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Methods for the Design and Analysis of Relationship and Partner Effects on Sexual Health

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Abstract

Sexual intercourse involves two people and many aspects of sexual health are influenced by, if not dependent, on interpersonal processes. Yet, the majority of sexual health research involves the study of individuals. The collection and analysis of dyadic data present additional complexities compared to the study of individuals. The aim of this article was to describe methods for the study of dyadic processes related to sexual health. One-sided designs, including the Partner Level Model (PLM), involve a single individual reporting on the characteristics of multiple romantic or sexual relationships and the associations of these factors with sexual health outcomes are then estimated. This approach has been used to study how relationship factors, such as if the relationship is serious or casual, are associated with engagement in HIV risk behaviors. Such data can be collected cross-sectionally, longitudinally or through the use of diaries. Two-sided designs, including the actor-partner interdependence model (APIM), are used when data are obtained from both members of the dyad. The goal of such approaches is to disentangle intra- and inter-personal effects on outcomes (e.g., the ages of an individual and his partner may influence sexual frequency). In distinguishable datasets, there is some variable that allows the analyst to differentiate between partners within dyads, such as HIV status in a serodiscordant couple. When analyzing data from these dyads, effects can be assigned to specific types of partners. In exchangeable dyadic datasets, no variable is present that distinguishes between couple members across all dyads. Extensions of these approaches are described.

Keywords

dyadic relationships; MSM; gay; HIV; romantic relationships; sexual health; sexual orientation

INTRODUCTION

Sexual intercourse involves at least two people, and many aspects of sexual health are influenced by, if not dependent, on interpersonal processes. Sexually transmitted infections (STIs) are an obvious example. HIV is contracted by individuals, but in the vast majority of cases is transmitted between two people (CDC, 2012). Furthermore, interpersonal aspects of the relationship matter for transmission. Sullivan, Salazar, Buchbinder, and Sanchez (2009) reported that, among men who have sex with men (MSM), 68% of HIV transmissions were in the context of a main sex partnership, defined as “someone who you feel committed to above all others.” This was contrasted with only 32% of HIV transmissions in the context of casual sex partnerships (Goodreau et al. [2012] estimated a lower proportion of HIV transmission due to main partnerships: 32–39%). Mustanski, Newcomb, and Clerkin (2011)

found in a longitudinal study of young MSM that relationships identified as “serious” were associated with a nearly eight fold increase in unprotected anal sex, a greater effect than even drug use prior to sex. The results of these two studies contradict traditional thinking that casual relationships should be the focus of HIV prevention among MSM.

Another example of the importance of interpersonal processes to sexual health comes from research on romantic relationships, which illustrate the diversity of applicable research designs. For example, studying romantic relationships can involve each individual reporting on their own relationship satisfaction or each reporting on areas they want their partner to change. These directly measured variables can be used as predictors, outcomes or the degree of concordance between partners can also be calculated and used as a variable. In many situations, the correlation or consistency between individuals in the relationships is of particular interest. For example, Marshall, Panuzio, Makin-Byrd, Taft, and Hotzworth-Monroe (2011) found low levels of agreement between partners in reports of violence in the relationship, but agreement was moderated by relationship satisfaction. Relationship satisfaction was associated with reporting concordance, such that high relationship satisfaction was related to reporting less of one’s partner’s abuse than the partner reported whereas low relationship satisfaction was related to reporting more of one’s partner’s abuse than the partner reported. A different pattern in terms of relationship satisfaction and concordance has been observed in research with male couples, which found that higher relationship satisfaction was associated with greater concordance about sexual agreements (Mitchell, Harvey, Champeau, & Seal, 2012). These differences highlight the importance of studying relationship processes in different types of dyads (i.e., male-male, female-female, female-male) as well as for different types of sexual health outcomes (i.e., abuse, agreements, etc.).

The above examples illustrate the substantial value of studying couples and/or interpersonal processes to understand sexual health, but yet most sexual health research focuses on individuals and individual-level processes (Karney et al., 2010). Why is that the case? Kenny, Kashy, and Cook (2006) suggested that most social science research has used this lens because of the individualistic nature of American culture and the dominant role of psychologists in the social and behavioral sciences, who generally emphasize the individual over higher levels of analysis. Another important reason they point out is that commonly used statistical methods, such as analysis of variance (ANOVA) and multiple regression, are not equipped for the analysis of dyadic data in their standard form. This is because these approaches assume independence of observations, which requires that, after controlling for variation due to the independent variable(s), the data from each individual in a study are unrelated to the data from other individuals in the study. These assumptions are violated when data are collected from couples or when an individual reports on multiple relationships. Extensions of these analytic approaches that account for this dependency in the data form the basis for many of the methods we describe in this article.

The purpose of this article is to provide an overview of the methods and analyses available for studying relationship and partner effects on sexual health. This article is included in the Special Section of *Archives of Sexual Behavior* focused on sexual health in male gay and bisexual couples to provide greater detail on these methods than can be included in any single empirical paper. As such, it can help readers to appreciate the methods and interpret the results in the articles within this issue, as well as other articles focused on interpersonal processes related to sexual health. By providing a non-technical explanation of the design and analyses, we also hope that this article can serve as a launching pad for investigators interested in moving beyond the individual to incorporating interpersonal processes into their studies of sexual health. However, such designs rapidly become very complex as they are extended and expanded and it is not possible to cover all of these details in this article. A

number of excellent resources exist for those who seek to learn more about these approaches. Kenny, Kashy, and Cook's (2006) volume on dyadic data analysis is an excellent explanation of a variety of approaches and their advanced applications and may be supplemented by detailed discussions of related issues in journal articles (e.g., Judd, Kenny, & McClelland, 2001; Kenny & Judd, 1986; Kenny, Kashy, & Bolger, 1998). Other journal articles provide descriptions of partner effects (Darbes & Lewis, 2005; Kenny & Cook, 1999), application of the actor-partner interdependence model in couples therapy (Cook & Snyder, 2005), and methods for diary research in studying interpersonal processes (Laurenceau & Bolger, 2005).

In this article, we begin by providing an overview of the design and analysis of relationship and partner effects. We then focus on two broad classes of approaches. The first is a "one-sided" design where an individual reports on multiple partners and aspects of sexual health resulting from that partnership. This design only collects data from one individual within the relationship. The second is the "two-sided" (reciprocal) design where two partners report on their relationship with one another. From our perspective, both of these approaches involve the collection of dyadic data as information is being collected about members or aspects of the dyad.

Overview of Dyadic Data Analysis

The fundamental challenge in analyzing data from couples is that individuals are situated within dyads (Gooty & Yammarino, 2011; Griffin & Gonzalez, 1995; Kenny et al., 2006; Selig, McNamara, Card, & Little, 2008). This nesting implies that an analyst must be aware of the influence of two factors in modeling relationship data: (1) the hierarchical structure of individuals within couples and (2) the non-independence of observations. We briefly discuss these two broad factors before reviewing approaches to modeling and hypothesis testing.

