11 %%]**.

During the last 12 months, did you have sex with a person who was*:*
(mark all that apply)

( ) Male
( ) Female
( ) Transgender: male to female
( ) Transgender: female to male

If 'male':

During the last 12 months, with how many men did you have anal or oral sex?:

____

Were any of these male sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?

( ) Yes
( ) No
( ) Don't know

If 'female':

During the last 12 months, with how many women did you have vaginal or anal sex?:

____

Were any of these female sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?

( ) Yes
( ) No
( ) Don't know

If 'Transgender: male to female':

During the last 12 months, with how many male to female transgender individuals did you have sex?:

____

Were any of these male to female transgender sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?

( ) Yes
( ) No
( ) Don't know

If 'Transgender: female to male'

During the last 12 months, with how many female to male transgender individuals did you have sex?:

____

Were any of these female to male transgender sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?

( ) Yes
( ) No
( ) Don't know

[if > 0 male partners in p12m. Actually this is always true at Baseline]

==

Partner classification and numbers – male partners p12m *(Baseline only)*

==

362. Of the [%%45:%%] male partners you had anal or oral sex with in the last 12 months, how many were:

[ ] main partners? (someone that you feel committed to above all others -- this is someone you might call your boyfriend, significant other, life partner, or husband)

[ ] casual partners? (someone that you do not feel committed to above all others)

[continuous sum shows total]

Please ensure that the total number of main + casual partners equals [%%45:During the last %%]. Your current total equals [%%249:total msp %%].

==
Male partner metadata screen 2 – p12m *(Baseline only)*
==

365. Of the [%%45:During the last %%] male partners you had anal or oral sex with in the last 12 months, how many did you meet on the Internet?

____

The total number of sex partners met on the Internet cannot be more than the total number of male sex partners ([%%45:During the last %%]).

366. Of the [%%45:During the last %%] male partners you had sex with in the last 12 months, how many did you have anal sex with?

____

367. Of the [%%45:During the last %%] male partners you had sex with in the last 12 months, how many did you have oral sex with?

____

The total number of anal sex partners cannot be more than the total number of male sex partners ([%%45:During the last %%]).

==
Male partner metadata screen 3 - p12m *(Baseline only)*
==
If >1 male AI partner:

368. Of your [%%49:Of the [%% %%] partners you had anal sex with in the last 12 months, how many did you have unprotected anal sex with? (This means that you or your partner did not use a condom at any point during sex, at least one time that you had anal sex)

____

ERROR: The number of male partners you had unprotected anal sex with can't be more than the total number of anal sex partners ([%%49:Of the [%% %%]).

If 1 male AI partner:

370. In the last 12 months, did you have unprotected anal sex with your male anal sex partner? (This means that you or your partner did not use a condom at any point during sex, at least one time that you had anal sex)

( ) Yes
( ) No
( ) Don't know

===
Transition from p12m to p6m metadata recall *(Baseline only)*
===

Thank you for telling us about your partners in the last 12 months.

Next, we'd like to ask you about your partners in the last 6 months (since the beginning of XXX).

Some of these questions will be very similar to earlier ones, but please keep in mind that they are now referring to partners you had since the beginning of [XXX]

Click Next Page to continue.

===
Partner genders and numbers – p6m
===

During the <u>last 6 months</u>, did you have sex with a person who was*:*
(mark all that apply)

( ) Male
( ) Female
( ) Transgender: male to female
( ) Transgender: female to male
( ) No sex in the last 6 months (Online pilot only)

If 'male':

During the last 6 months, with how many men did you have anal or oral sex?:

____

Was any of these male sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?
( ) Yes
( ) No
( ) Don't know

[if "yes" selected then all <u>male</u> partner-specific exchange questions are suddenly visible (<u>set default</u> to they are off)]

If 'female':

During the last 6 months, with how many women did you have vaginal or anal sex?:

____

Was any of these female sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?
( ) Yes
( ) No
( ) Don't know

[if "yes" selected then all <u>female</u> partner-specific exchange questions are suddenly visible (<u>set default</u> to they are off)]

If 'Transgender: male to female':

During the last 6 months, with how many male to female transgender individuals did you have sex?:

____

Was any of these [%%45:During the last %%] transgender: male to female sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?
( ) Yes
( ) No
( ) Don't know

[if "yes" selected then all transgender: male to female partner-specific exchange questions are suddenly visible (set default to they are off)]

If 'Transgender: female to male'

During the last 6 months, with how many female to male transgender individuals did you have sex?:

____

363. Was any of these [%%45:During the last %%] transgender: female to male sex partners an exchange partner -- that is a partner that you have sex with in exchange for money, drugs, food, or something else of value?

( ) Yes
( ) No
( ) Don't know

[if "yes" selected then all transgender: female to male partner-specific exchange questions are suddenly visible (set default to they are off)]

[if > 0 male partners in p6m]

==

Partner classification and numbers – non-transgender male partners p6m

==

362. Of the [%%45:%%] male partners you had anal or oral sex with in the last 6 months, how many were:

[ ] main partners? (someone that you feel committed to above all others -- this is someone you might call your boyfriend, significant other, life partner, or husband)

[ ] casual partners? (someone that you do not feel committed to above all others.)

[continuous sum shows total]

Please ensure that the total number of main + casual partners equals [%%45:During the last %%]. Your current total equals [%%249:total msp %%].

===
Partner metadata screen 2 – p6m
===

365. Of the [%%45:During the last %%] male partners you had anal or oral sex with in the last 6 months, how many did you meet on the Internet?

____

The total number of sex partners met on the Internet cannot be more than the total number of male sex partners ([%%45:During the last %%]).

366. Of the [%%45:During the last %%] male partners you had sex with in the last 6 months, how many did you have <u>anal sex</u> with?

____

367. Of the [%%45:During the last %%] male partners you had sex with in the last 6 months, how many did you have <u>oral sex</u> with?

____

The total number of anal sex partners cannot be more than the total number of male sex partners ([%%45:During the last %%]).

==
Partner metadata screen 3 – p6m
==

If >1 male AI partner:

368. Of your [%%49:Of the [%% %%] partners you had anal sex with in the last 6 months, how many did you have unprotected anal sex with? (This means that you or your partner did not use a condom at any point during sex, at least one time that you had anal sex).

____

ERROR: The number of male partners you had unprotected anal sex with can't be more than the total number of anal sex partners ([%%49:Of the [%% %%]).

If 1 male AI partner:

370. In the last 6 months, did you have unprotected anal sex with your male anal sex partner? (This means that you or your partner did not use a condom at any point during sex, at least one time that you had anal sex)

( ) Yes
( ) No
( ) Don't know

==
Intro partner list
==

This next section will be about some of your recent sex partners, regardless of gender.

In order to do that, we will ask you to provide nicknames for your recent sex partners. We will then use these nicknames to customize the questions so that they are specific to your partners.

It is important that you choose a nickname that will best help you remember the person. The names you provide are meant to help you only and should not reveal your partner's full identity. We do not want to know who your partners actually are.

Some examples of nicknames that you might choose are: a partner's first name, a nickname you call the partner by, the place where you both met or an online screen name.

==
Partner name list
==

Please give a nickname for each of your most recent sex partners over the last 6 months (since the beginning of [%%432:month_5 %%]).

Male, female, and transgender sex partners may be in this list:
For male partners, we mean people you had oral or anal sex with.
For female partners, we mean people you had vaginal, or anal sex with.

59. Space for 5 partners is provided, but you only need to fill in as many spaces as you need or can remember.

If you had more than 5 sex partners in the previous 6 months, we would like nicknames for the most recent 5.

Partner 1 (most recent) ________________
Partner 2 ________________
Partner 3 ________________
Partner 4 ________________
Partner 5 ________________

==
Partner calendar
==

221. For each sex partner listed, indicate, each month you had sex with that partner

Calendar created as follows:
Each names partner has a row
Each of the last 6 months is provided in a column
Response is required in each row

	Oct '09	***Nov '09***	***Dec '09***	***Jan '10***	***Feb '10***	***Mar '10***
<Partner_name_1>	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**
<Partner_name_2>	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**
<Partner_name_3>	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**
<Partner_name_4>	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**
<Partner_name_5>	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**

If there are no ambiguous partnerships with one-month overlaps:
==
Proceed to partnership-specific questions
==

Thank you for telling us the months in which you had sex with your partners.

Click Next to continue

skip to "Intro. to partner-specific questions"

If there are ambiguous partnerships with one-month overlaps:
==
Proceed to concurrency clarification questions
==

Thank you for telling us the months in which you had sex with your partners.

The next page will ask some questions to help us better understand what you just told us about your sexual partnerships.

Click Next to continue

==
Concurrency clarification questions
==

For each ambiguous partnership that has a one-month overlap, this question is provided:

You indicated that you had sex with both *[partner X]* and *[partner Y]* in the month of *[Month Z].*

Which of these statements about *[Month Z]* is most correct?

- I last had sex with *[partner X]* <u>before</u> I had sex with *[partner Y]*
- I last had sex with *[partner Y]* <u>before</u> I had sex with *[partner X]*
- I was having sex with both *[partner X]* <u>and</u> *[partner Y]* during the same time period
- Don't know

==
Intro. to partner-specific questions
==

On the next pages, we would like to ask you some questions about the sex partners for whom you gave nicknames.

For each partner you named, you will be asked similar questions. Some questions will be about the partner in general and some will be about your relationship with the partner.

The first questions will be about [%%403_O0:Space for 10&nb %%].

Click Next Page to begin.

==
Partner Demographics: #1
==

61. Is [%%454:cur_partner_nam %%] male, female, or transgender?
( ) Male
( ) Female
( ) Transgender: male to female
( ) Transgender: female to male

62. What is [%%454:cur_partner_nam %%]'s current age?

(if you an unsure of the exact age, choose an age that you think is close)

____

If "don't know"
63. Which of the following statements about [%%454:cur_partner_nam %%]'s age is most true?
( ) He or she is more than 10 years <u>younger</u> than I am
( ) He or she is 2-10 years <u>younger</u> than I am
( ) He or she is within a year of my age
( ) He or she is 2-10 years <u>older</u> than I am
( ) He or she is more than 10 years <u>older</u> than I am
( ) Don't know

64. Is [%%454:cur_partner_nam %%] Hispanic?
( ) Yes
( ) No
( ) Don't know

65. What race is [%%454:cur_partner_nam %%]? (check one)
( ) Asian/Pacific Islander
( ) Black/African-American
( ) White/Caucasian
( ) Native American/Alaska Native
( ) Mixed Race
( ) Other
( ) Don't know

If "mixed race"
66. You indicated that [%%454:cur_partner_nam %%] is of mixed race. Which terms best describe [%%454:cur_partner_nam %%]?
( ) Asian/Pacific Islander
( ) Black/African American
( ) White/Caucasian
( ) American Indian/Alaskan Native
( ) Other

67. Has [%%454:cur_partner_nam %%] had a paid job before?

( ) Yes
( ) No
( ) Don't know

If "Yes"
How would you describe [%%454:cur_partner_nam %%]'s current work situation?

(Check all that apply)
( ) Full time paid job (>30 hours/week)
( ) Part time paid job (<30 hours/week)
( ) Home duties/child care
( ) Full time student
( ) Part time student
( ) Voluntary/charitable work
( ) Have a job, but not at work due to extended illness, family leave, furlough or strike
( ) Disabled
( ) Unemployed for less than one year
( ) Unemployed for more than one year
( ) Don't know

What kind of work does or did [%%454:cur_partner_nam %%] do on his/her last main job?

____

If "no"
How would you describe [%%454:cur_partner_nam %%]'s current work situation?

(Check all that apply)
( ) Home duties/child care
( ) Full time student
( ) Part time student
( ) Voluntary/charitable work
( ) Disabled
( ) Unemployed for less than one year
( ) Unemployed for more than one year
( ) Don't know

In the last 6 months (since the beginning of [%%432:month_5 %%]), has [%%454:cur_partner_nam %%] been arrested?

( ) Yes
( ) No
( ) Don't know

If 'yes':
How many days did [%%454:cur_partner_nam %%] spend in jail or prison the last time [%%454:cur_partner_nam %%] was held?

( ) Under 30 days
( ) Over 30 days
( ) Don't know

==
Partnership description: #1
==

Please tell us a little about **you and [%%454:cur_partner_nam %%]**

Did you have sex with [%%454:cur_partner_nam %%] once, or more than once during the last 6 months?

( ) Once
( ) More than once
REQUIRED

If ‘more than once’, then ask: (one-time partners automatically casual)
Is/was [%%454:cur_partner_nam %%] someone that you feel or felt committed to above all others (someone you might call your boyfriend, significant other, life partner, or husband)?

( ) Yes
( ) No
( ) Don't know
REQUIRED

If ‘partner classification and numbers’ section above reveals exchange partners, then ask:
72. Is/was [%%454:cur_partner_nam %%] an exchange partner (someone who you have sex with in exchange for money, drugs, food, or something else of value)?

( ) Yes
( ) No
( ) Don't know
REQUIRED

73. If you had to further describe the type of sex partner [%%454:cur_partner_nam %%] is/was, which of the following would you choose?

Someone who …
( ) … is your primary sexual partner
( ) … you have sex with on a regular basis, <i>but who is not your main or primary partner</i>
( ) … you have had sexual contact with more than once, <i>but not on a regular basis</i>, and who you normally socialize with
( ) … you have had sexual contact with more than once, <i>but not on a regular basis</i>, and who you don’t socialize with
( ) … you had sexual contact with only 1 time, but could find again if necessary
( ) … you had never met before you had had sexual contact and never plan to see again
( ) … you gave sex to for money or other goods or someone who gave you sex for money or other goods

75. Please rate the strength of your relationship with [%%454:cur_partner_nam %%] on a scale from 1 (weak) to 10 (strong):

( ) 1 (very weak)
( ) 2
( ) 3
( ) 4
( ) 5

( ) 6
( ) 7
( ) 8
( ) 9
( ) 10 (very strong)

==
Geography: #1
==
Where did you first meet [%%454:cur_partner_nam %%]?
wheremeetP1 – P5

( ) Through friends
( ) School or work
( ) Circuit party or Rave
( ) At church
( ) Online
( ) Through a personal ad in a newspaper
( ) On a telephone chat line or dating line
( ) Bar/Club
( ) Cruising area
( ) On the street
( ) Adult bookstore
( ) Bath house
( ) Sex club
( ) Sex resort
( ) Private sex party
( ) Sports club or gym
( ) Vacation or cruise
( ) Social organization
( ) Other

if "Internet" …
Through which online service did you first meet [%%454:cur_partner_nam %%]?

( ) MySpace
( ) Facebook
( ) CraigsList
( ) Adam4Adam
( ) Manhunt
( ) D-list
( ) FindFred
( ) Friendster
( ) Grindr
( ) Other, *please specify:* _________
onlineserviceP1 – P5

if the partnership type was not "anonymous"(SG note: done in script):
Did you and [%%454:cur_partner_nam %%] live together at any point during the last 6 months (since the beginning of [%%432:month_5 %%])?
( ) Yes
( ) No

livetogetherP1 – P5

==
Disclosure of status
==

if had sex “more than once” above:
Did you and [%%454:cur_partner_nam %%] share both of your HIV statuses before you first had sex?

if had sex “once” above:
Did you and [%%454:cur_partner_nam %%] share both of your HIV statuses before you had sex?

( ) Yes
( ) No
( ) Don’t know
discussstatusfsP1 – P5

If ‘yes’ to discussing status:
What was [%%454:cur_partner_nam %%]’s status at that time?
( ) HIV-negative
( ) HIV-positive
( ) Don’t know
statusfsP1 – P5

If participant and his partner discussed their HIV statuses and partner was positive or negative, this page is shown. Otherwise skipped to next page:

==
Serosorting intent
==

if had sex "more than once" above:

How important was the knowledge that [%%454:cur_partner_nam %%] was [partner's HIV status] in deciding to first have sex with [%%454:cur_partner_nam %%]?%%]?

if had sex "once" above:

How important was the knowledge that [%%454:cur_partner_nam %%] was [partner's HIV status] in deciding to have sex with [%%454:cur_partner_nam %%]?

( ) Not important at all
( ) Slightly important
( ) Moderately important
( ) Very important
( ) Extremely important

statusimpP1 – P5

Online involveMENt pilot only. Done for ONLY first partner: if answers the above question:

We are trying to develop new questions to help understand the decisions that men make when choosing their sex partners.

Was this question clear to you?
( ) Yes
( ) No, *please explain and feel free to offer any suggestions:*

____

statusimpclearP1

[If had sex "more than once", then the participant next completes the sections pertaining to dates of first and last sex].
[If had sex "once", then the participant is skipped to the "Ongoing relationship" section"].
==
Date of first sex: #1
==

76. When did you first have sex with [%%454:cur_partner_nam %%]?

You may enter just the month and year, but if you know the exact date, please enter that instead.

If you are unsure of when you first had sex, try to select a time that you think is close.

It is OK if you first had sex with [%%454:cur_partner_nam %%] longer than 6 months ago; we still would like to know when you first had sex.

i: (drop-down box with months. "don't know the month" is provided as option) ***firstsexmoP1***
ii: (drop-down box with years) "don't know the year" is provided as option) ***firstsexyrP1***

OR

i: MM/DD/YYYY (calendar button) ***firstsexdtP1***

[ERROR: The time you first had sex with [%%454:cur_partner_nam %%] cannot be in the future. Please correct the date.]

[ERROR: Please select either the month and year OR the date you first had sex with [%%454:cur_partner_nam %%]]

Completed only for non-one-time partners

==
Date of first sex – unknown month or year: #1
==

if year is selected as "don't know the year"

It's OK if you can't remember the exact year.

Can you remember about how many years ago you first had sex with [%%454:cur_partner_nam %%]?

( ) Less than 1 year ago
( ) 1 – 2 years ago
( ) 2 – 5 years ago
( ) 5 – 10 years ago
( ) more than 10 years ago

firstsexyearsP1 – P5
(REQ)

if month is selected as "don't know the month" (but year is known)

It's OK if you can't remember the exact month.

Think back to the time in [Year of first sex] when you first had sex with [%%454:cur_partner_nam %%].

Perhaps you had sex around a special time of the year such as your birthday, or a holiday like July 4th or Halloween. Maybe you can remember that it was warm outside or it was after a trip you took.

Based on what you can recall, try to select what time during [Year of first sex] you first had sex with [%%454:cur_partner_nam %%]:

( ) January - March
( ) April - June
( ) July - September
( ) October - December
( ) (don't know when during the year)

[ERROR: The time during the year you indicated for when you first had sex with [%%454:cur_partner_nam %%] is in the future. Please correct this.]

firstsexmonthsP1 – P5
(REQ)

[ERROR: The date you gave for the last time you had sex with [%%454:cur_partner_nam %%] comes before the time you first had sex with [%%454:cur_partner_nam %%] . Please correct this date.]

[ERROR: The month you gave for the last time you had sex with [%%453:cur_partner_num %%] comes before when you first had sex with [%%453:cur_partner_num %%] . Please correct this.]

[ERROR: The time period you gave for the last time you had sex with [%%453:cur_partner_num %%] comes before when you first had sex with [%%453:cur_partner_num %%] . Please correct this.]

Completed only for non-one-time partners
==
Date of last sex: #1
==
Month of last sex is captured from partnership calendar in a hidden variable.

Earlier, you indicated that you last had sex with [%%454:cur_partner_nam %%] in the month of *[month of last sex from calendar]*. Is this correct?

( ) Yes
( ) No

lastsexmocorrectP1 – P5
(REQ)

If 'Yes'
Do you know the exact date on which you last had sex with [%%454:cur_partner_nam %%]?

( ) Yes
( ) No

lastsexknowdtP1 – P5
(REQ)

If 'Yes'
Please enter the date:
MM/DD/YYYY (calendar button)
lastsexdtP1 – P5
(REQ)

If 'No'
That's OK. The information that you have provided us with is still extremely helpful.
End of page. Participant clicks 'Next'

If 'No'
That's OK. Please correct our records about when you last had sex with [%%454:cur_partner_nam %%] using the spaces below.

You may pick one of the last 6 months, but if you know the exact date, please enter that instead.
If you are unsure of when you last had sex, try to select a time that you think might be close.

(drop-down box with the last 6 months. "don't know the month" is now not provided as option
lastsexmoP1 – P5

OR

same date field as above:
MM/DD/YYYY (calendar button)
lastsexdtP1
(one of the two fields is REQ)

[ERROR: The date you last had sex with [%%454:cur_partner_nam %%] cannot be in the future. Please correct the date.]

[ERROR: Please select either the month and year OR the date you last had sex with [%%454:cur_partner_nam %%]]

[ERROR: The date you gave for the last time you had sex with [%%454:cur_partner_nam %%] is more than 6 months ago (before [%%432:month_5 %%]). Please correct the date.

if the partnership type was not "anonymous"

==

Ongoing Relationship: #1

==

Do you think you will have sex with [%%454:cur_partner_nam %%] again?

( ) Yes
( ) No
( ) Not sure

ongoingP1 – P5

If partner is either transgender type:

==

Transgender partner anatomy: #1

==

You indicated that [%%454:cur_partner_nam %%] is transgender.

Does [%%454:cur_partner_nam %%] have a penis?

( ) Yes
( ) No
( ) Don't know

haspenisP1 – P5

[If had sex "once, the participant is skipped to the "Group sex" page]
[If had sex "more than once" and the partner has a penis, then the participant completes this section].

==
Sex frequency – partner with penis: #1
==

Now we'd like to ask you a few questions your relationship with [%%454:cur_partner_nam %%] in the last six months (since the beginning of [%%432:month_5 %%])

In the last six months, how many times have you had anal or oral sex with [%%454:cur_partner_nam %%]?

[Pull-down menu of choices:]

( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8
( ) 9
( ) 10
( ) More than 10 *(coded as 50)*
sexfreqmpP1 – P5

If "more than 10 times"
372. About how often did you have anal or oral sex with [%%454:cur_partner_nam %%] in the last six months?

( ) About once a month
( ) 2 or 3 times a month
( ) About once a week
( ) 2 or 3 times a week
( ) More than 3 times a week
sexfreqoftenmpP1 – P5

Have you had anal sex with [%%454:cur_partner_nam %%] in the last 6 months?

( ) Yes
( ) No
( ) Don't know
AImpP1 - P5

If 'yes'
Have you had unprotected anal sex with [%%454:cur_partner_nam %%] in the last 6 months? *(This means that you or* [%%454:cur_partner_nam %%] *did not use a condom at any point during sex, at least one time that you had anal sex.)*

( ) Yes
( ) No
( ) Don't know
UAImpP1 - P5

[If had sex "more than once" and the partner has no penis (or is trans and the participant replies "don't know" to having a penis), then the participant completes this section].

==

Sex frequency – partner without penis: #1

==

Now we'd like to ask you a few questions about your relationship with NAME in the last six months (since the beginning of [%%432:month_5 %%])

In the last six months, how many times have you had vaginal or anal sex with [%%454:cur_partner_nam %%]?

[Pull-down menu of choices:]

( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8
( ) 9
( ) 10
( ) More than 10 *(coded as 50)*
sexfreqfpP1 – P5

If "more than 10 times"

372. About how often did you have vaginal or anal sex with [%%454:cur_partner_nam %%] in the last six months?

( ) About once a month
( ) 2 or 3 times a month
( ) About once a week
( ) 2 or 3 times a week
( ) More than 3 times a week
sexfreqoftenfpP1 – P5

Have you had vaginal sex with [%%454:cur_partner_nam %%] in the last 6 months?

( ) Yes
( ) No
( ) Don't know
VImpP1 - P5

If 'yes'

Have you had unprotected vaginal sex with [%%454:cur_partner_nam %%] in the last 6 months? *(This means that you or* [%%454:cur_partner_nam %%] *did not use a condom at any point during sex, at least one time that you had vaginal sex.)*

( ) Yes
( ) No
( ) Don't know
UVImpP1 - P5

Have you had anal sex with [%%454:cur_partner_nam %%] in the last 6 months?

( ) Yes
( ) No
( ) Don't know
AImpP1 - P5

If 'yes'
Have you had unprotected anal sex with [%%454:cur_partner_nam %%] in the last 6 months? *(This means that you or* [%%454:cur_partner_nam %%] *did not use a condom at any point during sex, at least one time that you had anal sex.)*

( ) Yes
( ) No
( ) Don't know
UAImpP1 - P5

[only completed if sex more than once]

==
Sexual activity outside of this relationship: #1
==

In the last 6 months, during the time when you were sexually involved with [%%454:cur_partner_nam %%], with how many other people did you have sex?

____

othersexparticipantP1- P5

In the last 6 months, during the time you were sexually involved with [%%454:cur_partner_nam %%], did [%%454:cur_partner_nam %%] have sex with anyone else?

( ) Yes
( ) No
( ) Don't know

othersexpartnerP1- P5

===
Group sex: #1
===

In the last 6 months (since *[current month - 6]*), did you and [%%454:cur_partner_nam %%] ever have sex with other people at the same time? (Threesome or group sex)

( ) Yes
( ) No
( ) Don't know

groupsexP1 – P5

[If partner has a penis, then this section is completed]
[If partner doesn't have a penis, then the next section is completed]
==
Last sex – sexual activities – partner with penis: #1
==
[If had sex "once", then the phrase "The last time" is replaced with "When"]

376. The last time you had sex with [%%454:cur_partner_nam %%], did you have receptive anal sex? (This means that you were the bottom)
( ) Yes
( ) No
( ) Don't know
RAIlsP1 – P5

If 'yes'
377. Did [%%454:cur_partner_nam %%] use a condom the last time you had receptive anal sex (when you were the bottom)?
( ) [%%454:cur_partner_nam %%] did not use a condom **1**
( ) [%%454:cur_partner_nam %%] used a condom part of the time **2**
( ) [%%454:cur_partner_nam %%] used a condom the whole time **3**
( ) [%%454:cur_partner_nam %%] used a condom, but it broke **4**
( ) Don't know **9**
RAIlscondomP1 – P5

If "did not use a condom":
What was the <u>main</u> reason why a condom was not used the last time you had receptive anal sex with [%%454:cur_partner_nam %%]?
( ) A condom wasn't available. **1**
( ) A condom was available, but I didn't want to use one. **2**
( ) A condom was available, but [%%454:cur_partner_nam %%] didn't want to use one. **3**
( ) Other reason, *please specify:* __________ **4**
whynoRAIlscondomP1 – P5

378. The last time you had sex with [%%454:cur_partner_nam %%], did you have insertive anal sex? (This means that you were the top).
( ) Yes
( ) No
( ) Don't know
IAIlsP1 – P5

If 'yes'
379. Did you use a condom the last time you had insertive anal sex with [%%454:cur_partner_nam %%] (when you were the top)?
( ) I did not use a condom **1**
( ) I used a condom part of the time **2**
( ) I used a condom the whole time **3**
( ) I used a condom, but it broke **4**
( ) Don't know **9**
IAIlscondomP1 – P5

If "did not use a condom":
What was the <u>main</u> reason why a condom was not used the last time you had insertive anal sex with [%%454:cur_partner_nam %%]?

( ) A condom wasn't available. **1**
( ) A condom was available, but I didn't want to use one. **2**
( ) A condom was available, but [%%454:cur_partner_nam %%] didn't want to use one. **3**
( ) Other reason, *please specify:* __________ **4**
whynoIAIlscondomP1 – P5

===
Last sex – sexual activities – partner without penis: #1
===

[If had sex "once", then the phrase "The last time" is replaced with "When"]

376. The last time you had sex with [%%454:cur_partner_nam %%], did you have vaginal sex?
( ) Yes
( ) No
( ) Don't know
VIlsP1 – P5

If 'yes'
377. Did you use a condom the last time you had vaginal sex?
Choose one.
( ) I did not use a condom
( ) I used a condom part of the time
( ) I used a condom the whole time
( ) I used a condom, but it broke
( ) Don't Know
VIlscondomP1 – P5

If "did not use a condom":
What was the <u>main</u> reason why a condom was not used the last time you had anal sex with [%%454:cur_partner_nam %%]?
( ) A condom wasn't available. **1**
( ) A condom was available, but I didn't want to use one. **2**
( ) A condom was available, but [%%454:cur_partner_nam %%] didn't want to use one. **3**
( ) Other reason, *please specify:* __________ **4**
whynoVIlscondomP1 – P5

378. The last time you had sex with [%%454:cur_partner_nam %%], did you have anal sex?
( ) Yes
( ) No
( ) Don't know
AIlsfpP1 – P5

If 'yes'
379. Did you use a condom the last time you had anal sex with [%%454:cur_partner_nam %%]?
Choose one.
( ) I did not use a condom
( ) I used a condom part of the time
( ) I used a condom the whole time
( ) I used a condom, but it broke
( ) Don't Know
AIlsfpcondomP1 – P5

If "did not use a condom":
What was the <u>main</u> reason why a condom was not used the last time you had anal sex with [%%454:cur_partner_nam %%]?
( ) A condom wasn't available. **1**
( ) A condom was available, but I didn't want to use one. **2**
( ) A condom was available, but [%%454:cur_partner_nam %%] didn't want to use one. **3**
( ) Other reason, *please specify:* _________ **4**
whynoAIlsfpcondomP1 – P5

==
Last sex – circumstances: #1
==
[If had sex "once", then the phrase "The last time" is replaced with "When"]
We'd next like to ask some questions about the situation in which you and [%%454:cur_partner_nam %%] last had sex.

Where were you and [%%454:cur_partner_nam %%] the last time you had sex?
( ) My home **1**
( ) [%%454:cur_partner_nam %%]'s home **2**
( ) Bath house **3**
( ) Sex club **4**
( ) Sex resort **5**
( ) On vacation in a different city **6**
( ) Local hotel room **7**
( ) Circuit party or rave **8**
( ) Public restroom **9**
( ) Park **10**
( ) Car **11**
( ) Other, please specify ___________ **20**
locationlsP1 – P5

380. The last time you had sex with [%%454:cur_partner_nam %%], were you buzzed on alcohol?
( ) Yes
( ) No
( ) Don't know
alcohollsP1 – P5

380. The last time you had sex with [%%454:cur_partner_nam %%], were you high on drugs?
( ) Yes
( ) No
( ) Don't know
drugslsP1 – P5

If 'yes':
You indicated that you were high on a drug.
Please indicate which ones:
(*Select all that apply)*

( ) Amphetamine, meth, speed, crystal, crank, ice - *not injected **1***
( ) Amphetamine, meth, speed, crystal, crank, ice – *injected **2***
( ) Downers (Valium, Ativan, Xanax) **3**
( ) Pain killers (Oxycontin, Percocet) **4**
( ) Hallucinogens such as LSD **5**
( ) Ecstasy **6**
( ) Club drugs such as GHB, ketmamine **7**
( ) Marijuana **8**
( ) Poppers (amyl nitrite) **9**
( ) Crack - *not injected **10***
( ) Crack – *injected **11***
( ) Cocaine - *smoked or snorted **12***
( ) Cocaine – *injected with no other drugs **13***
( ) Heroin, *smoked or snorted but not injected* **14**
( ) Heroin - *injected with no other drugs **15***

( ) Heroin and cocaine - *injected together (speedballs)* ***16***

( ) Other drugs: __________________ **50**
whichdrugslsP1 – P5

[If had sex "once", then the participant skips this page, since the answers provided in "Disclosure of status" apply to last sex]

==

Last sex – HIV status knowledge: #1

==

381. The last time you had sex with [%%454:cur_partner_nam %%], did you know his/her HIV status?

( ) Yes
( ) No
( ) Don't know
HIVstatknowlsP1 - P5

If yes:

382. What was [%%454:cur_partner_nam %%]'s HIV status at that time?

( ) HIV-negative **"HIV-negative"**
( ) HIV-positive **"HIV-positive"**
HIVstatlsP1 – P5

Skip if didn't know status at last sex
Also skipped if sex once
==
Last sex – HIV status knowledge source
==
How did you know that [%%454:cur_partner_nam %%]'s was *[partner status]* when you last had sex?

( ) I already knew [%%454:cur_partner_nam %%] was *[partner status]* from previous contact with [%%454:cur_partner_nam %%] **1**
( ) I asked and [%%454:cur_partner_nam %%] told me **2**
( ) [%%454:cur_partner_nam %%] volunteered the information **3**
( ) I didn't ask, he didn't say, but I assumed [%%454:cur_partner_nam %%] was *[partner status]* ***4***

HIVstatsourceIsP1 – P5

[If the current partner is male, the two had UAI at last sex, then the participant completes this section].
[Otherwise the participant is skipped to the next section]
==
Last sex – strategic positioning: #1
==
[If had sex "once", then the phrase "When you last had sex" is replaced with "When you had sex"]

From what you've told us so far, when you last had sex with [%%454:cur_partner_nam %%], your HIV status was [participant's HIV status] and [%%454:cur_partner_nam %%]'s HIV-status was [partner's HIV status].

if had unprotected receptive anal sex:
When you last had sex, how important was this knowledge in deciding to have receptive anal sex (be a bottom) with [%%454:cur_partner_nam %%]?

( ) Not important at all **1**
( ) Slightly important **2**
( ) Moderately important **3**
( ) Very important **4**
( ) Extremely important **5**
stratposURAIlsP1 - P5

if had unprotected insertive anal sex:
When you last had sex, how important was this knowledge in deciding to have insertive anal sex (be a top) with [%%454:cur_partner_nam %%]?

( ) Not important at all **1**
( ) Slightly important **2**
( ) Moderately important **3**
( ) Very important **4**
( ) Extremely important **5**
stratposUIAIlsP1 - P5

==
Partner transition: #1 to #2
==

Thank you for telling us about [%%403_O0:Space for 10&nb %%].

Next, we'd like to ask you about [%%403_O1:Space for 10&nb %%].

Click Next Page to continue.

Partner 1 section replicated for partners 2-5, but excluded here for brevity.

Page shown only if >1 partner named

==

Relationships among partners

==

if 2 partner named:

Did **[%%403_O0:Space for 10&nb %%]** and **[%%403_O1:Space for 10&nb %%]** have sex with each other in the last 6 months, *or do you think they probably have*?

( ) Yes
( ) No

if >2 partners named:

If you know that two of these partners had sex with each other in the last 6 months, or think they probably have, click the box that matches both partners' nicknames on the grid.

	[p #1]	[p #2]	[p #3]	[p #4]	[p #5]
[partner #1 nickname]		**[ ]**	**[ ]**	**[ ]**	**[ ]**
[partner #2 nickname]			**[ ]**	**[ ]**	**[ ]**
[partner #3 nickname]				**[ ]**	**[ ]**
[partner #4 nickname]					**[ ]**

==
Final screen
==

Closing message for survey.

Instructions for telling staff that they have completed their Baseline survey.

Appendix 2: Partnership timing module algorithm code (SurveyGizmo v2.6 PHP scripting language)

```
// Calculate concurrency pairs

%%str = sgapiGetTableQuestionTitles(632);
%%output = sgapiPrint_R(%%str);


// populate arrays

// initialize counting variable that increments over each page

// Store partner names
       %%partner_names = sgapiGetValue(403);
       %%name_count = sgapiGetValue(443);


       %%partner_i_array = array();
       %%partner_j_array = array();
       %%month_array = array();
       %%concurrency_index = 0;

// Store question IDs for the calendar:
if (%%name_count == 1){
       %%row_ids = array(1829);
}else if (%%name_count == 2){
       %%row_ids = array(1849,1850);
}else if (%%name_count == 3){
       %%row_ids = array(1852,1853,1854);
}else if (%%name_count == 4){
       %%row_ids = array(1856,1857,1858,1859);
}else if (%%name_count == 5){
       %%row_ids = array(1861,1862,1863,1864,1865);
}


for (%%i = 0; %%i <= %%name_count - 2; %%i++){              // Partner i
 %%i_question = sgapiGetValue(sgapiArrayGet(%%row_ids, %%i));

 for (%%j = %%i + 1; %%j <= %%name_count - 1; %%j++){ // Partner j
 %%j_question = sgapiGetValue(sgapiArrayGet(%%row_ids, %%j));

  for (%%k = 0; %%k <= 5; %%k++){              // Month

    %%i_month = sgapiArrayGet(%%i_question,'O'.%%k) ;
    %%j_month = sgapiArrayGet(%%j_question,'O'.%%k) ;

   // Check for a match between i and j this month;
   if ((%%i_month != "") and (%%i_month == %%j_month)) {

      // month 0 rule - check for blank on month 1 ;
      if (%%k == 0) {
            if ((sgapiArrayGet(%%i_question,'O1') == "") or
(sgapiArrayGet(%%j_question,'O1') == "")) {

            sgapiArraySet(%%partner_i_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%i));
            sgapiArraySet(%%partner_j_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%j));
            sgapiArraySet(%%month_array, "O".%%concurrency_index,
sgapiArrayGet(sgapiGetValue(sgapiArrayGet(%%row_ids, %%i)),'O'.%%k));
```

```
            // LOAD UP AVAILABLE CONCURRENCY QUESTION OPTIONS IN ARRAY
            // numeric coding of responses hidden in WHITE

            %%x = array();

// figure out if both of these people are isolated sex within this month;
if ( (sgapiArrayGet(%%i_question,'O1') == "") and
(sgapiArrayGet(%%j_question,'O1') == "") ){
     %%isolated_sex = 1;
}
else{
     %%isolated_sex = 0;

}


// sex continued with parter j after partner i;
   if (((sgapiArrayGet(%%i_question,'O1') == "") and
(sgapiArrayGet(%%j_question,'O1') != "")) or (%%isolated_sex == 1 ) ){

   sgapiArraySet(%%x, "O0", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b>.") ;
}


// sex continued with parter i after partner j;
   if (((sgapiArrayGet(%%i_question,'O1') != "") and
(sgapiArrayGet(%%j_question,'O1') == "")) or (%%isolated_sex == 1 )){
            sgapiArraySet(%%x, "O1", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b>.") ;
}

// always ask:
            sgapiArraySet(%%x, "O2", "I was having sex with both
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>and</u>
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> during the same time
period.") ; // single quotes

            sgapiArraySet(%%x, "O3", "Don't know") ;

            // Store options for piping:
            sgapiSetValue(1305 + %%concurrency_index, %%x);

            %%concurrency_index++;
            }
      }

      // Similar story for month 5;
      elseif (%%k == 5) {
            if ((sgapiArrayGet(%%i_question,'O4') == "") or
(sgapiArrayGet(%%j_question,'O4') == "")) {

            sgapiArraySet(%%partner_i_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%i));
            sgapiArraySet(%%partner_j_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%j));
            sgapiArraySet(%%month_array, "O".%%concurrency_index,
sgapiArrayGet(sgapiGetValue(sgapiArrayGet(%%row_ids, %%i)),'O'.%%k));
```

```
            // LOAD UP AVAILABLE CONCURRENCY QUESTION OPTIONS IN ARRAY
            // numeric coding of responses hidden in WHITE

            %%x = array();

// figure out if both of these people are isolated sex within this month;
if ( (sgapiArrayGet(%%i_question,'O4') == "") and
(sgapiArrayGet(%%j_question,'O4') == "") ){
     %%isolated_sex = 1;
}
else{
     %%isolated_sex = 0;

}

// sex with parter i before partner j;
   if (((sgapiArrayGet(%%i_question,'O4') != "") and
(sgapiArrayGet(%%j_question,'O4') == "")) or (%%isolated_sex == 1 ) ){

   sgapiArraySet(%%x, "O0", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b>.") ;
}


// sex with parter j before partner i;
   if (((sgapiArrayGet(%%i_question,'O4') == "") and
(sgapiArrayGet(%%j_question,'O4') != "")) or (%%isolated_sex == 1 )){
            sgapiArraySet(%%x, "O1", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b>.") ;
}

// always ask:
            sgapiArraySet(%%x, "O2", "I was having sex with both
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>and</u>
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> during the same time
period.") ; // single quotes

            sgapiArraySet(%%x, "O3", "Don't know") ;

            // Store options for piping:
            sgapiSetValue(1305 + %%concurrency_index, %%x);

            %%concurrency_index++;

            }
      }

      // months 1,2,3,4: check for overlap in either prev or following month.
ask if blanks in opposing month corners. if both blank, ask;
      else{
            %%month_before = %%k-1;
            %%month_after = %%k+1;

            if (((sgapiArrayGet(%%i_question,'O'.%%month_after) == "") and
(sgapiArrayGet(%%j_question,'O'.%%month_before) == "")) or
((sgapiArrayGet(%%j_question,'O'.%%month_after) == "") and
(sgapiArrayGet(%%i_question,'O'.%%month_before) == "")))
 {

            sgapiArraySet(%%partner_i_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%i));
```

```
            sgapiArraySet(%%partner_j_array, "O".%%concurrency_index,
sgapiArrayGet(%%partner_names, 'O'.%%j));
            sgapiArraySet(%%month_array, "O".%%concurrency_index,
sgapiArrayGet(sgapiGetValue(sgapiArrayGet(%%row_ids, %%i)),'O'.%%k));


            // LOAD UP AVAILABLE CONCURRENCY QUESTION OPTIONS IN ARRAY
            // numeric coding of responses hidden in WHITE

            %%x = array();

// figure out if both of these people are isolated sex within this month -
UPDATE: THIS ISNT ACTUALLY NECESSARY;
if ((sgapiArrayGet(%%i_question,'O'.%%month_before) == "") and
(sgapiArrayGet(%%i_question,'O'.%%month_after) == "") and
(sgapiArrayGet(%%j_question,'O'.%%month_before) == "") and
(sgapiArrayGet(%%j_question,'O'.%%month_after) == "") ){
     %%isolated_sex = 1;
}
else{
     %%isolated_sex = 0;

}


// sex continued with parter j after partner i;
   if (((sgapiArrayGet(%%i_question,'O'.%%month_after) == "") and
(sgapiArrayGet(%%j_question,'O'.%%month_before) == "")) or (%%isolated_sex == 1
) ){
            sgapiArraySet(%%x, "O0", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b>.") ;
}


// sex continued with parter i after partner j;
   if (((sgapiArrayGet(%%i_question,'O'.%%month_before) == "") and
(sgapiArrayGet(%%j_question,'O'.%%month_after) == "")) or (%%isolated_sex == 1
)){
            sgapiArraySet(%%x, "O1", "I last had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> <u>before</u> I had sex with
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b>. ") ;
}

// always ask:
            sgapiArraySet(%%x, "O2", "I was having sex with both
<b>".sgapiArrayGet(%%partner_names, 'O'.%%i)."</b> <u>and</u>
<b>".sgapiArrayGet(%%partner_names, 'O'.%%j)."</b> during the same time
period.") ; // single quotes

            sgapiArraySet(%%x, "O3", "Don't know") ;

            // Store options for piping:
            sgapiSetValue(1305 + %%concurrency_index, %%x);

            %%concurrency_index++;

            }

      }
   }
```

```
  }
 }
}


// store arrays in questions for later use
sgapiSetValue(553,%%partner_i_array);
sgapiSetValue(590,%%partner_j_array);
sgapiSetValue(591,%%month_array);


// hide these arrays for now. can turn on later
   sgapiHideQuestion(553, true);
   sgapiHideQuestion(590, true);
   sgapiHideQuestion(591, true);


// store the total number of concurrency questions to ask
sgapiSetValue(512, %%concurrency_index);

// show or hide message
if ( %%concurrency_index == 0) {
sgapiHideQuestion(1187, true);
}
else {
sgapiHideQuestion(1186, true);
}
// jump to next page
```