The hierarchical structure of dyadic data—In dyadic datasets, data exist on two levels. At the individual level (Level 1 or the within-couple level), there are variables on which members of the same dyad may differ. For example, partners may differ from one another with respect to age or sexual satisfaction in their relationship. At the couple level (Level 2 or the between-couple level), there are variables on which both members of a dyad have the same value—a value that may differ from other couples. For example, partners share characteristics like relationship length or whether they live separately or together. The levels at which outcome and criterion variables exist must be considered in the selection of an analytic approach. Often, but not always, the hierarchical structure of dyadic data necessitates the use of multi-level modeling procedures; however, when outcome variables are shared by couple members (i.e., they exist at Level 2 or the couple level), analyses are restricted to the couple level because there is no within couple variability to model. This hierarchical structure is also present in datasets in which each participant reports on multiple partners. Within participants (Level 1), there are variables associated with the unique characteristics of each partner reported. Between participants, there are variables associated with the participant that are shared by each relationship partner that participants report (i.e., the participant's race stays constant across all of their partnerships).

The non-independence of data from relationship partners—As a result of their shared membership in a social group (the couple), the analyst cannot assume observations from members of the same couple are independent from one another (Kenny & Judd, 1986). Most standard applications of the general linear model (*t*-tests, ANOVA, multiple regression, etc.) invoke the assumption that observations are independent (Kenny & Judd, 1986). Violation of this assumption may result in an increase in Type I or Type II error depending upon the level and direction of the effect (individual vs. couple) (Gooty &

Yammarino, 2011; Kenny & Judd, 1986; Kenny et al., 2006). Analysts must, therefore, determine whether sufficient dependence is present among couple members' responses to meaningfully influence statistical tests.

The most common statistical measure of dependence is the intraclass coefficient (ICC) (Alferes & Kenny, 2009). Similar to Pearson's product-moment correlation (r), the ICC has an upper bound of 1.0; however, the lower bound of ICC is $-1/(n-1)$ where n is the number of individuals in each group. In the case of dyads, $n = 2$, the ICC's lower bound is -1.0 (Kenny et al., 1998). An ICC of zero implies that two members of the same couple are no more similar to one another than two members of different couples are. As the ICC increases in absolute value, it implies couple member's responses are increasingly similar to (or dissimilar from) one another. An ICC of 1.0 indicates that members of the same couple responded identically. Cohen's kappa is an analogous measure of association for dichotomous variables (Kenny et al., 1998, 2006). Interpretation of Cohen's kappa is identical to that of the ICC (Kenny et al., 2006). Kenny et al. (1998) suggested that, in the case of dyads, observations may be treated as independent if the ICC is less than 0.45 although even when this is the case there may be advantages to modeling the dependence. For one-sided designs, where an individual reports on multiple partnerships, the interpretation of the ICC is identical--a high ICC indicates a high degree of similarity in the characteristics of that individual's partners (i.e., most partners are older) or the outcome of interest across partners (i.e., condoms are never used across all partners). In studies of MSM using the one-sided design, the ICC varied considerably depending on the outcome of interest; it was small for relationship characteristic (e.g., violence in the relationship; 17%) and number of unprotected sex acts (29%), and was larger for alcohol (54%) and drug use (79%) prior to sex (Mustanski et al., 2011; Newcomb, Clerkin, & Mustanski, 2011).

One-Side Designs

"One-sided" or "one-with-many" designs analyze data on sexual behavior from the perspective of only one member of the dyad. Such designs involve administering questionnaires that ask participants to report on multiple sexual encounters (i.e., an episode-by-episode design) and/or sexual partnerships (i.e., a partner-by-partner design) during a discrete period of time (e.g., individual details on last three sexual partners, each partner in prior 3 months, etc.), as opposed to administering global measures of frequency of sexual behavior collapsed across partners. Questionnaires assess the specific sexual behaviors participants engage in with their partners as well as a variety of other situational and contextual variables associated with these encounters (e.g., location), partners (e.g., race, age) or partnerships (e.g., serious/casual relationship). This design may be administered retrospectively or prospectively, as is often the case with sexual diary data.

Other approaches to collecting data on sexual behavior from individuals include assessing sexual behavior and relationship characteristics within a single sexual partnership (e.g., most recent sexual partner) or administering more global questions that collapse across multiple previous sexual partnerships. While these types of designs may be expedient in terms of ease of administration and analysis, one-with-many designs are advantageous for a variety of reasons. First, analyses of single partnerships or more global associations assume, to varying degrees, that individuals are stable in their sexual behavior over time (i.e., individuals always or never use condoms). Prior research has not found high stability to characterize condom use (e.g., Cooper, 2010; Grov, Golub, Mustanski, & Parsons, 2010; Mustanski et al., 2011), suggesting that designs that collapse data collection across multiple partners may be ignoring the largest level of variability. One-with-many designs, on the other hand, are able to characterize predictors of risk for individuals whose sexual risk behavior varies over time by linking specific episodes of risk to the situational or contextual variables that are

associated with those episodes. For example, one-with-many designs are able to assess whether an individual is more or less likely to have unprotected sex based on the age of their sexual partners by directly linking sexual partner age to specific sexual acts and estimating the likelihood of sexual risk within-person across multiple partnerships. As such, one-with-many designs are most appropriate for use when modeling outcomes for which the researcher expects that a substantial proportion of the variance in the outcome is due to within-persons factors (i.e., change across situations) rather than differences between-persons.

There are several other important limitations of global association studies and studies of single sexual partnerships. First, failing to map specific situational or contextual variables directly onto an episode of sexual risk-taking does not establish the temporal relationships between independent variables and the outcome that are needed in order to make causal inference. While studies of single sexual partnerships can specifically map predictor variables onto an individual sexual partnership or episode, it is not possible to disentangle stable personality characteristics from situational correlates of risk when assessing only one sexual encounter or partnership. For example, the link between alcohol use and sexual risk has been decidedly mixed in the literature: global association studies tend to find a positive association (Cooper, 2002; Weinhardt & Carey, 2000), studies of single sexual partnerships find no relationship (Cooper, 2002; Leigh, 2002), and one-with many designs have produced mixed findings (Vosburgh, Mansergh, Sullivan, & Purcell, 2012). It has been suggested that the positive association found in global association studies may be explained by a third variable (e.g., personality domain) that is correlated with both the independent and dependent variables. One-with-many designs, however, compare a participant's behavior across multiple situations, thereby controlling for between-person effects (i.e., the person serves as his or her own control by comparing behavior across multiple events).

One-with-many design may also have benefits in terms of the measurement of sexual behavior. Evidence suggests that event-level approaches to collecting data on sexual behavior that specifically link questions assessing condom use to sexual encounters or partners are more accurate than retrospective accounts of sexual behavior collapsed across multiple partnerships (Schroder, Carey, & Venable, 2003). When answering items assessing global rates of sexual behaviors, participants tend to over- or under-estimate rates of sexual risk behavior depending on how frequently the participants have sex (Downey, Ryan, Roffman, & Kulich, 1995); participants tend to over-estimate rates of low frequency sexual behavior while under-estimating rates of high frequency behaviors. More recent evidence suggests that retrospective accounts of sexual behavior only match event-level accounts for participants whose sexual risk behavior is stable over time (Hoppe et al., 2008). Given that research has found that condom use is not stable over time or across partnerships in multiple demographic groups (e.g., Cooper, 2010; Grov et al., 2010; Mustanski et al., 2011), one-with-many designs that link sexual risk behaviors to specific encounter or partners may be more reliable than retrospective questionnaires that collapse across partners. Further research on the reliability of various approaches to collecting sexual behavior data is warranted.