Appendix 3: Code for processing of partnership module response data into triadic and individual concurrency outcomes (SAS)

A. checking in analysis - uaicombo dataset - prepare data – 7_31_2012.sas

```
* inherits the program used for the IAS and NHPC 2011 abstracts, and
then the 10/11/2011 programs;
libname checking "C:\document\eli\HIV\checking in\IAS and Paper
2\uaicombo dataset";
libname library "C:\document\eli\HIV\checking in\IAS and Paper
2\uaicombo dataset";

%inc "C:\document\eli\HIV\checking in\IAS and Paper
2\print_sex_cal.sas";

options nofmterr;



proc format library = library;
      value hiv_partic
            0 = "Negative"
            1 = "Positive"
            2 = "Indeterminant/Inconclusive"
            3 = "Didn't get the results of my last HIV test";

      value yn
            0 = "No"
            1 = "Yes";

      value raceth
            1 = "White non-Hispanic"
            2 = "Black non-Hispanic"
            3 = "Hispanic"
            4 = "Other";

            value raceth_full_partner
            1 = "Asian/Pacific Islander"
            2 = "Black/African-American"
            3 = "White/Caucasian"
            4 = "Native American/Alaska Native"
            5 = "Mixed race"
            6 = "Other"
            9 = "Don't know"
            10 = "Hispanic";

      value agecat_mmwr
            1 = "18-19"
            2 = "20-24"
            3 = "25-29"
            4 = "30-39"
            5 =   "40-49"
            6 =   "50+"
            10 = "< 18"       /* used for partner age only. all
participants >= 18 */
```

```
        ;

        value agecat_bopr
              1 = "18-24"
              2 = "25-30"
              3 = "30-35"
              4 = "35-45"
              5 =   "45+"
        ;

        value newhivstat
              0 = "Negative"
              1 = "Positive"
              2 = "Unknown"
        ;

        value intent
              1 = "Partner status unknown/Not important"
              2 = "Slightly important"
              3 = "Moderately important"
              4 = "Very important"
              5 = "Extremely important"
        ;

        value intent_bin
              0 = "Status unknown/Not or Slightly imp."
              1 = "Status moderately - extremely imp."

        ;

        value sex_type
              1 = "UAI partner"
              2 = "Protected AI/OI partner"
              3 = "OI only partner"
        ;
run;

* make general dataset from which to make the paper;
        data paper;
              set
                    checking.uaicombo (drop = raceth                )  ;


              * I dropped the version of race/ethnicity that came on the
datasets, since it was not computed for everybody. redo it again here;
                    * note that we have not re-coded 'other' races that
are actually black or white here ;
              if (hisplat = 1) then raceth = 3;   *hisp;
              else if (race = 2) then  raceth = 2; *black;
              else if (race = 3) then raceth = 1;  * white;
              else raceth = 4; * Other;

              if (sexp6m = 1) & (WHOSEXP6MN0 = 1) then do;
                    any_mp_p6m = 1;
                    mp_p6m = SEXNUMMP6M;
              end;
              else if (sexp6m = 0) & (WHOSEXP6MN0 = 0) then do;
```

```
                  any_mp_p6m = 0;
                  mp_p6m = 0;
            end;

            * else = ., which should mean somebody who did not complete
the survey;
                  * added 11/19/2011:  from the else if, it looks like
people who had sex but don't check males get marked as missing?
                                                      hopefully that
isnt anybody!;

            * 2/2/2011: agecat variable makes no sense. make new
categorization;

            if age in (18,19) then  agecat_mmwr = 1;
            else if age < 25 then   agecat_mmwr = 2;
            else if age < 30 then   agecat_mmwr = 3;
            else if age < 40 then   agecat_mmwr = 4;
            else if age < 50 then   agecat_mmwr = 5;
            else if age >= 50 then  agecat_mmwr = 6;

            if 18 <= age < 25 then  agecat_bopr = 1;
            else if age < 30 then   agecat_bopr = 2;
            else if age < 35 then   agecat_bopr = 3;
            else if age < 45 then   agecat_bopr = 4;
            else if age >= 45 then  agecat_bopr = 5;


            name_count = input(VAR443,1.); * convert name count form
char to int ;

            format rid 10.    raceth raceth. agecat_mmwr agecat_mmwr.
agecat_bopr agecat_bopr.;;

            * drop a lot of extra char variables to reduce dataset
size!!;
            drop                    MAINJO_E    MAINJO_F    MAINJO_G
      MAINJO_H    MAINJO_I    MAINJO_J    MAINJO_K    MAINJO_L
      MAINJO_M    MAINJO_N    MAINJO_O
                        MAINJO_P    MAINJO_Q    MAINJO_R    MAINJO_S
      MAINJO_T    MAINJO_U    MAINJO_V    MAINJO_W    MAINJO_X
      MAINJO_Y    MAINJO_Z    MAINJ_AA
                        MAINJ_AB    MAINJ_AC    MAINJ_AD    MAINJ_AE
      MAINJ_AF    MAINJ_AG    MAINJ_AH    MAINJ_AI    MAINJ_AJ
      MAINJ_AK    MAINJ_AL    MAINJ_AM
                        MAINJ_AN    MAINJ_AO    MAINJ_AP    MAINJ_AQ
      MAINJ_AR    MAINJ_AS    MAINJ_AT    MAINJ_AU    MAINJ_AV
      MAINJ_AW    MAINJ_AX    MAINJ_AY
                        MAINJ_AZ    MAINJ_BA    MAINJ_BB    MAINJ_BC
      MAINJ_BD    MAINJ_BE    MAINJ_BF    MAINJ_BG    MAINJ_BH
      MAINJ_BI    MAINJ_BJ    MAINJ_BK
                        MAINJ_BL    MAINJ_BM    MAINJ_BN    MAINJ_BO
      MAINJ_BP    MAINJ_BQ    MAINJ_BR    MAINJ_BS    MAINJ_BT
      MAINJ_BU    MAINJ_BV    MAINJ_BW
                        MAINJ_BX    MAINJ_BY    MAINJ_BZ    MAINJ_CA
      MAINJ_CB    MAINJ_CC    MAINJ_CD    MAINJ_CE    MAINJ_CF
      MAINJ_CG    MAINJ_CH    MAINJ_CI
```

```
                  MAINJ_CJ    MAINJ_CK    MAINJ_CL    MAINJ_CM
MAINJ_CN    MAINJ_CO    MAINJ_CP    MAINJ_CQ    MAINJ_CR
MAINJ_CS    MAINJ_CT    MAINJ_CU
                  MULTIR_Y    MULTIR_Z    MULTI_AA    MULTI_AB
MULTI_AC    MULTI_AD    MULTI_AE    MULTI_AF    MULTI_AG
MULTI_AH    MULTI_AI    MULTI_AJ
                  MULTI_AK    MULTI_AL    MULTI_AM    NEWEMG_A
NEWEMG_B    NEWEMG_C    NEWEMP_A    NEWEMP_B    NEWEMP_C
ONLINE_J    ONLINE_K    ONLINE_L
                  ONLINE_M    ONLINE_N    ONLINE_O    ONLINE_P
ONLINE_Q    ONLINE_R    ONLINE_S    ONLINE_T    ONLINE_U
ONLINE_V    ONLINE_W    ONLINE_X
                  ORIENT_A    ORIENT_B    ORIENT_C    RACEN6_A
RACEN6_B    RACEN6_C    RACEP1_A    RACEP1_B    RACEP1_C
RACEP2_A    RACEP2_B    RACEP2_C
                  RACEP3_A    RACEP3_B    RACEP3_C    RACEP4_A
RACEP4_B    RACEP4_C    RACEP5_A    RACEP5_B    RACEP5_C
VAR3231     VAR3232     VAR3233     VAR3234
                  VAR3235     VAR3236     VAR3237     VAR3238
VAR3239     VAR3240     VAR3242     VAR3243     VAR3244
VAR3245     VAR3249     VAR3250     VAR3251     VAR3252
VAR3253     VAR3254     VAR3255     VAR3256
                  VAR3257     VAR3258     VAR3260     VAR3261
VAR3262     VAR3263     VAR3269     VAR3270     VAR3271
VAR3272     VAR3273     VAR3274     VAR3275     VAR3276
VAR3277     VAR3278     VAR3279     VAR3280
                  VAR3281     VAR3284     VAR3285     VAR123_A
VAR123_B    VAR123_C    VAR123_D    VAR123_E    VAR123_F
VAR123_G    VAR123_H    VAR123_I    VAR123_J
                  VAR123_K    VAR123_L    VAR123_M    VAR123_N
VAR123_O    VAR123_P    VAR123_Q    VAR123_R    VAR123_S
VAR123_E    VAR123_F    VAR123_G
                  VAR123_H    VAR123_I    VAR123_J    VAR123_K
VAR123_L    VAR123_M    VAR123_N    VAR123_O    VAR123_P
VAR123_Q    VAR123_R    VAR123_S
                  WHYNOA_J    WHYNOA_K    WHYNOA_L    WHYNOA_M
WHYNOA_N    WHYNOA_O    WHYNOA_P    WHYNOA_Q    WHYNOA_R
WHYNOA_S    WHYNOA_T    WHYNOA_U
                  WHYNOA_V    WHYNOA_W    WHYNOA_X    WHYNOI_J
WHYNOI_K    WHYNOI_L    WHYNOI_M    WHYNOI_N    WHYNOI_O
WHYNOI_P    WHYNOI_Q    WHYNOI_R
                  WHYNOI_S    WHYNOI_T    WHYNOI_U    WHYNOI_V
WHYNOI_W    WHYNOI_X    WHYNOR_J    WHYNOR_K    WHYNOR_L
WHYNOR_M    WHYNOR_N    WHYNOR_O
                  WHYNOR_P    WHYNOR_Q    WHYNOR_R    WHYNOR_S
WHYNOR_T    WHYNOR_U    WHYNOR_V    WHYNOR_W    WHYNOR_X
WHYNOV_J    WHYNOV_K    WHYNOV_L
                  WHYNOV_M    WHYNOV_N    WHYNOV_O    WHYNOV_P
WHYNOV_Q    WHYNOV_R    WHYNOV_S    WHYNOV_T    WHYNOV_U
WHYNOV_V    WHYNOV_W    WHYNOV_X;
run;

      data checking.paper;
            set paper;
      run;
* 1. number began survey (n = 6104);
      proc freq data = paper;
```

```
                  tables status /missing;
            run;

      * 2. number that started my section (ie: had partners in p6m. a
very small number of people (41) have "missing" for mp_p6m but gave
names);
            proc freq data = paper;
                  tables any_mp_p6m*name_count /missing;
                  tables raceth;
            run;

            * WILL USE the 3519 that gave partner names;
            proc freq data = paper;
                  where (name_count ~= .);
                  tables any_mp_p6m*name_count /missing nocol
nopercent;
                  tables raceth;
            run;

      * 3. number that completed the questions AFTER my partner
section. Used as a surrogate for completion ;
            proc freq data = paper;
                  where (name_count ~= .) &
                        ((VAR3447 ~=. ) | (VAR3448 ~=.) | (VAR3450 ~=.)
| (PHYSHURT ~=.) | (PHYSSEX ~=.) |
                         (FORCESEX ~=.) | (FORCESEXP ~=.) | (FREECOND
~=.) | (USEFREE ~=.) );
                  tables any_mp_p6m*name_count /missing nocol
nopercent;
                  tables raceth;
            run;
            * n = 2778 completers. I will not use the completers, since
this disproportinately reduces the number of black men ;


/** outdated - not investigated since SBSRN abstract
      * 4. Investigate other curiosities relating to the sample size ;
            * see which IDs (n = 82) indicated sex with a man in p6m,
but have no partner names;
                  proc print data = paper;
                        where (any_mp_p6m = 1) & (name_count =.);
                        var rid;
                  run;
                        * all people seem to have quit the survey
between the two screens;

            * 13 people skipped have no male sex partners in p6m but
gave names.  ;
                  proc print data = paper;
                        where (any_mp_p6m = .) & (name_count ~= .);
                        var rid;
                  run;
                        * ALL 4 HAD SEX WITH WOMEN AND THUS COMPLETED
NAMES SECTION;
**/

      * look for duplicate IDs;
```

```
            proc sort data = paper; by rid datestrt; run;

            data dups;
                  set paper;
                  by rid;
                  * where (name_count ~= .);

                  if first.rid & ~last.rid then output;
                  else if ~first.rid & last.rid then output;
                  else if ~first.rid & ~last.rid then output;
            run;
                  * there is one duplicate ID: 118611651 UPDATE:
uaicombo dataset has no duplicates;

            proc freq data = paper;
*                 where (name_count ~= .);
                  tables incent*any_mp_p6m*name_count /missing nocol
nopercent;
                  tables gaveaddy*any_mp_p6m*name_count /missing nocol
nopercent;
                  tables raceth;
            run;


* make a dataset of guys who have provided partner names;
      data checking.gave_names;
            set paper;
            where (name_count ~= .); * I used to have to filter out
mising IDs too, but that is now fixed;
      run;



**** BEGIN MANIPULATION FOR CONCURRENCY CALCULATION **** ;

      * stack the 5 different partner calendars that are used for when
people name 1 - 5 partners
        such that the variables for the 1st, 2nd, etc. parter are the
same no matter the total number
        of partners names;
      data cal1;
            set checking.gave_names(
                        rename = (PARTNERNICKNAMEN0   = nameP1
                                    PARTNERNICKNAMEN1       = nameP2
                                    PARTNERNICKNAMEN2       = nameP3
                                    PARTNERNICKNAMEN3       = nameP4
                                    PARTNERNICKNAMEN4 = nameP5))
            ;


            if name_count = 1 then do;
                  Sex_m5P1 = VAR1829N0;
                  Sex_m4P1 = VAR1829N1;
                  Sex_m3P1 = VAR1829N2;
                  Sex_m2P1 = VAR1829N3;
                  Sex_m1P1 = VAR1829N4;
                  Sex_m0P1 = VAR1829N5;
```

```
end;

if name_count = 2 then do;
      Sex_m5P1 = VAR1849N0;
      Sex_m4P1 = VAR1849N1;
      Sex_m3P1 = VAR1849N2;
      Sex_m2P1 = VAR1849N3;
      Sex_m1P1 = VAR1849N4;
      Sex_m0P1 = VAR1849N5;

      Sex_m5P2 = VAR1850N0;
      Sex_m4P2 = VAR1850N1;
      Sex_m3P2 = VAR1850N2;
      Sex_m2P2 = VAR1850N3;
      Sex_m1P2 = VAR1850N4;
      Sex_m0P2 = VAR1850N5;
end;

if name_count = 3 then do;
      Sex_m5P1 = VAR1852N0;
      Sex_m4P1 = VAR1852N1;
      Sex_m3P1 = VAR1852N2;
      Sex_m2P1 = VAR1852N3;
      Sex_m1P1 = VAR1852N4;
      Sex_m0P1 = VAR1852N5;

      Sex_m5P2 = VAR1853N0;
      Sex_m4P2 = VAR1853N1;
      Sex_m3P2 = VAR1853N2;
      Sex_m2P2 = VAR1853N3;
      Sex_m1P2 = VAR1853N4;
      Sex_m0P2 = VAR1853N5;

      Sex_m5P3 = VAR1854N0;
      Sex_m4P3 = VAR1854N1;
      Sex_m3P3 = VAR1854N2;
      Sex_m2P3 = VAR1854N3;
      Sex_m1P3 = VAR1854N4;
      Sex_m0P3 = VAR1854N5;
end;

if name_count = 4 then do;
      Sex_m5P1 = VAR1856N0;
      Sex_m4P1 = VAR1856N1;
      Sex_m3P1 = VAR1856N2;
      Sex_m2P1 = VAR1856N3;
      Sex_m1P1 = VAR1856N4;
      Sex_m0P1 = VAR1856N5;

      Sex_m5P2 = VAR1857N0;
      Sex_m4P2 = VAR1857N1;
      Sex_m3P2 = VAR1857N2;
      Sex_m2P2 = VAR1857N3;
      Sex_m1P2 = VAR1857N4;
      Sex_m0P2 = VAR1857N5;

      Sex_m5P3 = VAR1858N0;
```

```
                Sex_m4P3 = VAR1858N1;
                Sex_m3P3 = VAR1858N2;
                Sex_m2P3 = VAR1858N3;
                Sex_m1P3 = VAR1858N4;
                Sex_m0P3 = VAR1858N5;

                Sex_m5P4 = VAR1859N0;
                Sex_m4P4 = VAR1859N1;
                Sex_m3P4 = VAR1859N2;
                Sex_m2P4 = VAR1859N3;
                Sex_m1P4 = VAR1859N4;
                Sex_m0P4 = VAR1859N5;
          end;

          if name_count = 5 then do;
                Sex_m5P1 = VAR1861N0;
                Sex_m4P1 = VAR1861N1;
                Sex_m3P1 = VAR1861N2;
                Sex_m2P1 = VAR1861N3;
                Sex_m1P1 = VAR1861N4;
                Sex_m0P1 = VAR1861N5;

                Sex_m5P2 = VAR1862N0;
                Sex_m4P2 = VAR1862N1;
                Sex_m3P2 = VAR1862N2;
                Sex_m2P2 = VAR1862N3;
                Sex_m1P2 = VAR1862N4;
                Sex_m0P2 = VAR1862N5;

                Sex_m5P3 = VAR1863N0;
                Sex_m4P3 = VAR1863N1;
                Sex_m3P3 = VAR1863N2;
                Sex_m2P3 = VAR1863N3;
                Sex_m1P3 = VAR1863N4;
                Sex_m0P3 = VAR1863N5;

                Sex_m5P4 = VAR1864N0;
                Sex_m4P4 = VAR1864N1;
                Sex_m3P4 = VAR1864N2;
                Sex_m2P4 = VAR1864N3;
                Sex_m1P4 = VAR1864N4;
                Sex_m0P4 = VAR1864N5;

                Sex_m5P5 = VAR1865N0;
                Sex_m4P5 = VAR1865N1;
                Sex_m3P5 = VAR1865N2;
                Sex_m2P5 = VAR1865N3;
                Sex_m1P5 = VAR1865N4;
                Sex_m0P5 = VAR1865N5;
          end;
                *     drop var1829N0 - var1829N5;
                *     drop var1849N0 - var1849N5 var1850N0 -
var1850N5;
                *     drop var1852N0 - var1852N5 var1853N0 -
var1853N5 var1854N0 - var1854N5;
                *     drop var1856N0 - var1856N5 var1857N0 -
var1857N5 var1858N0 - var1858N5 var1859N0 - var1859N5;
```

```
                  *     drop var1861N0 - var1861N5 var1862N0 -
var1862N5 var1863N0 - var1863N5 var1864N0 - var1864N5 var1865N0 -
var1865N5;
      run;

%macro make_partners_vert(dataset = );
      * make a local dataset that scans for the P1-P5 variables to
allow for manual error-checking;
      data varnames;
            length rename_P1 $ 5000 ;
            length rename_P2 $ 5000 ;
            length rename_P3 $ 5000 ;
            length rename_P4 $ 5000 ;
            length rename_P5 $ 5000 ;
            length keep_P1 $ 3000 ;
            length keep_P2 $ 3000 ;
            length keep_P3 $ 3000 ;
            length keep_P4 $ 3000 ;
            length keep_P5 $ 3000 ;

            rename_P1 = " ";
            rename_P2 = " ";
            rename_P3 = " ";
            rename_P4 = " ";
            rename_P5 = " ";
            keep_P1 = " ";
            keep_P2 = " ";
            keep_P3 = " ";
            keep_P4 = " ";
            keep_P5 = " ";

            * loop through each variable and construct RENAME strings
to rename each P1-P5 variable;
            %do x = 1 %to %sysfunc(attrn(%sysfunc(open(&dataset)),
nvars));
                  var_num = &x;
                  original_name = varname(open("&dataset"), &x);
                  if (find(original_name, "P1") > 0) &
(find(original_name, "P12") = 0) then do;
                        has_p1 = 1;
                        rename_p1 = trim(rename_p1)|| " " ||
compress(original_name || "=" ||
substrn(original_name,1,find(original_name, "P1")-1) ||
substrn(original_name,find(original_name, "P1")+2)) ;
                        keep_p1 = trim(keep_p1)|| " " || original_name;
                  end;
                  else has_p1 =0;

                  if find(original_name, "P2") > 0 then do;
                        has_p2 = 1;
                        rename_p2 = trim(rename_p2)|| " " ||
compress(original_name || "=" ||
substrn(original_name,1,find(original_name, "P2")-1) ||
substrn(original_name,find(original_name, "P2")+2)) ;
                        keep_p2 = trim(keep_p2)|| " " || original_name;
                  end;
                  else has_p2 =0;
```

```
                  if find(original_name, "P3") > 0 then do;
                        has_p3 = 1;
                        rename_p3 = trim(rename_p3)|| " " ||
compress(original_name || "=" ||
substrn(original_name,1,find(original_name, "P3")-1) ||
substrn(original_name,find(original_name, "P3")+2)) ;
                        keep_p3 = trim(keep_p3)|| " " || original_name;
                  end;
                  else has_p3 =0;

                  if find(original_name, "P4") > 0 then do;
                        has_p4 = 1;
                        rename_p4 = trim(rename_p4)|| " " ||
compress(original_name || "=" ||
substrn(original_name,1,find(original_name, "P4")-1) ||
substrn(original_name,find(original_name, "P4")+2)) ;
                        keep_p4 = trim(keep_p4)|| " " || original_name;
                        end;
                  else has_p4 =0;

                  if find(original_name, "P5") > 0 then do;
                        has_p5 = 1;
                        rename_p5 = trim(rename_p5)|| " " ||
compress(original_name || "=" ||
substrn(original_name,1,find(original_name, "P5")-1) ||
substrn(original_name,find(original_name, "P5")+2)) ;
                        keep_p5 = trim(keep_p5)|| " " || original_name;
                  end;
                  else has_p5 =0;

            output;
            %end;

            call symput("rename_p1", rename_p1);
            call symput("rename_p2", rename_p2);
            call symput("rename_p3", rename_p3);
            call symput("rename_p4", rename_p4);
            call symput("rename_p5", rename_p5);

            call symput("keep_p1", keep_p1);
            call symput("keep_p2", keep_p2);
            call symput("keep_p3", keep_p3);
            call symput("keep_p4", keep_p4);
            call symput("keep_p5", keep_p5);

*           drop rename_p1 - rename_p5;
      run;


      * make new datasets for partners 1 - 5;
            data partner_1;
                  set  &dataset (keep = rid name_count &keep_p1 rename
= (&rename_p1));
                  where (name_count ~= .) & (name_count > 0);
                  partner = 1;
```

```
                  rename      WHYNOIAILSCONDOMP1=WHYNOIAILSCONDOM
WHYNOIAILSCONDOMP1N3=WHYNOIAILSCONDOMN3
                              WHYNORAILSCONDOMP1=WHYNORAILSCONDOM
WHYNORAILSCONDOMP1N3=WHYNORAILSCONDOMN3; * these two sets of variables
originally had "P1P1" in the var name so they need to have the P1
removed a 2nd time;
            run;

            data partner_2;
                  set  &dataset (keep = rid name_count &keep_p2 rename
= (&rename_p2 FIRSTSEXYEARS = FIRSTSEXYEARS_num));
                  where name_count >= 2;
                  partner = 2;

                  FIRSTSEXYEARS = put(FIRSTSEXYEARS_num, 2.);
                  drop  FIRSTSEXYEARS_num;
            run;

            data partner_3;
                  set  &dataset (keep = rid name_count &keep_p3 rename
= (&rename_p3 FIRSTSEXYEARS = FIRSTSEXYEARS_num));
                  where name_count >= 3;
                  partner = 3;

                  FIRSTSEXYEARS = put(FIRSTSEXYEARS_num, 2.);
                  drop  FIRSTSEXYEARS_num;
            run;

            data partner_4;
                  set  &dataset (keep = rid name_count &keep_p4 rename
= (&rename_p4 FIRSTSEXYEARS = FIRSTSEXYEARS_num));
                  where name_count >= 4;
                  partner = 4;

                  FIRSTSEXYEARS = put(FIRSTSEXYEARS_num, 2.);
                  drop  FIRSTSEXYEARS_num;
            run;

            data partner_5;
                  set  &dataset (keep = rid name_count &keep_p5 rename
= (&rename_p5 FIRSTSEXYEARS = FIRSTSEXYEARS_num));
                  where name_count >= 5;
                  partner = 5;

                  FIRSTSEXYEARS = put(FIRSTSEXYEARS_num, 2.);
                  drop  FIRSTSEXYEARS_num;
            run;

            * make a dataset for the participant variable minus the
partner variables;
            data checking.just_participants;
                  set &dataset (drop = &keep_p1 &keep_p2 &keep_p3
&keep_p4 &keep_p5);
            run;
```

```
%mend make_partners_vert;
      options nosymbolgen ;
%make_partners_vert(dataset = Cal1) run;
quit;

* stack partner data!;
      data  checking.partners;
            set partner_1
                  partner_2
                  partner_3
                  partner_4
                  partner_5;
      run;

      * add in date of survey;
      proc sort data = checking.partners; by rid; run;
      data checking.partners;
            merge       checking.partners (in = from_partners)
                        checking.gave_names (keep = rid DATESTRT)
                  ;
            by rid;
            if ~from_partners then delete;
      run;


      proc sort data = checking.partners; by rid partner; run;

      data  checking.partners;; *checking.partners;
            set checking.partners;

            if (OTHERSEXPARTICIPANT > 0) then direct_concurrency = 1;
            else if (OTHERSEXPARTICIPANT ~= .) then direct_concurrency
= 0;


            * MAKE UAI LS (for males);
                  if (iails = 1) | (rails = 1) then mAIls = 1;
                  else if (iails ~= .) & (rails ~= .) then mAIls = 0;
      *no RAI and no IAI, or dont know;

                        * check for FULL condom usage at last AI;
                              if mAIls = 1 then do;
                                    if ((iails = 1 & iailscondom = 3) |
(iails in (0,9))) & ((rails = 1 & railscondom = 3) | (rails in (0,9)))
                                          then mUAIls = 0;         * if
had RAI then check if used condoms. same with IAI;

                                    else if (iailscondom in (1,2,4)) |
(railscondom in (1,2,4))      then mUAIls = 1; * no or partial use;
                                    * else condom use = . or 9 so set
UAI to missing;
                              end;
                              else mUAIls = mAIls ; * UAI = 0 or .;


            * MAKE UAI in p6m (for males) - AIMP and UAIMP are the raw
data p6m variables;
```

```
                  * the p6m raw questions are only asked if the
participant had sex with the partner >1x;
                  if morethanonce = 1 then do;
                        if (AIMP = 0) then do; mAIp6m = 0; mUAIp6m = 0;
end;
                        else if (AIMP = 1) then do; mAIp6m = 1; mUAIp6m
= UAIMP; end;
                  end;

                  else if morethanonce = 0 then do;
                          mAIp6m = mAIls;
                          mUAIp6m = mUAIls;
                  end;

            * Make variables for main/casual ;
                  if morethanonce = 0 then main_mod = 0;
                  else if morethanonce = 1 then main_mod = main;
                  * have not yet done exchange since this requires the
participant-level exchange partner in p6m question for the skip
pattern;


            * Dates of sex and duration of relationship.
                  Also needed for overlapping sex dates and UNAIDS
concurrency methods.
                  UNAIDS is calculated in this partners data step, but
overlapping sex dates is done in triads dataset;

                  * only measured for ongoing sex partners;
                  if morethanonce = 1 then do;

                        * FIRST SEX;
                              * exact date given;
                              if (FIRSTSEXDT ~= .) then dt_first_sex =
FIRSTSEXDT;

                              * month and year given;
                              else if ~(FIRSTSEXMO in ("","99")) &
~(FIRSTSEXYR in ("", "Don't know")) then do;
                                    dt_first_sex =
mdy(input(FIRSTSEXMO, 2.), 15 ,     input(FIRSTSEXYR, 4.)); * assume
15th of month;

                                    * if month and year are when survey
was taken, date = half-way btwn 1st of month and date of survey;
                                    if (input(FIRSTSEXMO, 2.) =
month(datestrt)) & (input(FIRSTSEXYR, 4.) = year(datestrt))  then
                                          dt_first_sex = ceil(datestrt
- day(datestrt)/2);  ;
                              end;

                              * year given, but month unknown;
                              else if (FIRSTSEXMO = "99") &
~(FIRSTSEXYR in ("", "Don't know")) then do;
                                    if (FIRSTSEXMONTHS = 1) then do;
      * Jan - March;
```

```
                                          dt_first_sex = mdy(2, 15,
input(FIRSTSEXYR, 4.));
                                          if dt_first_sex > datestrt
then dt_first_sex = datestrt - ceil((datestrt -
mdy(1,1,year(datestrt))) /2);
                                    end;
                                    else if (FIRSTSEXMONTHS = 2) then
do; * April - June;
                                          dt_first_sex = mdy(5, 15,
input(FIRSTSEXYR, 4.));
                                          if dt_first_sex > datestrt
then dt_first_sex = datestrt - ceil((datestrt -
mdy(4,1,year(datestrt))) /2);
                                    end;
                                    else if (FIRSTSEXMONTHS = 3) then
do; * July - Sept;
                                          dt_first_sex = mdy(8, 15,
input(FIRSTSEXYR, 4.));
                                          if dt_first_sex > datestrt
then dt_first_sex = datestrt - ceil((datestrt -
mdy(7,1,year(datestrt))) /2);
                                    end;
                                    else if (FIRSTSEXMONTHS = 4) then
do; * Oct - Dec;
                                          dt_first_sex = mdy(11, 15,
input(FIRSTSEXYR, 4.));
                                          if dt_first_sex > datestrt
then dt_first_sex = datestrt - ceil((datestrt -
mdy(10,1,year(datestrt))) /2);
                                    end;
                                    else if (FIRSTSEXMONTHS = 9) then
do;
                                          dt_first_sex = mdy(6, 15,
input(FIRSTSEXYR, 4.));
                                          if dt_first_sex > datestrt
then dt_first_sex = datestrt - ceil((datestrt -
mdy(1,1,year(datestrt))) /2); * between 1/1/YY and date of survey;
                                    end;
                              end;

                              * year unknown but they report how many
years ago;
                              else if (FIRSTSEXYR = "Don't know") then
do;
                                    if (input(FIRSTSEXYEARS, 2.) = 1)
then dt_first_sex = datestrt - 182; * < 1 year ago = - 6 months ;
                                    else if (input(FIRSTSEXYEARS, 2.) =
2) then dt_first_sex = datestrt - 548; * 1-2 years ago = -1.5 years ;
                                    else if (input(FIRSTSEXYEARS, 2.) =
3) then dt_first_sex = datestrt - 1278; * 2-5 years ago = -3.5 years ;
                                    else if (input(FIRSTSEXYEARS, 2.) =
4) then dt_first_sex = datestrt - 2739; * 5-10 years ago = -7.5 years ;
                                    else if (input(FIRSTSEXYEARS, 2.) =
5) then dt_first_sex = datestrt - 3653; * > 10 years ago = -10 years ;
                              end;
                              * otherwise, not enough information and
the date is left missing;
```

```
                        * LAST SEX;
                              * exact date given;
                              if (LASTSEXDT ~= .) then dt_last_sex =
LASTSEXDT;

                              * calendar month is correct. use that
one. Examine months of sex from calendar in reverse order;
                              else if (LASTSEXMOCORRECT = 1) then do;
      * last sex in the current month;
                                    if (Sex_m0 = 1)   then dt_last_sex
=     mdy(month(datestrt), ceil(day(datestrt)/2), year(datestrt)); *
this month. choose midpoint between 1st of month and day of survey;
                                    else if (Sex_m1 = 1) then
dt_last_sex = mdy(month(datestrt) - 1, 15, year(datestrt)); * last
month;
                                    else if (Sex_m2 = 1) then
dt_last_sex = mdy(month(datestrt) - 2, 15, year(datestrt)); * 2 months
ago, etc;
                                    else if (Sex_m3 = 1) then
dt_last_sex = mdy(month(datestrt) - 3, 15, year(datestrt));
                                    else if (Sex_m4 = 1) then
dt_last_sex = mdy(month(datestrt) - 4, 15, year(datestrt));
                                    else if (Sex_m5 = 1) then
dt_last_sex = mdy(month(datestrt) - 5, 15, year(datestrt));
                              end;

                              * calendar month is NOT correct. See
which pull-down option they chose for the last 6 months;
                                    * code is repeated from above. but
i split it out again to increase readibility of code! ;
                              else if (LASTSEXMOCORRECT = 0) then do;
      * last sex in the current month;
                                    if (LASTSEXMO = 1000)   then
dt_last_sex =     mdy(month(datestrt), ceil(day(datestrt)/2),
year(datestrt)); * this month. choose midpoint between 1st of month and
day of survey;
                                    else if (LASTSEXMO = 1001) then
dt_last_sex = mdy(month(datestrt) - 1, 15, year(datestrt)); * last
month;
                                    else if (LASTSEXMO = 1002) then
dt_last_sex = mdy(month(datestrt) - 2, 15, year(datestrt)); * 2 months
ago, etc;
                                    else if (LASTSEXMO = 1003) then
dt_last_sex = mdy(month(datestrt) - 3, 15, year(datestrt));
                                    else if (LASTSEXMO = 1004) then
dt_last_sex = mdy(month(datestrt) - 4, 15, year(datestrt));
                                    else if (LASTSEXMO = 1005) then
dt_last_sex = mdy(month(datestrt) - 5, 15, year(datestrt));
                              end;

                        * Fix screwy dates: ;

                              date_ambiguous = 0;
```

```
                              if dt_last_sex = mdy(12,31,1969) then do;
dt_last_sex = .;  date_ambiguous = 1; end;      * some dates in the
responses are this date?;

                              * negative intervals between first and
last sex - due to some cases where we had to take educated guesses;
                                    * so if within two months, assign a
1 day duration. not much better we can do!;
                              else if -61 <= (dt_last_sex -
dt_first_sex) <= -1 then do dt_last_sex = dt_first_sex + 1;
date_ambiguous = 1; end;

                              * if more than 61 days apart, then set
both dates to missing;
                              else if (dt_last_sex - dt_first_sex) < -
61 then do dt_last_sex = .;  dt_first_sex = .; date_ambiguous = 1; end;

                        *** PARTNER-LEVEL OUTCOMES, BASED ON DATES ***;

                              * PARTNERSHIP DURATION;
                              partnership_duration = dt_last_sex -
dt_first_sex;

                              * DATE-LEVEL UNAIDS concurrency indicator
@ -5 months (152 days). Cannot do 6 months since partner recall is only
6 months;
                              if dt_first_sex <= (datestrt - 152) <=
dt_last_sex then unaids_5mo = 1;
                              else if nmiss(dt_last_sex, datestrt,
dt_first_sex) = 0 then unaids_5mo = 0; * new fun way of counting
missing values;

                              * DATE-LEVEL UNAIDS concurrency indicator
@ -3 months (91 days). Cannot do 6 months since partner recall is only
6 months;
                              if dt_first_sex <= (datestrt - 91) <=
dt_last_sex then unaids_3mo = 1;
                              else if nmiss(dt_last_sex, datestrt,
dt_first_sex) = 0 then unaids_3mo = 0; * new fun way of counting
missing values;
                                    * UNAIDS measures are missing if
one-time partners;

                              * Actually, the UNAIDS measures are
supposed to be month-level and thus done on triads! ;
                  end;

                  else if morethanonce = 0 then do;

                        * UNAIDS measures are 0 for this partner, if 1x
partner;
                        unaids_5mo = 0;
                        unaids_3mo = 0;
                  end;

                  format dt_first_sex dt_last_sex mmddyy.;
      run;
```

```
            /***
                  * check first sex dates;
                  proc print data = checking.partners;
                        var rid morethanonce dt_first_sex FIRSTSEXDT
FIRSTSEXMO FIRSTSEXYR FIRSTSEXMONTHS FIRSTSEXYEARS datestrt;

                        format FIRSTSEXMO  FIRSTSEXYEARS $2. FIRSTSEXYR
$10.;
                  run;

                  * check last sex dates;
                  proc print data = checking.partners;
                        var rid morethanonce dt_last_sex
LASTSEXMOCORRECT LASTSEXKNOWDT LASTSEXMO LASTSEXDT sex_m0-sex_m5
datestrt;
                  run;

                  * check durations;

                  proc sort data = partners_dates; by
partnership_duration; run;
                  proc print data = checking.partners;
                        var rid morethanonce dt_first_sex dt_last_sex
partnership_duration date_ambiguous;
                  run;

                  proc print data = partners_UN;
                        var rid morethanonce datestrt dt_first_sex
dt_last_sex unaids_5mo unaids_3mo;
                  run;

            **/

      * now that i've added new variables to the partners, re-split
into the partners 1-5 datasets;
      data partner_1;   set checking.partners; where partner = 1; run;
      data partner_2;   set checking.partners; where partner = 2; run;
      data partner_3;   set checking.partners; where partner = 3; run;