In terms of data management and analytic considerations, one-with-many designs yield data where the repeated measurement of sexual behavior and associated situational and contextual variables (Level 1) are nested within participants (Level 2). Accordingly, analyses should be conducted with a multilevel modeling framework, such as hierarchical linear modeling (Raudenbush & Bryk, 2002), that is designed to account for dependency in observations in data that contain a nested structure. The appropriate analysis of multilevel data can determine the effects of both within-persons and between-persons factors on the outcome variable. For example, the within-persons effects of sexual partnership

characteristics (e.g., relationship type, sexual partner age) on sexual risk behavior can be examined at Level 1. At Level 2, the main effects of stable between-subjects characteristics (e.g., demographic or personality characteristics) can be examined as predictors of sexual risk. Finally, Level 2 effects can be examined as moderators of Level 1 effects (cross-level interactions) in order to examine group differences in the effects of within-persons factors on sexual risk. As an illustration, Cooper (2010) found a cross-level interaction between impulsivity (Level 2) and repeated sex with sexual partners (Level 1) on likelihood of condom use in a sample of heterosexual adolescents. In this analysis, youth who were low in impulsivity were more likely to use condoms at first sex than those high in impulsivity, but the likelihood of condom use decreased more sharply for low impulsive adolescents between first sex and subsequent sex with the same partner.

We will now describe two variations of the one-with-many design: the Partner-Level Model (PLM) and Sexual Diaries. Discussion of these designs will focus on methodological issues, including data management and analytic considerations. We will also provide illustrations of how these designs have been reported in the literature.

Partner-Level Model—The PLM is a variation of the one-with-many design in which participants report on their sexual behaviors at the level of the sexual partnership rather than at the level of the sexual encounter. The PLM design involves assessing multiple sexual partnerships within-persons and participants enumerate their sexual behaviors with each partner (e.g., number of sexual encounters, frequency of unprotected sex). Participants also detail a variety of other variables related to their partners, including characteristics of their sexual partners (e.g., partners' age and race), relationship characteristics (e.g., relationship type, relationship violence), and situational variables associated with the sexual partnership (e.g., frequency of substance use prior to sex). Collection of this type of data often requires participants to report on a pre-determined number of sexual partnerships within a discrete period of time, which is dependent upon the frequency of sexual behavior in the population of interest. The PLM design can be administered cross-sectionally or longitudinally in studies that have multiple waves of participant follow-up. Longitudinal applications of the PLM can be particularly informative as they enable the researcher to document more sexual partnerships over time and therefore increase the likelihood of observing within-persons change in sexual risk behavior. Furthermore, longitudinal applications of the PLM design have the ability to examine developmental changes in relationship factors. It may be that the influence of certain relationship factors on sexual behavior change over time within-persons or that the likelihood of engaging in certain types of partnerships decreases or increases across development. For example, the influence of having an older sexual partner on unprotected sex may diminish as individuals become older themselves. These changes may have important implications for identifying risk factors for sexual risk taking and other health risk behaviors.

The PLM evaluates sexual behavior at the level of the sexual partnership. In cases where the research is focused on sexual behaviors associated with HIV or STI risk, then the outcome variable is typically a count of unprotected sex episodes (e.g., total number of unprotected anal/vaginal sexual encounters within each partnership), given that participants may have had multiple sexual encounters within each partnership. In modeling count variables with this type of multilevel data, it is advisable to use a distributional assumption that accounts for non-normality in the distribution of count variables (e.g., Poisson). Furthermore, the distribution of the count of sexual behavior variables is often over-dispersed (i.e., the SD is larger than the mean) due to an over-preponderance of cases with the value zero and/or the presence of outliers. Over-dispersion should be accounted for in analyses, which may be achieved by using a negative binomial distribution (for more details on modeling count and over-dispersed data, see Barron, 1992; Long & Freese, 2006). In these models, effect sizes

are commonly expressed as event-rate ratios (ERR), which provide an estimate of the change in the event-rate of the outcome variable for each one unit increase in the independent variable. Similar to an odds ratio, an ERR greater than one indicates an increase in the event-rate of the outcome while an ERR less than one indicates a decrease.

An additional consideration for longitudinal PLM designs is that there is the potential for collecting data on repeat partnerships with subsequent waves of longitudinal follow-up (i.e., sexual partners who are reported at multiple waves) and this introduces further dependency in the dataset that requires some consideration in analyses. One possibility for addressing this concern is to include a variable denoting whether a partner is repeated from a previous wave of data collection as a Level 1 covariate in multivariate analyses in order to control for the effects of repeated partnerships on the outcome variable. This approach specifically models the effect of partners repeating over time, but does not correctly adjust for the dependency in observations of the same partner across waves. To do so requires a three level model with wave of observation nested within partners that are nested within individuals. However, in order to fit such a three level model and detect effects, the dataset would need to include a sufficient number of partnerships that are repeated across waves of data collection. Furthermore, the analysis of a three level model should have sufficient variance in sexual behavior across sexual encounters within partnerships, which would necessitate the calculation of the ICC of sexual risk within repeat partnerships. Prior studies, to our knowledge, have not estimated this ICC so we do not know the extent to which sexual behavior is consistent with the same partner over time. When there are insufficient repeated partners across waves to fit a three level model, we recommend testing the robustness of results to this issue. Specifically, we recommend conducting follow-up analyses on all multivariate models after removing all data on repeat partners from subsequent waves of data collection and comparing results to when these data are included. In our own research with young MSM, we have found that approximately 8% of partners were repeated across 6 month waves of data collection and that removing data on these repeat partners did not substantially alter the overall patterning and significance of findings (Clerkin, Newcomb, & Mustanski, 2011; Mustanski et al., 2011; Newcomb et al., 2011).

In the absence of survey software that is able to link sexual partners from previous surveys to follow-up waves when administering PLM questionnaires, it can be challenging to identify repeat partnerships across multiple waves of data collection. In order to achieve this aim, we recommend a systematic process that links sexual partner initials (participants provide initials of sexual partners that are referenced in all questions regarding that sexual partnership) with the following demographic characteristics reported of sexual partners: partner age, race, and gender. If partner initials match across waves, and these matched individuals also have identical demographic characteristics, they are labeled as repeat partners. Repeat partners that appear within the same survey wave are removed from analyses.

As an illustration of the PLM approach, we will describe results from a recent study of the influence of relationships characteristics on sexual risk behavior in a longitudinal study of young men who have sex with men (YMSM) (Clerkin et al., 2011; Mustanski et al., 2011; Newcomb et al., 2011). This study design collected retrospective reports on sexual partnerships (i.e., reports on up to 3 sexual partnerships during the previous 6 months) from 3 waves of data collection or an 18-month cumulative reporting period. Data on sexual partnerships were collected using the HIV-Risk Assessment for Sexual Partnerships (H-RASP) (see Appendix A), which was adapted from the AIDS-Risk Behavior Assessment (ARBA) (Donenberg, Emerson, Bryant, Wilson, & Weber-Shiffrin, 2001) to collect data from MSM on a partner-by-partner basis rather than in the aggregate. The measure assessed number of unprotected sex acts with that partner as well as a number of relationship factors

(e.g., serious versus casual, mode of meeting, use of substance prior to sex, balance of power, etc.) and partner characteristics (e.g., race, age difference, etc.).

The majority of the variance in the number of unprotected sex acts in this sample was due to within-persons factors (71%) ($ICC = .29$). In other words, 71% of the variability in sexual risk behavior was at the partnership level; participants were highly inconsistent in unprotected sex across partnerships. At Level 1, various sexual partnership-level characteristics (e.g., relationship status, violence, and forced sex) were examined as predictors of sexual risk (total number of unprotected anal or vaginal sex encounters with a given partners). At Level 2, characteristics of the participants that did not vary across partnerships (e.g., participant race) were examined as predictors of sexual risk as well as moderators of Level 1 effects (cross-level interactions) (e.g., the moderating effect of personality characteristics on the association between substance use with partners and sexual risk). For example, sensation seeking moderated the effect of alcohol use prior to sex on unprotected sex, such that participants high in sensation seeking showed a stronger positive association between these two variables (Newcomb et al., 2011).

The PLM design has also been used successfully with cross-sectional data. For example, Zea, Reisen, Poppen, and Bianchi (2009) examined the effects of relationship characteristics on sexual risk in immigrant Latino MSM. This study examined sexual risk at the level of the sexual encounter and asked participants to detail sexual behavior and relationship characteristics of up to three sexual encounters during the previous three months. These analyses examined the effects of several variables on odds of unprotected anal intercourse: within-persons (Level 1) effects (e.g., seroconcordance with partner, closeness with partner), demographic characteristics (e.g., Level 2: age, country of origin), and cross-level interactions (e.g., the moderating effect of participant age on the relationship between closeness with partners and odds of sexual risk).

Sexual Diaries—Another one-with-many approach to collecting data on sexual partnership and relationship factors involves administering sexual diary surveys to participants in which sexual encounters are tracked prospectively over a specified period of time. Sexual diary surveys can be designed to assess sexual behaviors, sexual partner characteristics, and a variety of other situational and contextual variables relevant to the sexual encounter or partner. Sexual diaries have been adapted to be administered online to minimize participant burden, and diaries are most often administered daily for a one-month assessment period (Groß et al., 2010; Mustanski, 2007) though other studies have administered daily diaries for up to two months (Gillmore et al., 2002; Leigh et al., 2008) or once-weekly diaries during 6-week (Boone, Cook, & Wilson, 2013; Carpenter, Stoner, Mikko, Dhanak, & Parsons, 2010) and 3-month (Newcomb & Mustanski, 2013) follow-up periods.

The data yielded from sexual diary studies differ somewhat in structure from PLM data in that individual sexual encounters (instead of sexual partnerships) are nested with participants. As such, sexual risk outcome variables for diary data are typically dichotomous in nature (e.g., unprotected anal/vaginal sex vs. protected anal/vaginal sex and/or other low-risk sexual behavior on a particular day), which necessitates the use of a Bernoulli distribution for analyses. As is the case with count variables, these data often yield an over-preponderance of cases of the outcome variable with the value zero, which may lead to over-dispersion.

As with the PLM design, sexual partners are often repeated across diary surveys. As such, data observations are not independent from the characteristics of the sexual dyad and it is necessary to account for this dependency in analyses. One option is to include the number of

previous sexual encounters with each partner or relationship status as covariates in analyses in order to control for the effects of these variables on the outcome. Other diary studies have created outcome variables that account for differing levels of risk by relationship status or whether partners were repeated across observations (Boone et al., 2013; Grov et al., 2010). However, this approach does not appropriately account for the dependency in these observations. As described above, we recommend considering the use of a three-level model if there are sufficient numbers of repeated observations. Of note, estimation of three level models with binary outcomes is particularly challenging and computationally intensive due to the fact that there are no closed-form solutions for the integration of the area under the curve (for more details on analytic considerations of multilevel models with binary outcomes, see Rodriguez & Goldman, 1995). It may also be useful to test for the robustness of results after removing all data on repeat partners from subsequent waves of data collection and comparing results to when these data are included.

Another consideration when analyzing data using models with nonlinear link functions is whether to estimate population-average or subject-specific effects. For continuous outcomes, the population-average and subject-specific estimates are asymptotically equivalent, but that is not the case for nonlinear models, and most acutely untrue for binary outcomes. In the types of analyses described in this article, the population-average model results are typically reported instead of the unit-specific model, because the goal is to make conclusions about the entire population of interest rather than to predict the scores of particular individuals or dyads (for more information, see Hu, Goldberg, Hedeker, Flay, & Pentz, 1998; Raudenbush & Bryk, 2002). Furthermore, population-average inferences make fewer assumptions and are more robust to erroneous assumptions about the random effects in the model (Heagerty & Zeger, 2000; Hubbard et al., 2010). These approaches also differ in their approach to handling missing data. Ultimately, analysts must select the approach that best reflects their research question, its assumptions, and the characteristics of their data.

To further illustrate applications of sexual diary methodology, we will describe two diary studies that examined relationship factors as predictors of sexual risk. Leigh, Vanslyke, Hoppe, Rainey, Morrison, and Gillmore (2008) examined the influence of alcohol use prior to sex and relationship type on condom use in university students and patients recruited from an STD clinic using a 2-month daily diary study. In this study, alcohol use was considered an event-level variable if drinking occurred at least 4 hours prior to the encounter (i.e., drinking prior to sex). At Level 1, Leigh et al. estimated the effects of alcohol use prior to sex and relationship type (casual vs. steady) on the odds of condom use at each sexual encounter. Other studies have examined cross-level interactions in predicting odds of sexual risk using diary data. For example, Newcomb and Mustanski (2013) examined racial differences in the effects of sexual partnership characteristics on odds of unprotected sex in MSM using data from a 3-month weekly diary study. In this study, participant race (Level 2) was examined as a moderator of the effects of within-person sexual partner characteristics (e.g., partner age; Level 1) on odds of sexual risk.

Two-Sided Designs

“Two sided” or “dyadic” designs analyze data reported by both members of a couple. They are not inherently restricted to variables that pertain to the relationship of the two reporting partners. For example, each member of a couple may report on his/her perceptions of sexual frequency within the relationship (a variable that relates to the reporting partners’ relationship) and also on his/her own behavior with partners outside of the relationship (a variable about behavior outside of the reporting partners’ relationship). The advantage of two-sided designs is that they provide the opportunity to investigate in detail the inter-relatedness of partner reports (e.g., Do both members of the relationship report equivalent levels of relationship satisfaction?), the mutual influence of partners on one another (e.g., Do

the communication skills of one's partner predict one's own relationship satisfaction?), as well as the correspondence between one partner's perception and the other partner's report (e.g., Do partners accurately perceive one another's level of sexual satisfaction?). Two-sided designs are limited in the extent to which they can provide a longitudinal perspective of partnering patterns across an individual's lifetime. Collecting data from past relationship partners or from relationships of very short duration (e.g., "one-night-stands") may not be feasible in many instances.