      data partner_4;   set checking.partners; where partner = 4; run;
      data partner_5;   set checking.partners; where partner = 5; run;

      * check that the direct question was only asked if had sex more
than once;
      proc freq data = checking.partners;
            tables morethanonce * direct_concurrency muaip6m/missing;


            tables mAIls*rails*iails/missing; * check that coded AI
correctly ;
            tables mAIls*partner /norow nopercent missing; *
missingness in AI data by partner # ;
      run;
proc contents data = checking.partners;
run;
proc sort data = checking.partners; by rid partner; run;
```

```
* create a dataset with all partner pairs for participants with
MULTIPLE (>1) partners ;
      * uses the same partner i and j notation as the SurveyGizmo
"calculate concurrency pairs" script;

      * 1. Generate 3 columns: participant_ID, partner i, partner j;
      data partner_pair_ids;
            set partner_1 (keep = rid name_count);

            do partner_i = 1 to name_count - 1;
                  do partner_j = partner_i + 1 to name_count ;
                        output;
                  end;
            end;
      run;

      * merge in the partner data for all partner i-s;
      proc sort data = partner_pair_ids; by rid partner_i; run;
      data partner_i;
            merge       partner_pair_ids (in = from_pairs)
                        partner_1 (rename = (partner = partner_i))
                        partner_2 (rename = (partner = partner_i))
                        partner_3 (rename = (partner = partner_i))
                        partner_4 (rename = (partner = partner_i))
                        partner_5 (rename = (partner = partner_i))
                        ;
            by rid partner_i;
            if ~from_pairs then delete;    * excludes partners from
people with just 1 partner;

      run;

      * merge in the partner data for all partner j-s;
      proc sort data = partner_pair_ids; by rid partner_j; run;
      data partner_j;
            merge       partner_pair_ids (in = from_pairs)
                        partner_1 (rename = (partner = partner_j))
                        partner_2 (rename = (partner = partner_j))
                        partner_3 (rename = (partner = partner_j))
                        partner_4 (rename = (partner = partner_j))
                        partner_5 (rename = (partner = partner_j))
                        ;
            by rid partner_j;
            if ~from_pairs then delete;    * excludes partners from
people with just 1 partner;

      run;

      proc sort data = partner_i; by rid partner_i partner_j; run;
      proc sort data = partner_j; by rid partner_i partner_j; run;

      * merge the partners with their participants, keeping just the
timing information, and try to deduce concurrency     by big overlaps
in months;
      data checking.partner_pairs;
```

```
            merge       partner_i
                              (     keep =      datestrt rid partner_i
partner_j   sex_m5 sex_m4 sex_m3 sex_m2 sex_m1 sex_m0 name
OTHERSEXPARTICIPANT morethanonce    main exchange gorbach mAIls mUAIls
mUAIp6m mAIp6m WHEREMEET
                                                DISCUSSSTATUSFS
STATUSFS STATUSIMP  AIMP UAIMP HIVSTATKNOWLS HIVSTATLS main_mod
      groupsex
                                                dt_first_sex
dt_last_sex
                                    rename =(sex_m5 = sex_m5_i sex_m4 =
sex_m4_i sex_m3 = sex_m3_i sex_m2 = sex_m2_i sex_m1 = sex_m1_i sex_m0 =
sex_m0_i name = name_i OTHERSEXPARTICIPANT = OTHERSEXPARTICIPANT_i
                                                morethanonce =
morethanonce_i    main = main_i exchange = exchange_i gorbach =
gorbach_i mAIls =  mAIls_i mUAIls = mUAIls_i mUAIp6m = mUAIp6m_i mAIp6m
= mAIp6m_i WHEREMEET = WHEREMEET_i
                                                DISCUSSSTATUSFS =
DISCUSSSTATUSFS_i STATUSFS = STATUSFS_i STATUSIMP = STATUSIMP_i AIMP =
AIMP_i UAIMP = UAIMP_i HIVSTATKNOWLS = HIVSTATKNOWLS_i HIVSTATLS =
HIVSTATLS_i
                                                main_mod = main_mod_i
groupsex = groupsex_i dt_first_sex = dt_first_sex_i dt_last_sex =
dt_last_sex_i
                              ))
                        partner_j
                              (     keep =      rid partner_i partner_j
      sex_m5 sex_m4 sex_m3 sex_m2 sex_m1 sex_m0 name
OTHERSEXPARTICIPANT morethanonce    main exchange gorbach mAIls mUAIls
mUAIp6m mAIp6m WHEREMEET
                                                DISCUSSSTATUSFS
STATUSFS STATUSIMP  AIMP UAIMP HIVSTATKNOWLS HIVSTATLS main_mod
      groupsex
                                                dt_first_sex
dt_last_sex
                                    rename =(sex_m5 = sex_m5_j sex_m4 =
sex_m4_j sex_m3 = sex_m3_j sex_m2 = sex_m2_j sex_m1 = sex_m1_j sex_m0 =
sex_m0_j name = name_j OTHERSEXPARTICIPANT = OTHERSEXPARTICIPANT_j
                                                morethanonce =
morethanonce_j    main = main_j exchange = exchange_j gorbach =
gorbach_j  mAIls =  mAIls_j mUAIls = mUAIls_j mUAIp6m = mUAIp6m_j
mAIp6m = mAIp6m_j WHEREMEET = WHEREMEET_j
                                                DISCUSSSTATUSFS =
DISCUSSSTATUSFS_j STATUSFS = STATUSFS_j STATUSIMP = STATUSIMP_j AIMP =
AIMP_j UAIMP = UAIMP_j HIVSTATKNOWLS = HIVSTATKNOWLS_j HIVSTATLS =
HIVSTATLS_j
                                                main_mod = main_mod_j
groupsex = groupsex_j dt_first_sex = dt_first_sex_j dt_last_sex =
dt_last_sex_j
                              ));

            by rid partner_i partner_j;

            * find how many months ago first sex was ;
                  if sex_m5_i = 1 then firstsex_i = 6; * 6 months
before interview;
                  else if sex_m4_i = 1 then firstsex_i = 5;
```

```
                        else if sex_m3_i = 1 then firstsex_i = 4;
                        else if sex_m2_i = 1 then firstsex_i = 3;
                        else if sex_m1_i = 1 then firstsex_i = 2;
                        else if sex_m0_i = 1 then firstsex_i = 1;  * within
the last month;

                        if sex_m5_j = 1 then firstsex_j = 6; * 6 months
before interview;
                        else if sex_m4_j = 1 then firstsex_j = 5;
                        else if sex_m3_j = 1 then firstsex_j = 4;
                        else if sex_m2_j = 1 then firstsex_j = 3;
                        else if sex_m1_j = 1 then firstsex_j = 2;
                        else if sex_m0_j = 1 then firstsex_j = 1;  * within
the last month;

                * find how many months ago last sex was ;
                        if sex_m0_i = 1 then lastsex_i = 1; * 6 months before
interview;
                        else if sex_m1_i = 1 then lastsex_i = 2;
                        else if sex_m2_i = 1 then lastsex_i = 3;
                        else if sex_m3_i = 1 then lastsex_i = 4;
                        else if sex_m4_i = 1 then lastsex_i = 5;
                        else if sex_m5_i = 1 then lastsex_i = 6;  * within
the last month;

                        if sex_m0_j = 1 then lastsex_j = 1; * 6 months before
interview;
                        else if sex_m1_j = 1 then lastsex_j = 2;
                        else if sex_m2_j = 1 then lastsex_j = 3;
                        else if sex_m3_j = 1 then lastsex_j = 4;
                        else if sex_m4_j = 1 then lastsex_j = 5;
                        else if sex_m5_j = 1 then lastsex_j = 6;  * within
the last month;

                        * THINK ABOUT: do we need to think about partners
before the 6 month calendar period?;


        run;



* now stack the concurrency clarification questions and merge in to see
if further concurrency revealed upon asking ;
        * scan within partner pairs to see if any "option 3s" selected!
We can even make a dataset with just option 3 selected and call it a
day;

        %macro stack_concurrency_qs (dataset = );
                        proc format library = library;
                                value conclarif
                                        0 = "Stopped partner i before j"
                                        1 = "Stopped partner j before i"
                                        2 = "With i and j concurrently"
                                        3 = "Don't know"
                                ;
                        run;
```

```
                    data x;
                          set &dataset; * (keep = rid var512 );

                          total_concurrency_q = input(var512, 2.); *
convert char to number;

                          if total_concurrency_q > 0 then do;
                                do current_q = 1 to total_concurrency_q;
                                      output;
                                end;
                          end;
                    run;

                    * scan through each concurrency question and grab the
question options and response for that question!!;
                    * i must do this cycling through 30 (max number of
concurrency q) rather than simply assign the current_q to a macro
variable via call symput or let
                      because these dont get evaluated within at the
right time by the macro engine;
                    data checking.concurrency_clarify_stacked;
                          set x;

                          %do i = 0 %to 29;
                                if &i = current_q - 1 then do; * the
questions are indexed by SurveyGizmo starting at 0 (ie: N0, N1), but I
like 1, 2, 3 ...;
                                      name_i = PARTNERIARRAYN&i;
                                      name_j = PARTNERJARRAYN&i;
                                      concurrency_month =
CONCURRENCYMONTHARRAYN&i;
                                      concurrency_clarify =
CONCURRENCYCLARIFY&i;
                                end;
                          %end;

                                                  format rid 10.;
                          keep rid  total_concurrency_q current_q name_i
name_j concurrency_month concurrency_clarify;
                          format concurrency_clarify conclarif.;
                    run;

                    * DROP all of the 30 individual variables!! ;

      %mend stack_concurrency_qs;
      %stack_concurrency_qs(dataset = checking.just_participants;);

      * we cannot simply merge the clarification questions into the
calendar-based partner pairs since there may be multiple records per
partner pair if they had
        multiple ambiguous months. for the purposes of understanding
concurrency, we only need the responses that are either = 2
(concurrency);

            * FUTURE NOTE: what to do with "3" (dont know) or = "."?;
```

```
    * CONCURRENT CLARIFY = CONCURRENT;
          proc means data =
    checking.concurrency_clarify_stacked n maxdec =0;
                where       concurrency_clarify = 2;
                class rid name_i name_j;
                var concurrency_clarify;
                output out = clarify_total_concurrent
n(concurrency_clarify) = confirmed_concurrent_months;
          run;

          * grab the correct records from the MEANS output;
                data clarify_total_concurrent;
                      set clarify_total_concurrent;
                      where _TYPE_ = 7;
                      drop _TYPE_ _FREQ_;

                      * 1. Must make the partner names uppercase. for
some reason, a few names have their cases changed in surveygizmo;
                            name_i = trim(upcase(name_i));
                            name_j = trim(upcase(name_j));

                            format rid 10.;
                run;

          * CONCURRENT CLARIFY = i before j;
          proc means data =
    checking.concurrency_clarify_stacked n maxdec =0;
                where       concurrency_clarify = 0;
                class rid name_i name_j;
                var concurrency_clarify;
                output out = clarify_total_i_before_j
n(concurrency_clarify) = confirmed_i_before_j_months;
          run;

          * grab the correct records from the MEANS output;
                data clarify_total_i_before_j;
                      set clarify_total_i_before_j;
                      where _TYPE_ = 7;
                      drop _TYPE_ _FREQ_;

                      * 1. Must make the partner names uppercase. for
some reason, a few names have their cases changed in surveygizmo;
                            name_i = trim(upcase(name_i));
                            name_j = trim(upcase(name_j));

                            format rid 10.;
                run;

          * CONCURRENT CLARIFY = j before i;
          proc means data =
    checking.concurrency_clarify_stacked n maxdec =0;
                where       concurrency_clarify = 1;
                class rid name_i name_j;
                var concurrency_clarify;
                output out = clarify_total_j_before_i
n(concurrency_clarify) = confirmed_j_before_i_months;
          run;
```

```
            * grab the correct records from the MEANS output;
                  data clarify_total_j_before_i;
                        set clarify_total_j_before_i;
                        where _TYPE_ = 7;
                        drop _TYPE_ _FREQ_;

                        * 1. Must make the partner names uppercase. for
some reason, a few names have their cases changed in surveygizmo;
                              name_i = trim(upcase(name_i));
                              name_j = trim(upcase(name_j));

                              format rid 10.;
                  run;


            * CONCURRENT CLARIFY = dont know or skipped question
(somehow? it was required! );
            proc means data =
      checking.concurrency_clarify_stacked n maxdec =0;
                  where       concurrency_clarify in (., 3);
                  class rid name_i name_j;
                  var concurrency_clarify;
                  output out = clarify_total_dk n(concurrency_clarify)
= confirmed_concurrent_dk nmiss(concurrency_clarify)
=confirmed_concurrent_dk_miss ;
            run;

            * grab the correct records from the MEANS output;
                  data clarify_total_dk;
                        set clarify_total_dk;
                        where _TYPE_ = 7;

                        * 1. Must make the partner names uppercase. for
some reason, a few names have their cases changed in surveygizmo;
                              name_i = trim(upcase(name_i));
                              name_j = trim(upcase(name_j));

                        * combine dont know and missing responses!;
                              confirmed_concurrent_dk =
confirmed_concurrent_dk +  confirmed_concurrent_dk_miss;

                              drop _TYPE_ _FREQ_
confirmed_concurrent_dk_miss;
                              format rid 10.;
                  run;


      * merge the partner_pairs dataset (has calendar data and obvious
overlaps) with the clarification questions. the clarification questions
only have the names, not i and j
            so we need to merge by them. but these order of the
pairings is the same between datasets ;

            * 1. Must make the partner names uppercase. for some
reason, a few names have their cases changed in surveygizmo;
                  data  checking.partner_pairs ;
```

```
                        set checking.partner_pairs;
                        name_i = trim(upcase(name_i));
                        name_j = trim(upcase(name_j));
                                              format rid 10.;
                  run;

            * 2. sort! ;
                  proc sort data = checking.partner_pairs; by rid
name_i name_j; run;
                  proc sort data = clarify_total_concurrent; by rid
name_i name_j; run;
                  proc sort data = clarify_total_i_before_j; by rid
name_i name_j; run;
                  proc sort data = clarify_total_j_before_i; by rid
name_i name_j; run;
                  proc sort data = clarify_total_dk; by rid name_i
name_j; run;


            * 3. merge the total number of confirmed concurrent months
back in!;
            data checking.partner_pairs;
                  merge       checking.partner_pairs
                              clarify_total_concurrent
                              clarify_total_i_before_j
                              clarify_total_j_before_i
                              clarify_total_dk
                              ;
                  by rid name_i name_j;


                  * though the calendar rows were required for every
partner, there are somehow ones where they skipped and were allowed to
proceed ;
                        * this could happen if you hit the back button
and everything turns yellow?;
                        * anyhow, if months of sex are all 0 for any
partner, then the first and last sex values are both = . for that
partner ;
                        * By excluding such partner pairs from this
DATA step, we set all of their concurrency type values to missing;

                        * ADDED 10/18/2011 ;

                  if (firstsex_i ~= .) & (firstsex_j ~= .) & (lastsex_i
~= .) & (lastsex_j ~= .)  then do;



                  * Now, lets see if there is obvious overlap in the
months and determine concurrency;

                  * there are only 2 ways by which there is OBVIOUS
concurrency that does not require follow-up questions;
                        * 1. if the pair of partners have >= 2 months
in common, then there is definitely concurrency;
```

```
                              months_matching =       (sex_m5_i +
sex_m5_j = 2) + (sex_m4_i + sex_m4_j = 2) + (sex_m3_i + sex_m3_j = 2) +
                                                            (sex_m2_i +
sex_m2_j = 2) + (sex_m1_i + sex_m1_j = 2) + (sex_m0_i + sex_m0_j = 2) ;
      * sums up which months have "1" marked for both people;

                        * 2. see if one partners months contains the
other partners months. If there is only a 1 month overlap, then this is
the only unambiguous way
                               for there to be concurrency. we needed
to ask follow-up questions for the remaining 1-month overlaps;
                              if (firstsex_i > firstsex_j) & (lastsex_i
< lastsex_j) then i_contains_j = 1; else i_contains_j = 0;
                              if (firstsex_j > firstsex_i) & (lastsex_j
< lastsex_i) then j_contains_i = 1; else j_contains_i = 0;

                              ** BIG UPDATE 10/18/2011 ** ;

                              * 2a.;
                              * serial sequence within 1-month overlap
denotes concurrency since 1 relationship is longer than 1 month;

                                    * ex:
                                    * partner   jan   feb   mar   apr
                                    *  1        x           -     -
      x
                                    *  2                    -     -
      x
                                    *
                                    * if 1 and 2 not concurrent in
april, then if 2 before 1, they are concurrent. if 1 before 2, they are
not concurrent
                                    *;

                                    * Special cases where only a 1-
month overlap, the overlap is the first or last month of sex (ie: not
obviously contained per above),  but sequence within that month denotes
concurrency ;

                                    * only first month of sex is that
same;
                                          if (firstsex_i = firstsex_j)
& (confirmed_i_before_j_months > 0) then do;
                                                if (lastsex_i <
lastsex_j) then i_contains_j = 1; * sex with i in a later month, but
had j after i in the first month;
                                                if (lastsex_j <
lastsex_i) & (firstsex_i ~= lastsex_i) then months_matching = 2; *
analog of the "only last month" section below;
                                          end;

                                          if (firstsex_i = firstsex_j)
& (confirmed_j_before_i_months > 0) then do;
                                                if  (lastsex_j <
lastsex_i) then j_contains_i = 1;                   * j in a later
month, but had i after j in the first month;
```

```
                                                        if    (lastsex_i <
lastsex_j) & (firstsex_j ~= lastsex_j)  then months_matching = 2; *
analog of the "only last month" section below;
                                                  end;


                                            * only last month of sex is the
same ;
                                                  if (lastsex_i = lastsex_j) &
(confirmed_j_before_i_months > 0) then do;
                                                        if (firstsex_i >
firstsex_j) then  i_contains_j = 1; * i was first in an earlier month,
but had j before i in last month ;
                                                        if (firstsex_j >
firstsex_i) & (firstsex_i ~= lastsex_i) then    months_matching = 2; *
j was first in an earlier month, but sex with i in >1 months, which
indicates back and forth alternating between i and j;
                                                  end;

                                                  if (lastsex_i = lastsex_j) &
(confirmed_i_before_j_months > 0) then do;
                                                        if (firstsex_j >
firstsex_i) then j_contains_i = 1;
      * j was first in an earlier month, but had i before j in last
month ;
                                                        if (firstsex_i >
firstsex_j) & (firstsex_j ~= lastsex_j) then months_matching = 2; * i
was first in an earlier month, but sex with j in >1 months, which
indicates back and forth alternating between i and j;
                                                  end;

                                      * 2b. another exception is that they dont
have 0 or 1 months matching, but there is back and forth alternating ;
                                            if (firstsex_i >= firstsex_j) &
(firstsex_j > lastsex_i) & (firstsex_j ~= lastsex_j) then
months_matching = 2;   * first sex with i is before first j, then first
j before last sex i;
                                            if (firstsex_j >= firstsex_i) &
(firstsex_i > lastsex_j) & (firstsex_i ~= lastsex_i) then
months_matching = 2;   * first sex with j is before first i, then first
i before last sex j;



                                            * note that in 2a and 2b,
months_matching is set to 2 to trigger concurrency and does not
necessarily mean two months overlap.
                                            concurrent_months below caluclates
that ;

                                * calculate! ;
                                      if (months_matching >= 2) | (i_contains_j
= 1) | (j_contains_i = 1) then calendar_overlap = 1; else
calendar_overlap = 0;    * can have 0 months matching but calendar
overlap if one interval entirely contains the other!;

                          * NOW use the clarification questions to make a final
determination of whether there is concurrency for this pair;
```

```
                        if (calendar_overlap = 1) | ((months_matching >
0) & (confirmed_concurrent_months > 0)) then concurrent_pair = 1 ;
                        else if ~(confirmed_concurrent_dk > 0 ) then
concurrent_pair = 0; *  if there is no obvious concurrency, and if
there is no unsolved ambiguous months (they didnt know or skipped the
clarification question), then declare concurrent!;
                              * else concurrent_pair = . because they
werent obviously concurrent and didnt know the answer to or skipped the
clarification question!!;
                              * 10/18/2011 = allowing missing
concurrency is a big change, but correct and will inflate concurrency
estimates! ;

                        * special case: This guy should have been asked
a clarification question and wasnt! its the only time this happened!
set him to missing ;
                        if (rid = 116525249) & (partner_i = 4) &
(partner_j = 5) then concurrent_pair = .;


                  /** 5/27/11: experimental adjustment to remove group
sex;

                        if (morethanonce_i =0) & (morethanonce_j = 0) &
(confirmed_concurrent_months > 0) then concurrent_pair = 0; * not
concurrent if both one-time partners and say they are concurrent;
                        else if  ( ((morethanonce_i =1) &
(morethanonce_j = 0)) | ((morethanonce_i =0) & (morethanonce_j = 1) ))
                              & ((months_matching = 1) &
(confirmed_concurrent_months > 0)) & (groupsex_i=1) & (groupsex_j=1)
                              then concurrent_pair = 0; * remove
concurrency if only have 1 month in common that isnt contained within
the interval of another and both had group sex;
                                          *** doing this BARELY changes
the dyadic results! ;
                  */

                              * ADDED 5/20/2011: There are 6 instances
where partners given the exact same names create erroenous concurrency
conclusions
                              when we merge in the concurrency
clarifications. to fix this, i required the use of the "confirmed
concurrent months"
                              above on having matching months!!;


                  ** calculate all sorts of concurrency and
connectivity measures for partner pairs where concurrency isnt missing
(ADDED 10/18/2011);
                  if (concurrent_pair ~= .) then do;

                        * calculate duration of overlaps in months ;
                              if calendar_overlap = 1 then do;
                                    concurrent_months = min(firstsex_i,
firstsex_j) - max(lastsex_i, lastsex_j) + 1; * this is the "inner"
overlapping span of months;
                              end;
```

```
                              else if (confirmed_concurrent_months > 0)
then concurrent_months = confirmed_concurrent_months; * simply the
number of months confirmed to be having sex at the same time;
                              else  concurrent_months = 0;

                        * calculate concurrent UAI with both partners -
last sex ;
                              if (concurrent_pair = 1) &  (mUAIls_i =
1) &  (mUAIls_j = 1) then concurrentUAIls_2p = 1;
                              else if (mUAIls_i ~= .) &  (mUAIls_j ~=
.) then concurrentUAIls_2p = 0;
                              else  concurrentUAIls_2p = .; *
missingness in UAI at last sex;

                              * UAI with 1 partner ;
                              if (concurrent_pair = 1) &  (mUAIls_i +
mUAIls_j = 1) then concurrentUAIls_1p = 1;
                              else if (mUAIls_i ~= .) &  (mUAIls_j ~=
.) then concurrentUAIls_1p = 0;
                              else  concurrentUAIls_1p = .; *
missingness in UAI at last sex;


                        * calculate concurrent UAI with both partners -
p6m ;
                              if (concurrent_pair = 1) &  (mUAIp6m_i =
1) &  (mUAIp6m_j = 1) then concurrentUAIp6m_2p = 1;
                              else if (mUAIp6m_i ~= .) &  (mUAIp6m_j ~=
.) then concurrentUAIp6m_2p = 0;
                              else  concurrentUAIp6m_2p = .; *
missingness in UAI at last sex;

                              * UAI with 1 partner ;
                              if (concurrent_pair = 1) &  (mUAIp6m_i +
mUAIp6m_j = 1) then concurrentUAIp6m_1p = 1;
                              else if (mUAIp6m_i ~= .) &  (mUAIp6m_j ~=
.) then concurrentUAIp6m_1p = 0;
                              else  concurrentUAIp6m_1p = .; *
missingness in UAI at last sex;

                        * calculate if each partner is 'at-
risk'/connected to the other.
                              this means (i before j) or (i and j
concurrently), but not (i after j);

                                    * first determine serial monogamy;
                                          * first line logic = (clearly
stopped with j before i with no overlap) OR ((j stop month = i start
month) AND (they arent concurrent) AND (they arent an ambiguous one
month overlap where they said j came after i) );

                                    if    (firstsex_i < lastsex_j) |
((firstsex_i = lastsex_j) & ~(concurrent_pair in (1)) &
~(confirmed_i_before_j_months > 0) ) then serial_j_first = 1; else
serial_j_first = 0;
                                    if    (firstsex_j < lastsex_i) |
((firstsex_j = lastsex_i) & ~(concurrent_pair in (1)) &
```

```
~(confirmed_j_before_i_months > 0) ) then serial_i_first = 1; else
serial_i_first = 0;


                                        * for reference:  ;
                                        *     value conclarif
                                                    0 = "Stopped
partner i before j"
                                                    1 = "Stopped
partner j before i"
                                                    2 = "With i and j
concurrently"
                                                    3 = "Don't know"
                                              ;

                              if (concurrent_pair) | (serial_j_first)
then i_at_risk_from_j = 1; else i_at_risk_from_j = 0;
                              if (concurrent_pair) | (serial_i_first)
then j_at_risk_from_i = 1; else j_at_risk_from_i = 0;

                  /*          * connected by UAI?;
                              if (i_at_risk_from_j = 1) &
(concurrentUAIp6m_2p = 1) then      i_at_risk_from_j_uai = 1;
                                    else if (concurrentUAIp6m_2p
~=  .)      then  i_at_risk_from_j_uai = 0;

                              if (j_at_risk_from_i = 1) &
(concurrentUAIp6m_2p = 1) then      j_at_risk_from_i_uai = 1;
                                    else if (concurrentUAIp6m_2p
~=  .)      then  j_at_risk_from_i_uai = 0;
                  */
                  end; * end the portion that excludes guys with
missing concurrency for the pair ;

                  end;  * end big, outer if statement ;


            *** Method of overlapping dates ***;

                  * Two ways - EXACT overlap and 1-month resolution
(most common);

                  * Doing this only for repeated sex partners, since no
dates were asked for one-time partners. To incorporate
                        one-time partners, we would need to use the
calendar responses;
                  if (morethanonce_i = 1) & (morethanonce_j = 1) &
                        (dt_first_sex_i ~= .) & (dt_last_sex_i ~= .) &
(dt_first_sex_j ~= .) & (dt_last_sex_j ~= .)
                  then do;

                        * EXACT date overlap;

                        if          dt_first_sex_i < dt_last_sex_j <
dt_last_sex_i then date_overlap_exact = 1;
                        else if dt_first_sex_j < dt_last_sex_i <
dt_last_sex_j then date_overlap_exact = 1;
```

```
                        else if dt_first_sex_i < dt_first_sex_j <
dt_last_sex_i then date_overlap_exact = 1;      * these 2 lines rely on
the fact that last sex is within last 6 months!;
                        else if dt_first_sex_j < dt_first_sex_i <
dt_last_sex_j then date_overlap_exact = 1;

                        else if (dt_first_sex_i ~=.) & (dt_first_sex_j
~=.) & (dt_last_sex_i ~=.) & (dt_last_sex_j ~=.) then
date_overlap_exact = 0;
                              * so if theres a one-time partner, dates
will be missing and overlap variables are missing. ;


                              * make sure sex dates in last 6 months;
                              if (datestrt - dt_last_sex_i > 170) |
(datestrt - dt_last_sex_j > 170) then mo_6_flag = 1;

                        * 1-month resolution overlap;
                              * convert date intervals into 1-month
vars;
                                    * figure out last 6 month/year
combos;
                                    datestrt_adj =mdy(month(datestrt),
15, year(datestrt)); * shift to center of month;

                                    sex_m0_dates_i = 0;
      sex_m0_dates_j = 0;
                                    sex_m1_dates_i = 0;
      sex_m1_dates_j = 0;
                                    sex_m2_dates_i = 0;
      sex_m2_dates_j = 0;
                                    sex_m3_dates_i = 0;
      sex_m3_dates_j = 0;
                                    sex_m4_dates_i = 0;
      sex_m4_dates_j = 0;
                                    sex_m5_dates_i = 0;
      sex_m5_dates_j = 0;

                                    * cycle through each day of sex
with each partner to see if in one of the last 6 months;

                                    do cur_date = dt_first_sex_i to
dt_last_sex_i by 1;
                                          if (month(cur_date) =
month(datestrt_adj)) & (year(cur_date) = year(datestrt_adj)) then
sex_m0_dates_i = 1;
                                          else if (month(cur_date) =
month(datestrt_adj - 30)) & (year(cur_date) = year(datestrt_adj - 30))
then sex_m1_dates_i = 1;
                                          else if (month(cur_date) =
month(datestrt_adj - 60)) & (year(cur_date) = year(datestrt_adj - 60))
then sex_m2_dates_i = 1;
                                          else if (month(cur_date) =
month(datestrt_adj - 90)) & (year(cur_date) = year(datestrt_adj - 90))
then sex_m3_dates_i = 1;
```

```
                                        else if (month(cur_date) =
month(datestrt_adj - 120)) & (year(cur_date) = year(datestrt_adj -
120)) then sex_m4_dates_i = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 150)) & (year(cur_date) = year(datestrt_adj -
150)) then sex_m5_dates_i = 1;
                                  end;

                                  do cur_date = dt_first_sex_j to
dt_last_sex_j by 1;
                                        if (month(cur_date) =
month(datestrt_adj)) & (year(cur_date) = year(datestrt_adj)) then
sex_m0_dates_j = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 30)) & (year(cur_date) = year(datestrt_adj - 30))
then sex_m1_dates_j = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 60)) & (year(cur_date) = year(datestrt_adj - 60))
then sex_m2_dates_j = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 90)) & (year(cur_date) = year(datestrt_adj - 90))
then sex_m3_dates_j = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 120)) & (year(cur_date) = year(datestrt_adj -
120)) then sex_m4_dates_j = 1;
                                        else if (month(cur_date) =
month(datestrt_adj - 150)) & (year(cur_date) = year(datestrt_adj -
150)) then sex_m5_dates_j = 1;
                                  end;


                        * find how many months ago first sex was ;
                              if sex_m5_dates_i = 1 then
firstsex_dates_i = 6; * 6 months before interview;
                              else if sex_m4_dates_i = 1 then
firstsex_dates_i = 5;
                              else if sex_m3_dates_i = 1 then
firstsex_dates_i = 4;
                              else if sex_m2_dates_i = 1 then
firstsex_dates_i = 3;
                              else if sex_m1_dates_i = 1 then
firstsex_dates_i = 2;
                              else if sex_m0_dates_i = 1 then
firstsex_dates_i = 1;  * within the last month;

                              if sex_m5_dates_j = 1 then
firstsex_dates_j = 6; * 6 months before interview;
                              else if sex_m4_dates_j = 1 then
firstsex_dates_j = 5;
                              else if sex_m3_dates_j = 1 then
firstsex_dates_j = 4;
                              else if sex_m2_dates_j = 1 then
firstsex_dates_j = 3;
                              else if sex_m1_dates_j = 1 then
firstsex_dates_j = 2;
                              else if sex_m0_dates_j = 1 then
firstsex_dates_j = 1;  * within the last month;
```

```
                        * find how many months ago last sex was ;
                              if sex_m0_dates_i = 1 then
lastsex_dates_i = 1; * 6 months before interview;
                              else if sex_m1_dates_i = 1 then
lastsex_dates_i = 2;
                              else if sex_m2_dates_i = 1 then
lastsex_dates_i = 3;
                              else if sex_m3_dates_i = 1 then
lastsex_dates_i = 4;
                              else if sex_m4_dates_i = 1 then
lastsex_dates_i = 5;
                              else if sex_m5_dates_i = 1 then
lastsex_dates_i = 6;  * within the last month;

                              if sex_m0_dates_j = 1 then
lastsex_dates_j = 1; * 6 months before interview;
                              else if sex_m1_dates_j = 1 then
lastsex_dates_j = 2;
                              else if sex_m2_dates_j = 1 then
lastsex_dates_j = 3;
                              else if sex_m3_dates_j = 1 then
lastsex_dates_j = 4;
                              else if sex_m4_dates_j = 1 then
lastsex_dates_j = 5;
                              else if sex_m5_dates_j = 1 then
lastsex_dates_j = 6;  * within the last month;


                  **** Just like with calendar method there are only 2
ways by which there is OBVIOUS [dates] concurrency that does not
require follow-up questions;
                        * 1. if the pair of partners have >= 2 months
in common, then there is definitely concurrency;
                              months_matching_dates =
      (sex_m5_dates_i + sex_m5_dates_j = 2) + (sex_m4_dates_i +
sex_m4_dates_j = 2) + (sex_m3_dates_i + sex_m3_dates_j = 2) +

      (sex_m2_dates_i + sex_m2_dates_j = 2) + (sex_m1_dates_i +
sex_m1_dates_j = 2) + (sex_m0_dates_i + sex_m0_dates_j = 2) ;     *
sums up which months have "1" marked for both people;

                        * 2. see if one partners months contains the
other partners months. If there is only a 1 month overlap, then this is
the only unambiguous way
                               for there to be concurrency. we needed
to ask follow-up questions for the remaining 1-month overlaps;
                              if (firstsex_dates_i > firstsex_dates_j)
& (lastsex_dates_i < lastsex_dates_j) then i_contains_dates_j = 1; else
i_contains_dates_j = 0;
                              if (firstsex_dates_j > firstsex_dates_i)
& (lastsex_dates_j < lastsex_dates_i) then j_contains_dates_i = 1; else
j_contains_dates_i = 0;

                        * calculate! ;
```

```
                              if (months_matching_dates >= 2) |
(i_contains_dates_j = 1) | (j_contains_dates_i = 1) then date_overlap =
1;
                              else date_overlap = 0;    * can have 0
months matching but calendar overlap if one interval entirely contains
the other!;



                        ** dates at month-level resolution, INCLUDING
1-month ties. done in Nelson and Glynn, but silly !!! **;
                                    if (months_matching_dates >= 1)
then date_overlap_ties = 1;
                                    else date_overlap_ties = 0;    *
can have 0 months matching but calendar overlap if one interval
entirely contains the other!;


                        *  ADD UNAIDS AT MONTH-LEVEL HERE!;
                              * UNAIDS @ -3 months: had sex with each
partner 3 months before interview and overlapped at least 2 months -
using Lancet definition of 3 months, which is my typical definition of
4 months!;
                              if (sex_m3_dates_i = 1) & (sex_m3_dates_j
= 1) & (months_matching_dates >= 2) then unaids_3mo_dates = 1;
                              else unaids_3mo_dates = 0;

                              * UNAIDS @ -5 months: had sex with each
partner 5 months before interview and overlapped at least 2 months;
                              if (sex_m5_dates_i = 1) & (sex_m5_dates_j
= 1) & (months_matching_dates >= 2) then unaids_5mo_dates = 1;
                              else unaids_5mo_dates = 0;

                  end;

                  * if either in the pair are one-time partners, then
classify triad as not concurrent, by dates methods;
                  else if (morethanonce_i = 0) | (morethanonce_j = 0)
then do;
                              date_overlap = 0;
                              date_overlap_exact = 0;
                              date_overlap_ties = 0;
                              unaids_3mo_dates = 0;
                              unaids_5mo_dates = 0 ;
                  end;


                  format rid 10.;
      run;

            proc print data = checking.partner_pairs;
                  where (date_overlap = .) ;
                  var rid partner_i partner_j morethanonce_i
morethanonce_j
                        dt_first_sex_i dt_last_sex_i  dt_first_sex_j
dt_last_sex_j  mo_6_flag;
            run;
```

```
            proc print data = checking.partner_pairs;
                  where (morethanonce_i = 1) & (morethanonce_j = 1) ;
                  var datestrt
                        dt_first_sex_i dt_last_sex_i  dt_first_sex_j
dt_last_sex_j
                         sex_m0_dates_i  sex_m1_dates_i  sex_m2_dates_i
sex_m3_dates_i  sex_m4_dates_i  sex_m5_dates_i
                         sex_m0_dates_j  sex_m1_dates_j  sex_m2_dates_j
sex_m3_dates_j  sex_m4_dates_j  sex_m5_dates_j date_overlap
unaids_3mo_dates unaids_5mo_dates;
            run;

            proc freq data = checking.partner_pairs ;
                  where (morethanonce_i = 1) & (morethanonce_j = 1) ;
                  tables date_overlap_exact concurrent_pair ;
                  tables date_overlap_exact*concurrent_pair /agree;
                  tables date_overlap*concurrent_pair /agree;
                  tables date_overlap_exact*date_overlap /agree;
                  tables date_overlap * (unaids_3mo_dates
unaids_5mo_dates)/ agree;
            run;
                  /*
                        proc freq data = checking.partner_pairs;
                              table serial_j_first *
confirmed_concurrent_months /missing;
                              table serial_i_first *
confirmed_concurrent_months /missing;
                        run;

                        proc print data = checking.partner_pairs;
                              var rid partner_i partner_j;
                              where calendar_overlap &
(confirmed_concurrent_months > 0) ;
                        run;
                  */

      * Ensure that concurrency and all serial configurations are
mutually exclusive! ;
      proc freq data = checking.partner_pairs;
            tables serial_j_first * serial_i_first;
            tables serial_j_first * concurrent_pair;
            tables serial_i_first * concurrent_pair;
      run;

      * add some participant data into pair data;
      data checking.partner_pairs;
            merge
                  checking.partner_pairs (in = from_pairs)
                  checking.gave_names (keep = rid race hisplat raceth
HRESULT agecat agecat_mmwr agecat_bopr incent /*gaveaddy*/ rename =
(race = race_participant));
            by rid;
            if ~from_pairs then delete;
      run;
```

```
      * calculate summary concurrency measures for each PARTICIPANT
(rather than at the partner pair level):
            1. any concurrent partnerships yes/no
            2. the number of concurrent pairs of partners
                  a. exact and month-level date overlaps!!
            3. number of unique partners the person involved in
concurrent relationships
            4. number of concurrency/months (#2 x the overlapping
months). this indicates severity of overlap
                  a. UAI versions

            UNAIDS measures - at partner level, summarized for
participants. Added 8/27/2012
            5. UNAIDS measure at -5 months
            6. UNAIDS measure at -3 months;



            * #2 and #4: sum up within participants the number of
concurrent pairs and months ;
            proc means data = checking.partner_pairs n sum maxdec=0 ;
                  class rid;
                  var concurrent_pair concurrent_months mUAIls_i
mUAIls_j ;
                  output out = pair_summary sum(concurrent_pair
concurrent_months concurrentUAIls_2p concurrentUAIls_1p
concurrentUAIp6m_2p concurrentUAIp6m_1p

      date_overlap_exact date_overlap date_overlap_ties
unaids_3mo_dates unaids_5mo_dates) =
                                    concurrent_pairs concurrent_months
concurrentUAIls_2p_sum concurrentUAIls_1p_sum concurrentUAIp6m_2p_sum
concurrentUAIp6m_1p_sum

      date_overlaps_exact date_overlaps date_overlaps_ties
unaids_3mo_dates_total unaids_5mo_dates_total;
            run;
                  * clean up;
                  data pair_summary;
                        set pair_summary;
                        where _TYPE_ = 1;
                        drop _FREQ_ _TYPE_;
                  run;

            * #3: number of unique partners the person involved in
concurrent relationships (number of their 5 partnerships during which
they had another partner);
            data concurrent_stacked;
                  set  checking.partner_pairs (keep = rid partner_i
concurrent_pair rename = (partner_i = partner))
                         checking.partner_pairs (keep = rid partner_j
concurrent_pair rename = (partner_j = partner))
                        ;
                  where concurrent_pair;
            run;
            proc sort data = concurrent_stacked nodupkey; by rid
partner ; run;
```

```
                  * sum up the number of concurrent partners within
each participant;

                  proc means data = concurrent_stacked n sum maxdec=0;
                        class rid;
                        var concurrent_pair ;
                        output out = concurrent_partner_summary
sum(concurrent_pair) = concurrent_partners ;
                  run;
                        * clean up;
                        data concurrent_partner_summary;
                              set concurrent_partner_summary;
                              where _TYPE_ = 1;
                              drop _FREQ_ _TYPE_;
                        run;

      *     5. UNAIDS measure at -5 months
            6. UNAIDS measure at -3 months;
                  proc means data = checking.partners n nmiss sum
maxdec=0;
                        class rid;
                        var unaids_5mo unaids_3mo ;
                        output out = unaids_summary sum(unaids_5mo
unaids_3mo) = unaids_5mo_total unaids_3mo_total ;
                  run;
                        * clean up;
                        data unaids_summary;
                              set unaids_summary;
                              where _TYPE_ = 1;
                              drop _FREQ_ _TYPE_;
                        run;
                        proc sort data = unaids_summary ; by rid  ;
run;


      * dataset with summary measures #2-6 to merge into main
participant dataset!;
            data concurrency_summary;
                  merge  pair_summary
                              concurrent_partner_summary
                              unaids_summary;
                  by rid;

                  if concurrent_pairs = 0 then concurrent_partners = 0;
            run;


      * now merge in #5 and #6 - UNAIDS;


      * take the dataset of people who gave partner names for sex
partners within 6 months and add the concurrency summary measures;
      data checking.paper_with_concurrency;
            merge
                  checking.gave_names
                  concurrency_summary;
```

```
            by rid;

            * summary measure #1 = any concurrency! ;
            if concurrent_pairs > 0 then any_concurrency = 1;
            else if name_count = 1 then any_concurrency = 0;
            else if (concurrent_pairs ~= .) then any_concurrency = 0;
      * name_count is >1 and concurrent_pairs isnt missing, ie: 0, then
set = 0 ;
                  * else concurrent pairs is missing and had > 1
partner, so any_concurrency should be missing ;


            * Manhart direct question for concurrency: - the partner-
level questions are only asked for non-one time partners! ;
                  * initialize to zero ;
                             * generally not ideal programming
technique, but should work ok here ;
                  *direct_concurrency = 0;

                  if (OTHERSEXPARTICIPANTP1 > 0) |
(OTHERSEXPARTICIPANTP2 > 0)  | (OTHERSEXPARTICIPANTP3 > 0) |
(OTHERSEXPARTICIPANTP4 > 0)  |(OTHERSEXPARTICIPANTP5 > 0)
                        then direct_concurrency = 1;

                  * if all repeat partner direct Qs indicate no
concurrency ;
                  else if sum(OTHERSEXPARTICIPANTP1,
OTHERSEXPARTICIPANTP2, OTHERSEXPARTICIPANTP3,
                                     OTHERSEXPARTICIPANTP4,
OTHERSEXPARTICIPANTP5) = 0
                        then direct_concurrency = 0;

                  * if all 5 partners are one-time then no
direct_concurrency;
                  else if sum(morethanoncep1, morethanoncep2,
morethanoncep3, morethanoncep4, morethanoncep5) = 0
                        then direct_concurrency = 0;

            * after evaluate above, if skipped any partner entirely and
havent alreayd disclosed concurrency, then cannot
                        determine whether direct concurrency! ;
                  if (n(morethanoncep1, morethanoncep2, morethanoncep3,
morethanoncep4, morethanoncep5) < name_count)
                        & (direct_concurrency ~= 1)
                        then direct_concurrency = .;

            if (any_concurrency = . ) | (direct_concurrency =.)  then
concurrency_agree = .;
            else if  any_concurrency = direct_concurrency then
concurrency_agree = 1;
            else concurrency_agree = 0;

            *     CANNOT compare to overlapping dates method since we
dont get dates for one-time partners!
                  we can consider doing some workaround using knowledge
of the month of overlap or a hybrid by using the clarification
questions?;
```

```
            * binary indicators for single and double UAI with partners
pairs at last sex and p6m;
                  if name_count > 1 then do;
                        if concurrentUAIls_2p_sum > 0 then
concurrentUAIls_2p = 1;
                        else if concurrentUAIls_2p_sum ~= . then
concurrentUAIls_2p = 0;

                        if concurrentUAIls_1p_sum > 0 then
concurrentUAIls_1p = 1;
                        else if concurrentUAIls_1p_sum ~= . then
concurrentUAIls_1p = 0;

                        if concurrentUAIp6m_2p_sum > 0 then
concurrentUAIp6m_2p = 1;
                        else if concurrentUAIp6m_2p_sum ~= . then
concurrentUAIp6m_2p = 0;

                        if concurrentUAIp6m_1p_sum > 0 then
concurrentUAIp6m_1p = 1;
                        else if concurrentUAIp6m_1p_sum ~= . then
concurrentUAIp6m_1p = 0;

                        partner_pairs = comb(name_count, 2); * need a
denominator for partner pair questions;

                        * what proportion of partner parirs are
concurrent UAI?;
                        concurrentUAIls_2p_prop =
concurrentUAIls_2p_sum / partner_pairs;
                  end;
                  else do;
                        * had just one partner - set binary variables
and sums for concurrent UAI to 0;
                        concurrentUAIls_2p = 0;
                        concurrentUAIls_1p = 0;
                        concurrentUAIp6m_2p = 0;
                        concurrentUAIp6m_1p = 0;

                        concurrentUAIls_2p_sum = 0;
                        concurrentUAIls_1p_sum = 0;
                        concurrentUAIp6m_2p_sum = 0;
                        concurrentUAIp6m_1p_sum = 0;
                        partner_pairs = 0;
                  end;



            * add UAI in p12m as a single indicator of risk;
                  if (UAINUMMP12M > 0) | (UAI1MP12M > 0) then UAIp12m =
1;
                  else if ~((UAINUMMP12M = .) & (UAI1MP12M = .)) then
UAIp12m = 0;

            * concurrent density (akin to kappa) = # of concurrent
partners/#partners;
```

```
                        concurrency_density = concurrent_partners/name_count;

                * add in any UAI in p12m for Table 1;
                        if (UAINUMMP12M ~= .) then UAIp12m = (UAINUMMP12M >
0); * multiple partners;
                        if (UAI1MP12M ~= .) then UAIp12m = UAI1MP12M; *
single partner;


                * binary dates concurrency concurrency;
                        if date_overlaps >= 1 then any_concurrency_dates = 1;
                        else if name_count = 1 then any_concurrency_dates =
0;    * should be redundant, since all partners in partners dataset vs
triads for other concurrency measures;
                        else if (date_overlaps ~= .) then
any_concurrency_dates = 0;     * name_count is >1 and concurrent_pairs
isnt missing, ie: 0, then set = 0 ;

                        if date_overlaps_exact >= 1 then
any_concurrency_dates_exact = 1;
                        else if name_count = 1 then
any_concurrency_dates_exact = 0;     * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                        else if (date_overlaps_exact ~= .) then
any_concurrency_dates_exact = 0;     * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                        if date_overlaps_ties >= 1 then
any_concurrency_dates_ties = 1;
                        else if name_count = 1 then
any_concurrency_dates_ties = 0;      * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                        else if (date_overlaps_ties ~= .) then
any_concurrency_dates_ties = 0;      * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                * binary UNAIDS concurrency;
                        if unaids_5mo_total > 1 then
any_concurrency_unaids_5mo = 1;
                        else if name_count = 1 then
any_concurrency_unaids_5mo = 0;      * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                        else if (unaids_5mo_total ~= .) then
any_concurrency_unaids_5mo = 0;      * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                        if unaids_3mo_total > 1 then
any_concurrency_unaids_3mo = 1;
                        else if name_count = 1 then
any_concurrency_unaids_3mo = 0; * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                        else if (unaids_3mo_total ~= .) then
any_concurrency_unaids_3mo = 0;      * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                        * ADD IN MONTHS;
```

```
                  if unaids_5mo_dates_total > 1 then
any_concurrency_unaids_5mo_mon = 1;
                  else if name_count = 1 then
any_concurrency_unaids_5mo_mon = 0; * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                  else if (unaids_5mo_dates_total ~= .) then
any_concurrency_unaids_5mo_mon = 0; * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                  if unaids_3mo_dates_total > 1 then
any_concurrency_unaids_3mo_mon = 1;
                  else if name_count = 1 then
any_concurrency_unaids_3mo_mon = 0; * should be redundant, since all
partners in partners dataset vs triads for other concurrency measures;
                  else if (unaids_3mo_dates_total ~= .) then
any_concurrency_unaids_3mo_mon = 0; * name_count is >1 and
concurrent_pairs isnt missing, ie: 0, then set = 0 ;

                  * 11/19/2011:     whats up with me defining UAIp12m
twice, slightly differently?;

            format hresult hiv_partic. any_concurrency
direct_concurrency concurrency_agree  UAIp12m yn. raceth raceth. rid
10.; *628;

      run;

      proc freq data = checking.paper_with_concurrency;
            tables      name_count
                        date_overlaps * any_concurrency_dates
                        date_overlaps_Exact *
any_concurrency_dates_Exact/norow nopercent nocol missing;
      run;

      * 5/13/2011: add completion of AIp6M questions to the main
participant dataset, as this is important for the UAI analyses
            where we want to exclude people that didnt answer any AI
p6m/last sex questions;

            * in all previous analyses (SBSRN and IAS/NHPC 2011
abstracts, I using completeness of IAI/RAI at Last sex, rather
                  than syntheizing the p6m and last sex AI questions.
This is the correct way to do it! ;

            proc sort data = checking.partners; by rid partner; run;

            data aip6m;
                  set checking.partners;
                  by rid;
                  retain mAIp6m_P1 mAIp6m_P2 mAIp6m_P3 mAIp6m_P4
mAIp6m_P5;

                  if first.rid then do;
                        mAIp6m_P1 =. ; mAIp6m_P2 =. ; mAIp6m_P3 =. ;
mAIp6m_P4 =. ; mAIp6m_P5 =. ;
                  end;
```

```
                if partner = 1 then mAIp6m_P1 = mAIp6m;
                if partner = 2 then mAIp6m_P2 = mAIp6m;
                if partner = 3 then mAIp6m_P3 = mAIp6m;
                if partner = 4 then mAIp6m_P4 = mAIp6m;
                if partner = 5 then mAIp6m_P5 = mAIp6m;
            run;

            * keep only last record within people;
            data aip6m;
                set aip6m;
                by rid;
                if ~last.rid then delete;

                keep  rid mAIp6m_P1 mAIp6m_P2 mAIp6m_P3 mAIp6m_P4
mAIp6m_P5; *  name_count partner;
            run;

            * add the 5 AI variables into the main dataset;
            data checking.paper_with_concurrency;
                merge  checking.paper_with_concurrency
                            aip6m;
                by rid;
            run;

******************;

      * calculate summary concurrency measures for each PARTNER (rather
than at the partner pair level): ;

            data concurrent_stacked_partner;
                * break out the partner pairs dataset into one record
for each partner;
                set  checking.partner_pairs (keep = rid partner_i
concurrent_pair i_at_risk_from_j serial_j_first serial_i_first
mUAIp6m_i mUAIp6m_j  concurrentUAIp6m_2p
                                                          rename =
(partner_i = partner i_at_risk_from_j = at_risk_from_other
serial_j_first = serial_other_first serial_i_first = serial_me_first))

                         checking.partner_pairs (keep = rid partner_j
concurrent_pair j_at_risk_from_i serial_j_first serial_i_first
mUAIp6m_i mUAIp6m_j  concurrentUAIp6m_2p
                                                          rename =
(partner_j = partner j_at_risk_from_i = at_risk_from_other
serial_i_first = serial_other_first serial_j_first = serial_me_first))
                        ;

                      * from each partners perspective, add exposure
via UAI;

                            * Add UAI to additional exposure due to
concurrency;
                            if  (mUAIp6m_i = 1) &  (mUAIp6m_j = 1)
then mUAIp6m_2p = 1;
                            else if (mUAIp6m_i ~= .) &  (mUAIp6m_j ~=
.) then mUAIp6m_2p = 0;
```

```
                              else  mUAIp6m_2p = .; * missingness in
UAI in p6m;

                              *     at_risk_from_other =
serial_other_first OR concurrent_pair. the 2 are mutually exclusive!
      ;
                              if (at_risk_from_other = 1) & (mUAIp6m_2p
= 1) then at_risk_from_other_UAI = 1;
                              else if (at_risk_from_other ~= .) &
(mUAIp6m_2p ~= .) then at_risk_from_other_UAI = 0;

                              if (serial_other_first = 1) & (mUAIp6m_2p
= 1) then serial_other_first_UAI = 1;
                              else if (serial_other_first ~= .) &
(mUAIp6m_2p ~= .) then serial_other_first_UAI = 0;

                              * concurrentUAIp6m_2p ALREADY EXISTS! NO
NEED TO COMPUTE!;


                                    /*** OLD:
                                          if (at_risk_from_other = 1) &
(serial_other_first=  1)  then additional_partners_concurrency = 0 ;
      * connected by serial monog;
                                          else if (at_risk_from_other =
1) & (concurrent_pair = 1) then additional_partners_concurrency = 1;
                                          else
additional_partners_concurrency = 0;

                                          if (at_risk_from_other = 1) &
(serial_other_first=  1) & (concurrent_pair = 0) then
additional_partners_concurrency = 0 ;     * connected by serial monog;
                                          else if (at_risk_from_other =
1) & (concurrent_pair = 1) then additional_partners_concurrency = 1;
                                          else
additional_partners_concurrency = 0;
                                    ****/
            run;

            /*** 5/20/2011: investigating 6 people who have no
overlapping months but were asked concurrency follow-up questions for
another month = confusion because they had the same name as another of
that participants partners
                  proc freq data =  concurrent_stacked_partner;
                        tables at_risk_from_other* (serial_other_first
concurrent_pair);
                  run;

                  proc print data =  concurrent_stacked_partner;
                        where serial_other_first and concurrent_pair;
                        var rid partner;
                  run;

                  proc freq data =  concurrent_stacked_partner;
                        tables serial_other_first*concurrent_pair;
                  run;
```

```
            ***/

            proc sort data = concurrent_stacked_partner ; by rid
partner ; run;

                  * sum up the number of partners and UAI partners EACH
PARTNER is exposed to;

                  proc means data = concurrent_stacked_partner n sum
maxdec=0;
                        class rid partner;
                        var   at_risk_from_other serial_other_first
concurrent_pair
                                    at_risk_from_other_UAI
serial_other_first_UAI concurrentUAIp6m_2p;

                        output out = at_risk_partner_summary
                                    sum(at_risk_from_other
serial_other_first concurrent_pair
                                    at_risk_from_other_UAI
serial_other_first_UAI concurrentUAIp6m_2p)
                                          =
                                    at_risk_from_other
serial_other_first concurrent_pair
                                    at_risk_from_other_UAI
serial_other_first_UAI concurrent_pair_UAI

                                                ; *
at_risk_from_concurrent_uai ;
                  run;
                        * clean up;
                        data  at_risk_partner_summary;
                              set  at_risk_partner_summary;
                              where _TYPE_ = 3;
                              drop _FREQ_ _TYPE_;

                              * additional exposure due to concurrent
UAI;

                        run;


            * merge into partners dataset!!!;
            proc sort data = checking.partners; by rid partner; run;
            proc sort data = at_risk_partner_summary; by rid partner;
run;

            data checking.partners;
                  merge       checking.partners
                              at_risk_partner_summary (in = in_summary
keep = rid partner
                                    at_risk_from_other
serial_other_first concurrent_pair
                                    at_risk_from_other_UAI
serial_other_first_UAI concurrent_pair_UAI)
      ;
                  by rid partner;
```

```
                  * partners of participants with only 1 partner = set
values to 0 (including UAI one, which artificially inflates its sample
size!);
                  if ~in_summary then do;
                                 at_risk_from_other = 0;
                                 serial_other_first = 0;
                                 concurrent_pair  = 0;
                                 at_risk_from_other_UAI= 0;
                                 serial_other_first_UAI= 0;
                                 concurrent_pair_UAI= 0;

                                 partic_has_one_partner = 1;
                  end;
                  else  partic_has_one_partner = 0;
            run;


******************;

      **** PARTNERS WITH extra HIV status computations and PARTICIPANT
DEMOGRAPHICS. For use in concurrency analysis (Table with partner
chars), assortativity analysis, serosorting analysis;

      proc sort data = checking.partners; by rid; run;
      proc sort data = checking.paper_with_concurrency; by rid; run;

      data checking.partners_with_part_demo;
            merge       checking.partners (in = from_partners)
                        checking.paper_with_concurrency (keep = rid age
agecat_mmwr incent raceth  EVERTEST HRESULT name_count rename
=(age=age_partic));
            by rid;

            if ~from_partners then delete;

            unique_partner_num = _N_;

            * The 3 main vars of interest: DISCUSSSTATUSFS, STATUSFS,
STATUSIMP ;

            * recode HIV status of participant: 0 = neg, 1 = pos, 2 =
unknown;
                  if (evertest = 0) | (hresult in (2,3)) then
hiv_status_partic = 2; * never tested or indet. or didn't get result =
UNKNOWN status;
                  else if (hresult in (0,1)) then hiv_status_partic =
hresult; * last status is neg (0) or pos (1);
                        * else = .!;

            * recode perceived HIV status of partner AT FIRST/ONLY SEX;
                  if (DISCUSSSTATUSFS = 0) | ((DISCUSSSTATUSFS = 1) &
(STATUSFS = 9)) then hiv_status_partner = 2; * if didnt disclose or did
but dont know the result, then STATUS = UNKNOWN;
                  else if ((DISCUSSSTATUSFS = 1) & (STATUSFS = 1)) then
hiv_status_partner = 0; * partner was HIV-;
```

```
                    else if ((DISCUSSSTATUSFS = 1) & (STATUSFS = 2)) then
hiv_status_partner = 1; * partner was HIV+;
                          * else, either discuss status or status
questions are missing! ;

            * compute concordances = ;

            * recode intention to serosort, based on disclosure;
                  if (hiv_status_partner = 2) | (STATUSIMP = 1) then
serosort_intent = 1; * if no disclosure, status unknown, or not
important then no intentional serosorting;
                  else  serosort_intent = STATUSIMP; * = 2,3,4,5, or .
for importance of status;

                  * make binary indicator for intent - (not import. or
slightly) = 0, (moderately-extremely) = 1 );
                  if serosort_intent in (1,2) then intent_bin = 0;
                  if serosort_intent in (3,4,5) then intent_bin = 1;

                  * compute all concordances = crude serosorting;
                        if (hiv_status_partic = 0) &
(hiv_status_partner = 0) then serosort_crude = 1;
                        else if (hiv_status_partic = 1) &
(hiv_status_partner = 1) then serosort_crude = 1;
                        else if (hiv_status_partic ~= .) &
(hiv_status_partner ~= .) then serosort_crude = 0;

                        * account for UAI;
                        if (serosort_crude = 1) & (mUAIp6m = 1) then
serosort_crude_uai = 1;
                        else if  (serosort_crude ~= .)      & (mUAIp6m
~= .) then serosort_crude_uai = 0;

                  * compute intentional concordances;
                        if (hiv_status_partic = 0) &
(hiv_status_partner = 0) & (intent_bin = 1) then serosort_intentional =
1;
                        else if (hiv_status_partic = 1) &
(hiv_status_partner = 1) & (intent_bin = 1) then serosort_intentional =
1;
                        else if (hiv_status_partic ~= .) &
(hiv_status_partner ~= .) & (intent_bin ~= .) then serosort_intentional
= 0;

                        * account for UAI;
                        if (serosort_intentional = 1) & (mUAIp6m = 1)
then serosort_intentional_uai = 1;
                        else if  (serosort_intentional ~= .)      &
(mUAIp6m ~= .) then serosort_intentional_uai = 0;

            ** Classify partners by sexual activity type: UAI vs.
oral+protected AI vs. Oral only **;
                  * the mAI and mUAI indicators already account factor
in whether its a one-time partner or not, so dont need to worry about
that;
```

```
                    if (mUAIp6m = 1) then partner_sex_type = 1;
      * UAI partner;
                    else if (mAIp6m = 1) then partner_sex_type = 2;
      * AI/Oral sex but not UAI;
                    else if (mAIp6m = 0) then partner_sex_type = 3;
      * oral sex only;

            * raceth for partner - 4 levels;
                  if (hispanic = 1) then raceth_partner = 3;
      *hisp;
                  else if (race = 2) then  raceth_partner = 2; *black;
                  else if (race = 3) then raceth_partner = 1;  * white;
                  else if (race ~= .) then raceth_partner = 4; * Other;

            * raceth for partner, full - matches Christine's free
condom usage paper classification;
                  if (hispanic = 1) then raceth_partner_full = 10;
      *hisp;
                  else raceth_partner_full = race;

            * agecat_mmwr for partner;
                  * 1. Code adjusted age that handles uncertain age
values;
                        if ~(age in (999, .)) then age_adj = age; *
exact age known;
                        else if (age = 999) then do;
      * age is unknown and then asked for a range (AGESTATEMENT) that
needs to be compared to participants age;
                              if (AGESTATEMENT = 1) then age_adj =
age_partic - 10;              * "more than 10 years younger than i am"
;
                              else if  (AGESTATEMENT = 2) then age_adj
= age_partic - 2;             * "2-10 years younger than i am" ;
                              else if  (AGESTATEMENT = 3) then age_adj
= age_partic ;                * "within a year of my age" ;
                              else if  (AGESTATEMENT = 4) then age_adj
= age_partic + 2;             * "2-10 years older than i am" ;
                              else if  (AGESTATEMENT = 5) then age_adj
= age_partic + 10;            * "more than 10 years older than i am" ;
                              * else age_adj = .;
                        end;
                        * else age_adj = .;

                  * 2. Take adjusted age and categorize! ;
                        if age_adj = . then  agecat_mmwr_partner = .;
                        else if age_adj  < 18 then
      agecat_mmwr_partner = 10;
                        else if age_adj  in (18,19) then
      agecat_mmwr_partner = 1;
                        else if age_adj  < 25 then
      agecat_mmwr_partner = 2;
                        else if age_adj  < 30 then
      agecat_mmwr_partner = 3;
                        else if age_adj  < 40 then
      agecat_mmwr_partner = 4;
                        else if age_adj  < 50 then
      agecat_mmwr_partner = 5;
```

```
                        else if age_adj  >= 50 then
      agecat_mmwr_partner = 6;

            format hiv_status_partic hiv_status_partner newhivstat.
      serosort_intent intent. intent_bin intent_bin. partner_sex_type
sex_type.
                        raceth_partner raceth. raceth_partner_full
RACETH_FULL_PARTNER. agecat_mmwr_partner agecat_mmwr.;
      run;

      * check age reclassification;
      proc print data = checking.partners_with_part_demo;
            where age_adj = 10;
            var age  age_adj agecat_mmwr_partner agestatement
age_partic;
      run;

      proc univariate data = checking.partners_with_part_demo;

            var age_adj;
            id age_partic AGESTATEMENT raceth;
      run;
```