From an analytic perspective, there are two types of dyadic datasets, distinguishable and exchangeable. The nature of the dataset dictates the research questions to which data may be applied and the analytic methods which may be employed. Notably, distinguishability must be determined at the level of the construct based upon the nature of the dyads which comprise the dataset. A dataset may be treated as distinguishable if, and only if, all the dyads within it are distinguishable with respect to some variable relevant to the construct being studied. It is conceivable that the same dataset may be treated as distinguishable in some analyses and exchangeable in others.

In distinguishable datasets, there is some construct-relevant variable that allows the analyst to differentiate between partners within dyads (Selig et al., 2008). For example, in serodiscordant couples, HIV status distinguishes partners from one another. Each dyad has a "seronegative" and a "seropositive" partner. In exchangeable dyadic datasets, no such variable is present that distinguishes between couple members across all dyads (Kenny et al., 2006). For example, in a dataset of seroconcordant same-sex couples, there may not be a meaningful way to systematically designate one person as "Partner 1" versus "Partner 2" across all dyads. In order for the variable to be potentially distinguishing, it must be consistent across all couples in the set. In a dataset where some couples are concordant and some are discordant, HIV status does not distinguish the members within all couples in the set and the analyst must therefore treat them as exchangeable with respect to HIV status.

The mere presence of a potentially distinguishing variable does not imply that the dataset should be treated as such. One must also consider the relevance of a potential distinguishing variable to the construct being studied (Kenny et al., 2006). For example, a dataset comprised entirely of serodiscordant same-sex couples is potentially distinguishable with respect to HIV status; however, the data might be treated as exchangeable in an analysis in which HIV status is not theoretically relevant to the constructs being studied, (e.g., examining the association between partners' ages and television viewing habits). Finally, some datasets may have multiple distinguishing variables (e.g., a dataset comprised of heterosexual serodiscordant couples is distinguishable on gender and HIV status). In these cases, the analyst must examine which potential distinguishing variable is most related to the construct under investigation (Kenny et al., 2006).

When analyzing data from exchangeable dyads, the analyst can assign effects to partners. As an example, in a dataset comprised of serodiscordant couples, a researcher might examine the association between HIV negative partners' age and HIV positive partners' sexual satisfaction. When working with exchangeable dyads, an analyst can calculate the effects of individuals on their partners, but cannot assign the effect to one "type" of partner or the other. As an example, imagine Mark and Robert are members of a couple in a dataset comprised of exchangeable dyads. If an individual's age is associated with his sexual satisfaction in the dataset, then that single effect describes the association between Robert's age and sexual satisfaction as well as Mark's age and sexual satisfaction.

Actor-Partner Interdependence Model—The non-independence of data from couple members could be modeled through the application of multi-level models in which

individuals are nested within couples (Kenny, Bolger, & Kashy, 2002; Raudenbush & Bryk, 2002); however, the types of questions of interest in couples' research often involve sophisticated hypotheses about the influence of one partner on another. In other words, researchers are often interested in how the characteristics of one individual are associated with her/his own characteristics and those of his/her partner.

The APIM was developed to answer these types of within-couple questions and models may also incorporate couple-level variables such as relationship length (Kenny et al., 2006). The APIM is a multi-level modeling procedure (Kenny et al., 2006). At Level 1, the APIM specifies four possible associations between the outcome and predictor observations taken from couple members (see Fig. 1). Paths A and D represent "Actor Effects," in which each partner's score on the predictor is associated with that person's own score on the outcome. Paths B and C represent "partner effects," in which each person's score on the outcome is associated with his partner's score on the predictor. For example, one may predict a participant's sexual satisfaction score from that participant's own age (the actor-effect of age) and from the age of the participant's partner (the partner effect) (Kenny et al., 2006).

When dyads are distinguishable, paths A, B, C, and D represent the estimation of four unique effects. Figure 2 represents the application of the APIM model to a dataset of serodiscordant couples. Here Path A represents the association between age and sexual satisfaction among HIV negative partners and Path D represents this association among HIV positive partners. Path C represents the effect of HIV positive partners' age on their negative partners' sexual satisfaction and Path B represents the association of HIV negative partners' age on their HIV positive partners' sexual satisfaction.

When dyads are exchangeable, Paths A and D of Fig. 1 are redundant estimates of the association between a participants' outcome score and that participants' predictor score. Paths B and C are redundant estimates of a participants' outcome score and his/her partners' predictor score. This can be understood through an examination of how partner scores are created in an exchangeable dataset. For any variable x , a partner score x_p is created by assigning a participant his partner's score. For example, Kevin and Daniel are partners and they report scores of 27 and 36, respectively, on a measure of sexual satisfaction. Kevin's partner score is 36 (the score reported by Daniel) and Daniel's partner score is a 27 (the score reported by Kevin).

$$\begin{aligned}x_{\text{partner A}} &= x_{\text{p partner B}} \\x_{\text{partner B}} &= x_{\text{p partner A}}\end{aligned}$$

The sample data below is an example of actor-partner data in which there is a categorical predictor x , coded 0 or 1, and a continuous outcome variable y , ranging from 1 to 5. The following equalities exist within the APIM at Level 1:

$$\begin{aligned}Mx &= Mx_p \text{ and } \text{Var } x = \text{Var } x_p \\ \text{cov } xy &= \text{cov } x_p y_p \text{ and } \text{cov } xy_p = \text{cov } x_p y\end{aligned}$$

Because the scores for each partner are simply switched in creating the partner version of a variable, the actor and partner versions of a variable have the same mean and variance. Because the variances are equal, equalities also exist among covariances. In reference to the APIM path model in Fig. 1, Path A = Path D and Path B = Path C. This has important implications for the interpretation of effects. If Mark and Robert are members of a couple in such an analysis, a significant actor effect represents both the association between Mark's

age and his own sexual satisfaction score as well as Robert's age and his own sexual satisfaction score. Meanwhile, a significant partner effect of age on sexual satisfaction simultaneously represents the association between Marks' age and Robert's sexual satisfaction as well as Robert's age and Mark's sexual satisfaction. This is in contrast to results from a distinguishable dyad, where effects could be assigned to a specific type of partner. For example, imagine Mark is HIV positive and Robert is HIV negative and they participated in a study of age and sexual satisfaction among serodiscordant dyads. The partner effect among HIV positive men represents the association between Robert's age and Mark's sexual satisfaction; whereas the partner effect among HIV negative men represents the association between Mark's age and Robert's sexual satisfaction. These two effects can vary freely in the model and their equivalence can be tested using model constraints (Kenny et al., 2006).

Other Approaches to Two-sided Analyses—The APIM represents a comprehensive analytic framework organizing effects within and between couples; however, it is not the only framework which may guide dyadic data analysis. We briefly discuss the application of repeated-measures ANOVA and multiple regression models conducted only at the couple-level. In addition, we briefly review alternative analytic approaches to the APIM, which do not require the specialized software and skill required by multi-level modeling.

Repeated-measures ANOVA is relevant to research questions involving couple-level predictors (Kenny et al., 2006). For example, Parsons, Starks, Gamarel, and Grov (2012) utilized repeated measures ANOVA to examine differences in sexual satisfaction among monogamous, monogamish, open and discrepant couples. In this framework, partner members' responses are treated as repeated observations. The mean of couple member's responses is modeled as the outcome, and the error term associated F statistic is corrected by removing variability due to couple membership (Tabachnick & Fidell, 2007). Covariates may be included in such models (repeated-measures analysis of covariance) (ANCOVA); however, the use of repeated-measures ANOVA/ANCOVA is limited in that many statistical programs (e.g., SPSS) can only accommodate couple-level covariates (Tabachnick & Fidell, 2007). For example, the age difference of couple members may be included as a covariate, but the individual ages of each partner could not be.

In some instances, the outcome variable exists only at the couple level (e.g., unprotected sex between the couple members). For example, Starks, Gamarel, and Johnson (2012) integrated responses from both dyad members in determining the occurrence of HIV transmission risk within the couple. In such cases, the model is a true one-level model and N equals the number of couples. When dyads are exchangeable, such models are restricted to couple-level predictors. Individual-level predictors may be included in instances where dyads are distinguishable.

Judd, Kenny, and McClelland (2001) describe an approach to the calculation of within and between couple effects by regressing the sums and differences of couple scores on outcome variables with the sums and differences of predictor variables. The advantage of their approach is that all of the necessary calculations may be conducted using ordinary least squares regression. The disadvantage is that four separate regression equations must be calculated and interpreted in order to explicate actor and partner effects at the individual level and effects of couple-level variables. While originally developed for distinguishable dyads, Darbes and Lewis (2005) applied this approach to exchangeable dyads by first designating partners by rank on the outcome variable (the partner with the higher outcome variable score was always partner 1). Such applications are useful in datasets with continuous outcome variables in which the occurrence of "ties" (or no variation) between couple members is rare. The arbitrary assignment of partners within dyads would

compromise results. Griffin and Gonzalez (1995) provide an alternative strategy for calculating Level 1 (actor and partner) associations based upon the ICC. The disadvantage of their approach is that the sample size correction necessary to evaluate statistical significance is complicated and not embedded in traditional software programs.

Conclusions

As illustrated by the examples provided in this article and the other articles in this Special Section, the study of interpersonal processes related to sexual health is a growth area. The advantages of these approaches, relative to studying individuals, are clear. They allow for a more sophisticated understanding of important relational processes that have been demonstrated to explain a relatively large proportion of the variance across a range of sexual health outcomes. In addition to the methodological issues described here, there are other important practical considerations when conducting dyadic research. The recruitment of couples, for example, presents additional logistical hurdles relative to studying individuals. For example, the schedule of both members of the couple must be accommodated when scheduling the study visit and it may be necessary to provide incentives to both participants, making such research more expensive. It is also critical to implement an approach for validating the relationship in the dyad so that individuals do not form “fake couples” in order to garner incentives. Studies often ask questions separately of the individuals about their relationship (e.g., Where did you meet? Where did you last have dinner together?) to potentially expose such couples and remove them from the study. Depending on the focus of the study, it may also be important to have a plan if violence occurs in the relationship (especially if sensitive or conflictual topics are discussed) or if one partner was unduly coerced into research participation. Nevertheless, approaches have been established to successfully address these concerns when conducting dyadic research.

There are a number of extensions of the approaches we described in this article that we consider to be promising future directions. First is the application of network science methodology to the study of romantic and sexual relationships, particularly among networks that are characterized by relatively small size or high levels of homophily, such as Black young MSM who are known to have small and tight nit sexual networks (Clerkin et al., 2011; Newcomb & Mustanski, 2013). Such networks allow for rapid movement of infectious diseases through a population and indeed the collection of network information--even just from the perspective of individual participants--has shown to provide incremental information about HIV risk above and beyond self-reported behavior (Perisse et al., 2010). The approaches described above, which focus solely on dyadic information, fail to incorporate important information about the network of relationships among individuals within a community and we encourage future research that applies network science methods to the study of interpersonal processes and sexual health.

Second, longitudinal research is needed that studies relationships over time in order to understand their developmental course and milestones and how they relate to health outcomes. Longitudinal research that integrates developmental science is of particular value for answering questions about how relationship processes differ throughout the life course. For example, having a partner several years older increases unprotected sex among young MSM, but the effect is unlikely to be the same among older MSM (Mustanski et al., 2011; Newcomb & Mustanski, 2013). Other interpersonal processes may also differ across development and explicating this would be very valuable.

Third, there is need for development and application of approaches that produce less recall bias, maximize ecological validity, and allow for the study of microprocesses that influence behavior. Earlier in this article, we discussed online daily diaries as one such approach;

another is ecological momentary assessment (EMA), which involves repeated sampling of behaviors and experiences in real time and in participants' natural environments (Shiffman, Stone, & Hufford, 2008). EMA data are often collected using technologies such as cell phones, electronic diaries, and physiological sensors. Newer analytic approaches for EMA data, such as mixed-effects location scale models (Hedeker, Mermelstein, & Demirtas, 2012), may be extended to dyadic data. A recent study with heterosexual couples has demonstrated the feasibility of collecting sexual behavior EMA data (Sunner, Walls, Blood, Mehta, & Shrier, 2013). This study also produced the interesting finding that couples agreed on condom use for nearly all sex events, but reported different reasons for the sex event. It also highlighted the value in using EMA to study motivational and relational processes related to sexual behavior. Further applications of these methods are needed to study interventions that promote sexual health within male couples. We believe there is tremendous potential in translating the findings of research with male couples to create innovative interventions that support couples to have healthy relationships that can improve the health of individuals within them.

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References

- Alferes VR, Kenny DA. SPSS programs for the measurement of nonindependence in standard dyadic designs. *Behavioral Research Methods*. 2009; 41:47–54.
- Barron D. The analysis of count data: Over-dispersion and autocorrelation. *Sociological Methodology*. 1992; 22:179–220.
- Boone MR, Cook SH, Wilson P. Substance use and sexual risk behavior in HIV-positive men who have sex with men: An episode-level analysis. *AIDS and Behavior*. 2013; 17:1883–1887. [PubMed: 22392156]
- Carpenter KM, Stoner SA, Mikko AN, Dhanak LP, Parsons JT. Efficacy of a web-based intervention to reduce sexual risk in men who have sex with men. *AIDS and Behavior*. 2010; 14:549–557. [PubMed: 19499321]
- CDC. HIV surveillance report, 2010. Atlanta, GA: U.S. Department of Health and Human Services; 2012.
- Clerkin EM, Newcomb ME, Mustanski B. Unpacking the racial disparity in HIV rates: The effect of race on risky sexual behavior among Black young men who have sex with men (YMSM). *Journal of Behavioral Medicine*. 2011; 34:237–243. [PubMed: 21107898]
- Cook WL, Snyder DK. Analyzing nonindependent outcomes in couple therapy using the actor-partner interdependence model. *Journal of Family Psychology*. 2005; 19:133–141. [PubMed: 15796659]
- Cooper ML. Alcohol use and risky sexual behavior among college students and youth: Evaluating the evidence. *Journal of Studies on Alcohol*. 2002; 14:101–117.
- Cooper ML. Toward a person x situation model of sexual risk-taking behaviors: illuminating the conditional effects of traits across sexual situations and relationship contexts. *Journal of Personality and Social Psychology*. 2010; 98:319–341. [PubMed: 20085403]
- Darbes LA, Lewis MA. HIV-specific social support predicts less sexual risk behavior in gay male couples. *Health Psychology*. 2005; 24:617–622. [PubMed: 16287408]
- Donenberg GR, Emerson E, Bryant FB, Wilson H, Weber-Shiffrin E. Understanding AIDS-risk behavior among adolescents in psychiatric care: Links to psychopathology and peer relationships.