B. print_sex_cal.sas

```
/*    print_sex_cal.sas
 *
 *    prints out sex partner calendars after SG partner data has been
processed
 *
 */


%macro print_sex_cal(id=, library=);
      proc format library = work;
            value dash_x      0 = "-" 1 = "X";
      run;

      ods rtf startpage=no ;
      * grab months for labels;
      data _null_;
            set &library..just_participants (where = (rid = &id) keep
=rid var421 var428-var432);


            call symput("m5", compress(VAR432));
            call symput("m4", compress(VAR431));
            call symput("m3", compress(VAR430));
            call symput("m2", compress(VAR429));
            call symput("m1", compress(VAR428));
            call symput("m0", compress(VAR421));
      run;

      proc print data = &library..partners_with_part_demo label
width=minimum split="_" ;
            where rid = &id;
            title "Calendar, RID = &id";

            id name;
            var sex_m5 sex_m4 sex_m3 sex_m2 sex_m1 sex_m0 mUAIp6m
at_risk_from_other  at_risk_from_other_UAI serial_other_first
serial_other_first_UAI concurrent_pair  concurrent_pair_UAI;

            format name $10. sex_m0 - sex_m5 dash_x. mUAIp6m yn.;
            label
                  name = "Name"
                  sex_m5 = "&m5" sex_m4 = "&m4" sex_m3 = "&m3" sex_m2 =
"&m2" sex_m1 = "&m1" sex_m0 = "&m0" mUAIp6m = "UAI partner?";
      run;

      proc sort data = &library..partner_pairs; by rid partner_i
partner_j; run;
      proc print data = checking.partner_pairs noobs;
            where rid = &id;
            var name_i name_j calendar_overlap
confirmed_concurrent_months concurrent_pair concurrent_months
firstsex_i firstsex_j lastsex_i lastsex_j;
            format name_i name_j $10.;
      run;
```

```
    proc print data = &library..concurrency_clarify_stacked noobs;
          where rid = &id;
          var name_i name_j concurrency_month concurrency_clarify;
    run;
    ods rtf startpage=yes ;


%mend print_sex_cal;
```