- Journal of the American Academy of Child and Adolescent Psychiatry. 2001; 40:642–653. [PubMed: 11392341]
- Downey L, Ryan R, Roffman R, Kulich M. How could I forgot? Inaccurate memories of sexual intimate moments. *Journal of Sex Research*. 1995; 32:177–191.
- Gillmore M, DMM, Leigh BC, Hoppe MJ, Gaylord J, Rainey DT. Does “high = high risk”? An event-based analysis of the relationship between substance use and unprotected sex among gay and bisexual men. *AIDS and Behavior*. 2002; 6:361–370.
- Goodreau SM, Carnegie NB, Vittinghoff E, Lama JR, Sanchez J, Grinsztejn B, Buchbinder SP. What drives the US and Peruvian HIV epidemics in men who have sex with men (MSM)? *PLoS ONE*. 2012; 7:e50522. [PubMed: 23209768]
- Gooty J, Yammarino FJ. Dyads in organizational research: Conceptual issues and multilevel analyses. *Organizational Research Methods*. 2011; 14:456–483.
- Griffin DW, Gonzalez R. Correlational analysis of dyad-level data in the exchangeable case. *Psychological Bulletin*. 1995; 118:430–439.
- Grov C, Golub SA, Mustanski B, Parsons JT. Sexual compulsivity, state affect, and sexual risk behavior in a daily diary study of gay and bisexual men. *Psychology of Addictive Behaviors*. 2010; 24:487–497. [PubMed: 20853934]
- Heagerty PJ, Zeger SL. Marginalized multilevel models and likelihood inference (with comments and a rejoinder by the authors). *Statistical Science*. 2000; 15:1–26.
- Hedeker D, Mermelstein RJ, Demirtas H. Modeling between-subject and within-subject variances in ecological momentary assessment data using mixed-effects location scale models. *Statistics in Medicine*. 2012; 31:3328–3336. [PubMed: 22419604]
- Hoppe MJ, Morrison DM, Gillmore MR, Beadnell B, Higa DH, Leigh BC. Agreement of daily diary and retrospective measures of condom use. *AIDS and Behavior*. 2008; 12:113–117. [PubMed: 17492375]
- Hu FB, Goldberg J, Hedeker D, Flay BR, Pentz MA. Comparison of population-averaged and subject-specific approaches for analyzing repeated binary outcomes. *American Journal of Epidemiology*. 1998; 147:694–703. [PubMed: 9554609]
- Hubbard AE, Ahern J, Fleischer NL, Van der Laan M, Lippman SA, Jewell N, Satariano WA. To GEE or not to GEE: comparing population average and mixed models for estimating the associations between neighborhood risk factors and health. *Epidemiology*. 2010; 21:467–474. [PubMed: 20220526]
- Judd CM, Kenny DA, McClelland GH. Estimating and testing mediation and moderation in within-subject designs. *Psychological Methods*. 2001; 6:115–134. [PubMed: 11411437]
- Karney BR, Hops H, Redding CA, Reis HT, Rothman AJ, Simpson JA. A framework for incorporating dyads in models of HIV-prevention. *AIDS and Behavior*. 2010; 14:189–203. [PubMed: 20838872]
- Kenny, D.; Bolger, N.; Kashy, D. Traditional methods for estimating multilevel models. In: Moskowitz, DS.; Hershberger, SL., editors. *Modeling intraindividual variability with repeated measures data: Methods and applications*. Mahwah, NJ: Lawrence Erlbaum Associates; 2002. p. 1-21.
- Kenny DA, Cook W. Partner effects in relationship research: Conceptual issues, analytic difficulties, and illustrations. *Personal Relationships*. 1999; 6:433–448.
- Kenny DA, Judd CM. Consequences of violating the independence assumption in analysis of variance. *Psychological Bulletin*. 1986; 99:422–431.
- Kenny, DA.; Kashy, D.; Bolger, N. Data analysis in social psychology. In: Gilbert, D.; Fiske, S.; Lindsey, G., editors. *Handbook of social psychology*. 4. New York: McGraw-Hill; 1998. p. 233-265.
- Kenny, DA.; Kashy, DA.; Cook, WL. *Dyadic data analysis*. New York: Guilford Press; 2006.
- Laurenceau JP, Bolger N. Using diary methods to study marital and family processes. *Journal of Family Psychology*. 2005; 19:86–97. [PubMed: 15796655]
- Leigh BC. Alcohol and condom use: A meta-analysis of event-level studies. *Sexually Transmitted Diseases*. 2002; 29:476–482. [PubMed: 12172533]

- Leigh BC, Vanslyke JG, Hoppe MJ, Rainey DT, Morrison DM, Gillmore MR. Drinking and condom use: Results from an event-based daily diary. *AIDS and Behavior*. 2008; 12:104–112. [PubMed: 17333311]
- Long, JS.; Freese, J. Regression models for categorical dependent variables using Stata. 2. College Station, Tex: StataCorp LP; 2006.
- Marshall AD, Panuzio J, Makin-Byrd KN, Taft CT, Holtzworth-Munroe A. A multilevel examination of interpartner intimate partner violence and psychological aggression reporting concordance. *Behavior Therapy*. 2011; 42:364–377. [PubMed: 21658520]
- Mitchell JW, Harvey SM, Champeau D, Seal DW. Relationship factors associated with HIV risk among a sample of gay male couples. *AIDS and Behavior*. 2012; 16:404–411. [PubMed: 21614560]
- Mustanski B. The influence of state and trait affect on HIV risk behaviors: A daily diary study of MSM. *Health Psychology*. 2007; 26:618–626. [PubMed: 17845113]
- Mustanski B, Newcomb ME, Clerkin EM. Relationship characteristics and sexual risk-taking in young men who have sex with men. *Health Psychology*. 2011; 30:597–605. [PubMed: 21604883]
- Newcomb ME, Clerkin EM, Mustanski B. Sensation seeking moderates the effects of alcohol and drug use prior to sex on sexual risk in young men who have sex with men. *AIDS and Behavior*. 2011; 15:565–575. [PubMed: 20960048]
- Newcomb ME, Mustanski B. Racial differences in same-race partnering and the effects of sexual partnership characteristics on HIV risk in MSM: A prospective sexual diary study. *Journal of Acquired Immune Deficiency Syndromes*. 2013; 62:329–333. [PubMed: 23187943]
- Parsons JT, Starks TJ, Gamarel KE, Grov C. Non-monogamy and sexual relationship quality among same-sex male couples. *Journal of Family Psychology*. 2012; 26:669–677. [PubMed: 22906124]
- Perisse AR, Langenberg P, Hungerford L, Boulay M, Charurat M, Schechter M, Blattner W. Egocentric network data provide additional information for characterizing an individual's HIV risk profile. *AIDS*. 2010; 24:291–298. [PubMed: 19904198]
- Raudenbush, SW.; Bryk, AS. Hierarchical linear models: Applications and data analysis methods. 2. Thousand Oaks, CA: Sage Publications; 2002.
- Rodriguez G, Goldman N. An assessment of estimation procedures for multilevel models with binary responses. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*. 1995; 158:73–89.
- Schroder KE, Carey MP, Venable PA. Methodological challenges in research on sexual risk behavior: II. Accuracy of self-reports. *Annals of Behavioral Medicine*. 2003; 26:104–123. [PubMed: 14534028]
- Selig, JP.; McNamara, KA.; Card, NA.; Little, TD. Techniques for modeling dependency in interchangeable dyads. In: Card, NA.; Selig, JP.; Little, TD., editors. Modeling dyadic and interdependent data in the developmental and behavioral sciences. New York: Taylor & Francis Group; 2008. p. 191-212.
- Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. *Annual Review of Clinical Psychology*. 2008; 4:1–32.
- Starks TJ, Gamarel KE, Johnson MO. Relationship characteristics and HIV transmission risk in same-sex male couples in HIV serodiscordant relationships. *Archives of Sexual Behavior*. 2013
- Sullivan PS, Salazar L, Buchbinder S, Sanchez TH. Estimating the proportion of HIV transmissions from main sex partners among men who have sex with men in five US cities. *AIDS*. 2009; 23:1153–1162. [PubMed: 19417579]
- Sunner LE, Walls C, Blood EA, Mehta CM, Shrier LA. Feasibility and utility of momentary sampling of sex events in young couples. *Journal of Sex Research*. 2013; 50:688–696. [PubMed: 22823546]
- Tabachnick, BG.; Fidell, LS. Using multivariate statistics. Boston, MA: Pearson Education; 2007.
- Vosburgh HW, Mansergh G, Sullivan PS, Purcell DW. A review of the literature on event-level substance use and sexual risk behavior among men who have sex with men. *AIDS and Behavior*. 2012; 16:1394–1410. [PubMed: 22323004]
- Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. *Annual Review of Sex Research*. 2000; 11:125–157.