ORIGINAL STUDY

High Prevalence of Sexual Concurrency and Concurrent Unprotected Anal Intercourse Across Racial/Ethnic Groups Among a National, Web-Based Study of Men Who Have Sex With Men in the United States

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Background: Men who have sex with men (MSM) are the largest human immunodeficiency virus (HIV) risk group in the United States. Sexual concurrency may contribute to high HIV incidence or to racial/ethnic HIV disparities among MSM. Limited information is available on concurrency and racial/ethnic differences among MSM or on the extent to which MSM engage in concurrent unprotected anal intercourse (UAI).

Methods: Data are from baseline responses in a prospective online study of MSM aged 18 years or older, having 1 or more male sex partners in the past 12 months, and recruited from social networking Web sites. Pairwise sexual concurrency and UAI in the previous 6 months among up to 5 recent partners was measured, using an interactive questionnaire. Period prevalences of concurrency and concurrent UAI were computed and compared across racial/ethnic groups at the individual and triad (a respondent and 2 sex partners) levels.

Results: A total of 2940 MSM reported on 8911 partnerships; 45% indicated concurrent partnerships, and 16% indicated concurrent UAI in the previous 6 months. Respondents were more likely to have UAI with 2 partners when they were concurrent, compared to serially monogamous (odds ratio, 1.93, 95% confidence interval, 1.75–2.14). No significant differences in levels of individual concurrency or concurrency among triads were found between non-Hispanic white, non-Hispanic black, and Hispanic men.

Conclusions: Concurrency and concurrent UAI in the previous 6 months was common. Although there were no differences by race/ethnicity, the high levels of concurrency and concurrent UAI may be catalyzing the transmission of HIV among MSM in general.

In 2009, men who have sex with men (MSM) were the group most represented among new human immunodeficiency virus (HIV) infections (61%) and individuals living with HIV (55%) in the United States.[1,2] Furthermore, since 2000, MSM have been the only transmission group in which incident HIV cases have increased.[1,3,4]

In addition to the disparities between MSM and other HIV risk groups, there are substantial disparities among MSM. Estimates of both prevalence and incidence are consistently higher among black and Hispanic MSM, compared with white MSM, with young black MSM facing the greatest disparity in HIV incidence.[2,5]

The reasons that MSM of color are more at risk for HIV infection are unclear. Studies of individual-level risk factors have consistently revealed equivalent or lower levels of such behaviors among men of color.[6,7] Differential sexual network properties have been hypothesized as a contributor to this disparity, although the published data are limited. Sexual concurrency, defined as "overlapping sexual partnerships where sexual intercourse with one partner occurs between 2 acts of intercourse with another partner,"[8] is thought to be an important catalyst of HIV transmission. This is because concurrency increases the exposure of one's partners to each other and increases the likelihood that a newly infected individual would transmit HIV to an uninfected partner during the highly infectious acute period of HIV infection.[9,10] Concurrency has been demonstrated in simulations of US heterosexuals to accelerate HIV/sexually transmitted infection transmission and drive racial disparities,[11,12] and network factors such as concurrency have been suggested possible determinants of the racial disparity among MSM in the United States.[6]

Concurrency may contribute to the disparities seen in the US HIV epidemics yet remains little studied empirically among MSM.[13] Among predominantly heterosexual men in the United States sampled from 2002 to 2003, Adimora et al.[14] found a 12-month period prevalence of concurrency of 11% and 14% among those reporting at least 1 sex partner. Only 1 report has been published on the prevalence of concurrency among MSM, by race/ethnicity.[15] In that study of MSM in San Francisco, among those with multiple sex partners, 65% of white men reported concurrency, compared with 56% of black men. These results are limited by the measure of concurrency used, which considered partnerships close in time but not necessarily overlapping to be concurrent and thus may have misclassified serial monogamy as concurrency. They are further limited by the small number of black MSM (n = 18) and the restriction to 1 US city.

Three key methodological gaps have traditionally precluded accurate empirical understandings of concurrency: those of measuring concurrency accurately, at the appropriate levels of analysis, and with the incorporation of risk behavior.

Participant concurrency response data have traditionally been collected in several ways, all of which have limitations

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Supported by the National Institute on Minority Health and Health Disparities RC1MD004370, National Institute of Mental Health R01MH085600, Eunice Kennedy Shriver National Institute for Child Health and Human Development R01HD067111, and P30AI050409—the Emory Center for AIDS Research.

The authors have no conflicts of interest to declare.

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Received for publication November 8, 2011, and accepted May 9, 2012.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (http://www.stdjournal.com).

DOI: 10.1097/OLQ.0b013e31825ec09b

and limited agreement with one another.[16,17] The theoretically most precise method is to gather dates of first and last sex for participants' named sex partners and examine the resulting intervals for overlaps. Yet, this is subject to errors in recall and logical inconsistencies. Others have asked for these dates at the 1-month level of detail, but this results in temporal ambiguities and misclassification of concurrency, particularly for short-term casual relationships.[14,16,18] Another method is to directly ask a participant, for each of his/her partners, about the existence of concurrent partners, but this precludes an understanding of partner sequencing and of the other concurrent partners involved[16,19] and ultimately limits the understanding of concurrency.

The level of analysis of concurrency may be important to understanding the possible impact of concurrency within sexual networks. Concurrency is most often described at the individual study participant level, but there is another level which is more relevant to understanding HIV transmission dynamics, the triad. Triads are the level at which concurrency's bidirectional transmission potential acts and represent the unit of an individual and 2 of his/her sex partners (also known as a partnership pair). Yet, information may be lost when summarizing an individual's sexual history across triads, rendering this an insufficient measure for prevention applications. This is because individuals may be concurrent with only certain pairs of partners and may differentially contribute to community transmission risk based on the number and types of concurrent triads they have. One may gain a better understanding of the features associated with concurrent partnerships and their contribution to community risk, if concurrency is analyzed at the triadic level.

Furthermore, most reports have focused on quantifying the prevalence of concurrency, irrespective of dyadic risk behaviors. This alone is insufficient to describe the potential increase in disease transmission associated with concurrency because condoms may be used with one or both of the sex partners involved. In a triad, if condoms are used consistently and completely with either or both partners, then the attendant concurrency is irrelevant to network transmission dynamics. There is a need to understand biologically relevant concurrency—that is, triads in which incomplete condom use with both partners actually enables disease transmission.

However, biologically relevant concurrency has been seldom measured or described at either the participant or triad levels. Descriptions of concurrency at the triadic level or that incorporate condom use are scant. Doherty et al.[20] have published the only findings on biologically relevant concurrency among triads from the US heterosexual data described previously and found that among these men, 28% of concurrent triads involved unprotected vaginal intercourse with both partners. To date, no data have been published on biologically relevant concurrency or concurrency at the triadic level among MSM.

In this work, we seek to quantify the prevalence of concurrency among MSM, by race/ethnicity, in a national online study of MSM in the United States. To do so accurately and robustly, we address the previously mentioned methodological gaps by using an improved concurrency measurement tool,[21] quantify both concurrency and concurrent unprotected anal intercourse (UAI), and conduct analyses at both at the individual and triadic levels.

MATERIALS AND METHODS

Study Design

Data come from the baseline responses of a 12-month prospective online study of HIV behavioral risks among MSM in the United States, being conducted by Emory University. Internet-using MSM were recruited from August to December 2010 through selective placement of banner advertisements on Web sites.[22] To attain the broadest sample of online MSM, most of the respondents were recruited from social networking Web sites (e.g., Facebook, MySpace, although limited recruitment occurred on one dating Web site). No other dating or hook-up sites were included, to avoid oversampling higher-risk MSM. Men who clicked on the advertisements were taken to an online eligibility screening survey. Eligible individuals for the baseline questionnaire were male, at least 18 years, and had a male sex partner in the past 12 months. Following the administration of an online consent document, participants completed a 60-minute questionnaire. The study was reviewed and approved by the institutional review board of Emory University.

To allow testing of race/ethnicity-related hypotheses with adequate power, this analysis includes only white non-Hispanic, black non-Hispanic, and Hispanic respondents. The questionnaire's dyadic sexual behaviors module was oriented about a 6-month recall period, and thus, we further restricted our analysis to the 91% of respondents who additionally had sex within the previous 6 months.

Sexual Concurrency and Partnership Data Collection

Participants who had a sex partner within 6 months were asked to provide nicknames for up to 5 most recent anal, oral, or vaginal sex partners within the previous 6 months, followed by a partnership timing module, and behavioral inventory for each partner.

A brief description of the partnership timing module follows. Participants were provided a calendar grid that displayed the previous 6 months in columns and partner nicknames on the rows and asked to indicate in which months they had sex with each partner (Fig. 1A). Two or more common months of sex between 2 partners classified the triad as concurrent. If the responses indicated a single overlapping month between 2 partners and was thus ambiguously concurrent or serial, follow-up questions (Fig. 1B) were asked to establish whether the participant was with the 2 partners serially or concurrently during the indicated month. This technique benefits from the easier recall afforded by month-level calendar and direct questioning approaches but gains the exact sequencing information provided by measuring dates of sex.[21] The questionnaire was designed in SurveyGizmo 2.6 and hosted on www.surveygizmo.com.

Concurrency Outcomes

Based on the calendar responses, measures of concurrency were calculated at the triadic and participant levels. For each triad, the duration of overlap in months was calculated (range, 1–6). Triads were considered concurrent if the months of sex with both partners overlapped by 2 months or longer, if they overlapped by 1 month and one partner's interval entirely contained the 1 month relationship of the other partner, or based on responses to the clarification questions. Each concurrent and serially monogamous triad of partners was classified according to whether UAI occurred with both partners in the previous 6 months.

From the triadic data, we calculated at the participant-level: cumulative occurrence of concurrency and concurrent UAI in the previous 6 months, the number of concurrent triads, UAI triads, unique concurrent partners, and the total months of concurrent overlap ("concurrency-months").

Partners of all sexes were counted in concurrency determinations (female and transgender partners represented <3% of partnerships). Although we collected UAI for partners of

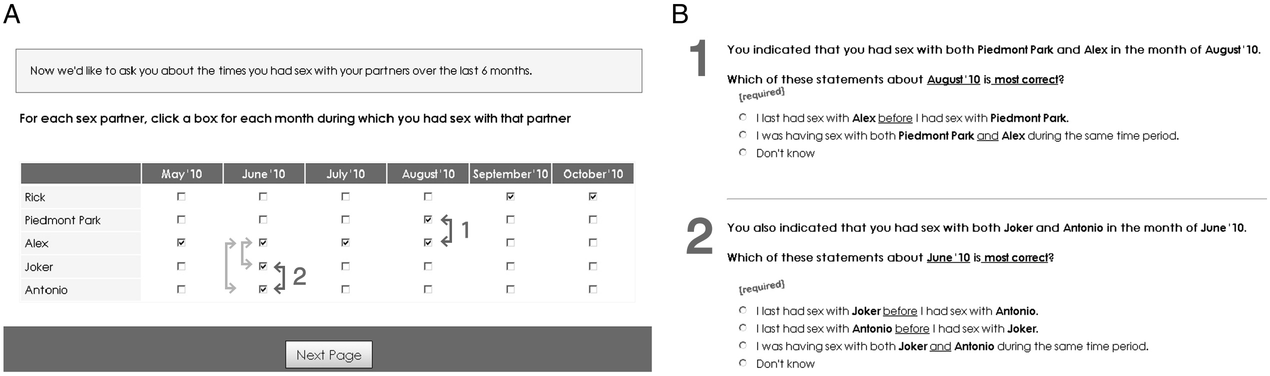

Figure 1. A. The study participant indicates the months in which he had sex with each named partner. Partner pairs are examined at each month. Ambiguous overlaps between partners (black) are selected for further questioning. Obviously concurrent overlaps (gray) are not selected. B. For each ambiguous month, the participant indicates the appropriate serial configuration of his partners, or that he was concurrently having sex with both.

all sexes, we chose to only include male partnerships in our outcome of concurrent UAI.

Analysis

Participant-level demographics and concurrency outcomes were summarized descriptively, stratified by participant race/ethnicity, and compared using χ^2 and Kruskal-Wallis tests. The concurrency outcomes were summarized overall and for those who had concurrent partnerships. Categorical measures were compared across racial/ethnic groups using χ^2 tests and continuous ones using 1-way analysis of variance. Racial/ethnic group comparisons were done both overall and pairwise, with white non-Hispanic MSM as the referent group.

Data were next examined at the triad level, using all possible pairs of partners reported by each participant with more than 1 partner (up to ${}_5C_2$ = 10 triads per participant) (Fig. 2). The association between a triad being concurrent and involving UAI with both partners was calculated using odds ratios (ORs) and compared by race/ethnicity using the χ^2 and Breslow-Day tests. This was done both overall and for just triads in which anal intercourse occurred with both partners. We additionally adjusted our OR estimates for repeated measures on participants using a repeated measures generalized estimating equations logistic regression model with an exchangeable ln(OR) correlation structure.[23]

The post-processing of the response data and all analyses were conducted in SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

A total of 6104 men reporting a male sex partner in the previous 12 months began the online behavioral questionnaire. Among them, 4138 (68%) remained in the questionnaire and answered questions about male sex within the previous 6 months, with 3768 (91%) having a partner within the previous 6 months. Of these MSM, 3471 (92%) completed the partnership timing module. The 2940/3471 (85%) MSM who self-reported white, black, or Hispanic race/ethnicity form the basis for this analysis.

The analytic sample was 63% white non-Hispanic, 21% black non-Hispanic, and 17% Hispanic. The overall median age was 27 years (interquartile range, 22–39 years; range, 18–79 years) and white participants were on average older than their black and Hispanic counterparts (median of 29, 26, 25 years, respectively, $P < 0.0001$). Nine percent of white, 18% of black, and 7% of Hispanic MSM self-reported being HIV positive ($P < 0.0001$). White participants were more likely to hold a college degree compared with black and Hispanic participants (44% vs. 34%, 33% respectively, $P < 0.0001$) and less likely to identify as bisexual (12% vs. 30%, 19% respectively, $P < 0.0001$). These participants provided data on 8911 partners. Seventy-three percent of participants (2144/2940) reported more than 1 sex partner in the previous 6 months, allowing for concurrency to be determined among 12,812 triads.

The participant-level concurrency findings are presented by race/ethnicity in Table 1. Among all participants, 45% of white, 45% of black, and 46% of Hispanic participants indicated at least 1 pair of concurrent partnerships (concurrent triad) in the previous 6 months ($P = 0.84$). No other concurrency metric was found to be racially differential at the participant unit of analysis (Table 1). Overall, 16% of participants indicated a concurrent UAI triad. The 1326 MSM with at least 1 concurrent triad in the previous 6 months had a mean of 3.6 concurrent triads, involving a mean of 3.5 unique partners and 8.6 concurrency-months, and 39% engaged in UAI with both partners of a concurrent triad.

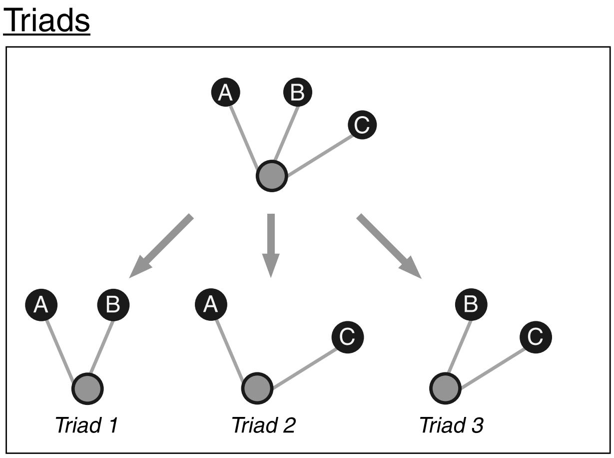

Figure 2. An individual with p partners ($p > 1$) has ${}_pC_2$ triads, or partner pairs, which may be concurrently or serially arranged. An individual (grey circle) with 3 partners (A, B, C) yields 3 triads.

Table 2 displays findings at the triad level. Among the 12,812 triads involving participants with more than 1 partner, 38% were concurrent (rather than serially monogamous). These findings did not significantly vary by race/ethnicity (adjusted $P = 0.21$). The duration of concurrent overlap was significantly shorter for white MSM compared with black and Hispanic MSM (51% had ≤1 month overlap vs. 48% and 49%, respectively; table-wide $P = 0.02$), but this modest difference is likely not practically important. Unprotected anal intercourse occurred with both partners among 31% of concurrent triads and was also not different by race/ethnicity (adjusted $P = 0.09$).

In addition, there was a positive association between triadic concurrency and UAI: triads were more likely to involve UAI with both partners if they were concurrent (unadjusted OR, 1.93; 95% confidence interval [CI], 1.75–2.14) (adjusted OR, 1.57; 95% CI, 1.41–1.75). This association was consistent across levels by participant race/ethnicity (adjusted $P = 0.95$).

Individual and triadic level concurrency results are also provided stratified by categories of participant age in Supplementary Digital Content Tables 1 and 2, http://links.lww.com/OLQ/A50.

DISCUSSION

In this largest study of concurrency among MSM to date, the 6-month period prevalence of concurrency was high, with the prevalence at least 4 times that reported among their heterosexual counterparts in a nationally representative survey and involving more partners,[14] but consistent with the limited reports on MSM.[15]

Although the level of condom use among concurrent MSM triads was similar to that reported for heterosexuals,[20] the overall levels of concurrent unprotected sex were higher owing to the greater prevalence of concurrency. Men who have sex with men who had a concurrent partnership were also concurrent with more partners than are concurrent heterosexuals. Combining these concurrency findings with the greater per-episode transmission risk of UAI compared to unprotected vaginal intercourse,[24] MSM may face a far higher transmission burden owing to biologically relevant concurrency, and concurrency may be an important factor in the disproportionately high incidence seen among MSM.

At the individual level, we observed comparable levels of concurrency and concurrent UAI across race/ethnic groups, furthering our existing understanding that MSM of color do not engage in riskier sexual behaviors with the knowledge that MSM of color also do not have riskier patterns of concurrency at this level. Nonetheless, the implications of this finding for explaining differential HIV incidence are not conclusive. Similar but high levels of concurrent UAI, in conjunction with racial/ethnic differences in HIV prevalence and potentially in assortativity and network size between the sexual networks of black, white, and Hispanic MSM, may still help explain disparities in HIV transmission and highlight a significant role for concurrency. Furthermore, although we describe the prevalence of individual patterns of engaging in concurrent sex, this cannot be directly related to individual HIV acquisition risk because this risk is imparted onto one's partners, not oneself. Our data revealed substantial racial/ethnic mixing (partnership racial concordance of 66% for white, 65% for black, and 37% for Hispanic participants). To the extent that racial mixing is occurring, a participant's race/ethnicity is not a reliable marker of his partner's race/ethnicity, and it is difficult to make conclusions about racial/ethnic differences in HIV risk. Further analyses are needed.

Among our sample, concurrent partners were more like likely to be ones with whom unprotected sex occurred, compared to serial partners. This association of 2 transmission risk factors is a newly documented compound risk that was enabled through the use of triad-level analyses, and further characterization of the circumstances underlying concurrency is needed.

This work is strengthened by the use of an improved measurement technique that gathered precise partner sequence data and was enabled by the programming of advanced online tools. Many of the partnerships reported by participants were short-term, with half being 1-time encounters. The use of the typical approaches that classify concurrency at the 1-month level of detail would have led to substantial undercounting of concurrency because many partnership overlaps involving 1-time encounters would be counted as single-month overlaps and thus assumed to be serial. Furthermore, by quantifying concurrency at the level at which it occurs, that of triads, and at the level of biological relevance, concurrent UAI, we have been able to provide a fuller picture of concurrency among this sample of MSM, by race/ethnicity.

We recognize that our findings may be affected by the selection biases inherent in online behavioral research, which take the form of sampling, click-through, and questionnaire dropout biases. Although it is difficult to quantify how these potential

TABLE 1. Participant-Level Concurrency and Concurrent UAI in the Previous 6 Months Among 2940 MSM, by Participant Race/Ethnicity

	White, Non-Hispanic (n = 1843)	Black, Non-Hispanic (n = 604)	Hispanic (n = 493)	*P*
Overall	n (%)	n (%)	n (%)	
Any concurrent triad*	829 (45.0)	269 (44.5)	228 (46.3)	0.84
Any concurrent UAI triad†	269/1574 (17.1)	70/454 (15.4)	56/396 (14.1)	0.31
Mean number of concurrent UAI triads (SD, n)†	0.42 (1.38, 1574)	0.38 (1.21, 454)	0.28 (0.91, 442)	0.13‡
Participants with concurrent partnerships	(n = 829)	(n = 269)	(n = 228)	
Any concurrent UAI triad (%)†	269/663 (40.6)	70/190 (36.8)	56/164 (34.2)	0.26
Mean number concurrent UAI triads (SD, n)†	1.01 (1.98, 663)	0.92 (1.74, 190)	0.67 (1.33, 164)	0.11‡
Mean number concurrent triads (SD)	3.70 (2.91)	3.57 (2.93)	3.53 (2.74)	0.67
Mean unique concurrent partners (SD)	3.49 (1.24)	3.38 (1.26)	3.42 (1.22)	0.44
Total concurrency-months (SD)	8.65 (12.06)	8.72 (12.51)	8.22 (8.22)	0.88

*Triads (partnership pairs) are composed of a participant and 2 sex partners and are the fundamental unit of concurrency.
†Alternate sample sizes indicated where there are missing UAI response data.
‡White non-Hispanic versus Hispanic, $P = 0.04$.

TABLE 2. Triad-Level Concurrency and Concurrent UAI in the Previous 6 Months Among 12,812 Partner Triads, Involving 2114 MSM Participants With Multiple Partners in the Previous 6 Months, by Participant Race/Ethnicity*

	White, Non-Hispanic (n = 7907)	Black, Non-Hispanic (n = 2728)	Hispanic (n = 2177)	Unadjusted *P*	Adjusted *P*†
	n (%)	n (%)	n (%)	n (%)	n (%)
Concurrent triad, n (%)	3064 (38.8)	960 (35.2)	805 (37.0)	0.0032	0.21
Duration of concurrent overlap, mo				0.02	—
≤1	1557 (50.8)	458 (47.7)	398 (49.4)		
2	424 (13.8)	149 (15.5)	145 (18.0)		
3	376 (12.3)	108 (11.3)	85 (10.6)		
4	207 (6.8)	77 (8.0)	45 (5.6)		
5	195 (6.4)	54 (5.6)	40 (5.0)		
≥6	305 (10.0)	114 (11.9)	92 (11.4)		
UAI in previous 6 mo, overall				***P* interaction**	
Among concurrent triads	667/2039 (32.7)	174/563 (30.9)	110/486 (22.6)	**Unadjusted**	**Adjusted†**
Among nonconcurrent triads	739/3719 (19.9)	200/1095 (18.3)	161/1062 (15.2)		
Prevalence OR (95% CI)	*1.96 (1.73–2.22)*	*2.00 (1.58–2.53)*	*1.64 (1.25–2.15)*	*0.46*	*0.95*
UAI in previous 6 mo, among AI triads					
Among concurrent triads	667/1290 (51.7)	174/398 (43.7)	110/319 (34.5)		
Among non-concurrent triads	739/1856 (39.8)	200/652 (30.7)	161/553 (29.1)		
Prevalence OR (95% CI)	*1.62 (1.40–1.87)*	*1.76 (1.36–2.27)*	*1.28 (0.95–1.72)*	*0.26*	*0.57*

*Triads (partnership pairs) are composed of a participant and 2 sex partners and are the fundamental unit of concurrency.
†Adjusted for repeated measures on respondents.

biases may have skewed our results, compared with the first (2003–2005) and second (2008), MSM cycles of National HIV Behavioral Surveillance System (NHBS), our data show comparable racial diversity as well as patterns of behavioral risk.[25,26] For example, the median number of casual sex partners in the previous 12 months in both NHBS cycles was 3, whereas our sample had a median of 4 partners, and participants in both studies had a median of 1 main sex partner. Although our data are not nationally representative, this comparability to NHBS and the large sample size, coupled with the demographic and geographic diversity of this study, provide for robust estimates of concurrency among MSM. It is still possible that MSM sampled online or using the venue-based time-space sampling methods of NHBS do not represent the true distribution of risk behaviors among the general population of MSM. If online respondents of all racial/ethnic groups are more likely to engage in high-risk sexual behaviors, comparisons of concurrency between these groups could be biased toward the null hypothesis of equality. Caution should thus be exercised with generalizing these results to the general US population of MSM.

A few decisions may have limited our measurement of concurrency. In allowing participants to provide data on only up to 5 most recent sex partners, other partners earlier in the interval may not have been reported. Moreover, by using a 6-month recall period for sexual timing, concurrencies involving intermittent partnerships in which sex occurs less than twice during the recall period are missed. Both of these limitations would lower estimates of concurrency and thus our findings may be conservative. Although the concurrent triads involving a serodiscordant partnership most directly impact HIV transmission, we chose to not consider participant-reported partner HIV serostatuses in our analyses. Other results from these data demonstrated only a moderate level of dyadic presexual discussion of HIV status (50%–70%).[27] Considering the high proportion of HIV-infected MSM who are unaware that they are infected[2] and the potential for partners to misrepresent their statuses, these participant-reported data would be an unreliable marker for this purpose. Future studies should quantify the subset of concurrent UAI triads that could actually increase HIV propagation, by ascertaining the true infection statuses of both participants and partners.

We observed very high prevalences of engaging in concurrent sex and concurrent UAI in the previous 6 months among MSM, and these concurrencies may contribute to current high rates of HIV transmission among MSM. Although these prevalences were not different by participant race/ethnicity, further analyses need to be conducted to understand the risk conferred to sex partners of different race/ethnicities as a result of concurrency. Our findings of high levels of concurrency and an association between concurrency and UAI highlight the need for further research to both understand the factors associated with concurrency and the degree of transmission among MSM that is attributable to this phenomenon. If subsequent works demonstrate concurrency to be a significant contributor to HIV transmission and modifiable behavioral determinants are identified, then the development of concurrency-related prevention interventions may be highly impactful for MSM in the United States. Consideration should be given to the addition of brief concurrency assessments in health care provider settings and to the incorporation of concurrency messaging into risk-reduction counseling.

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