Zea MC, Reisen CA, Poppen PJ, Bianchi FT. Unprotected anal intercourse among immigrant Latino MSM: the role of characteristics of the person and the sexual encounter. *AIDS and Behavior*. 2009; 13:700–715. [PubMed: 19030982]

APPENDIX: HIV Risk Assessment for Sexual Partnerships (H-RASP)

Directions/Prompt

These next questions will be about vaginal, anal, or oral sex. Vaginal sex refers to penis in vagina; anal sex refers to penis in the anus or butt; and oral sex refers to penis in mouth, or mouth on vagina, or mouth in or around the butt. Remember your answers to these questions will be private. Please try your best to answer each question.

Entry Questions

HRASP_1. In your ENTIRE LIFE, how many females have you had oral, vaginal, or anal sex with? [numerical response]

HRASP_2. In your ENTIRE LIFE, how many males have you had oral or anal sex with? [numerical response]

If HRASP_1 > 0: HRASP_3. You said you had oral, vaginal, or anal sex with a total of [HRASP_1] females in your ENTIRE LIFE. In the PAST 6 MONTHS, how many females have you had oral, vaginal or anal sex with? [numerical response]

If HRASP_2 > 0: HRASP_4. You said you had oral or anal sex with a total of [HRASP_2] males in your ENTIRE LIFE. In the PAST 6 MONTHS, how many males have you had oral or anal sex with? [numerical response]

Partner-By-Partner Questions

Directions/Prompt

When answering the next question think about the PAST 6 MONTHS; the time period between [sixmonthsMONTH] [sixmonthsYEAR] and today.

If $HRASP_3 + HRASP_4 > 0$:

Initials_P1. Enter the initials of the MOST recent sexual partner you had in the PAST 6

MONTHS. If you do not know this partner's name, pick two letters that will help you remember, like 'BP' for 'the guy at my Birthday Party'.

If $HRASP_3 + HRASP_4 > 1$:

Initials_P2. Please enter the initials of the sexual partner you had before [Initials_P1], within the PAST 6 MONTHS. If you do not know this partner's name, pick two letters that will help you remember, like 'BP' for 'the guy at my Birthday Party'.

If $HRASP_3 + HRASP_4 > 2$:

Initials_P3. Please enter the initials of the sexual partner you had before [Initials_P1] and [Initials_P2], within the PAST 6 MONTHS. If you do not know this partner's name, pick two letters that will help you remember, like 'BP' for 'the guy at my Birthday Party'.

Partner 1

PBP_1. Is [Initials_P1] male, female, or transgender?

1, Male | 2, Female | 3, MTF (Male to Female Transgender) | 4, FTM (Female to Male Transgender)

PBP_2. How did you meet [Initials_P1]?

1, You went to the same school/college/university | 2, You met through a phone app | 3, You lived in the same neighborhood | 4, This person was a friend of another friend of yours | 5, You met at a party | 6, You met at a bar | 7, You met on the internet | 8, You met in a park | 9, You met in a bathhouse | 10, You met in some other way

If PBP_2 = 10: PBP_3. Please specify how you met [Initials_P1] [literal response]

PBP_4. What was the HIV status of [Initials_P1]?

1, He/she was HIV positive | 2, He/she was HIV negative | 3, I don't know his/her HIV status

If PBP_4 = 1 OR 2: PBP_5. How did you find out about [Initials_P1]'s HIV status?

1, He/she told me | 2, I found out through another person | 3, I assumed his/her HIV status | 4, Other

If PBP_5 = 4: PBP_6. Please specify how you found out about [Initials_P1]'s HIV status [literal response]

If PBP_4 = 1 OR 2: PBP_7. How confident are you about [Initials_P1]'s HIV status?

1, Extremely | 2, Somewhat | 3, Not really | 4, Not at all

PBP_8. How would you describe [Initials_P1]'s race or ethnic background?

1, White (non-Hispanic or Latino/a) | 2, Black/ African American (not Hispanic or Latino/a) | 3, Hispanic or Latino/a | 4, Asian or Pacific Islander | 5, Native American | 6, Other | 7, Multi-racial

If PBP_8 = 6: PBP_9. You described [Initials_P1]'s race or ethnic background as Other, please specify [literal response]

If PBP_8 = 7: PBP_10. You described [Initials_P1]'s race or ethnic background as Multi-racial, please specify [literal response]

PBP_11. What was your relationship with [Initials_P1]?

1, Serious relationship (boyfriend/girlfriend), someone you dated for awhile and feel very close to | 2, Casually dating but not serious | 3, Sleeping with this person (fuck buddy or booty call) but not dating | 4, One night stand | 5, Stranger or anonymous person

If PBP_11 = 1, 2, OR 3: PBP_12. How long have you been with [Initials_P1]?

1, Less than a month | 2, 1 to 3 months | 3, 4 to 6 months | 4, 7 months to 11 months | 5, 1 to 3 years | 6, Over 3 years

PBP_13. I really wanted my relationship with [Initials_P1] to last.

1, Strongly agree | 2, Agree | 3, Disagree | 4, Strongly disagree

PBP_14. [Initials_P1] was having sex with someone else.

1, Strongly agree | 2, Agree | 3, Disagree | 4, Strongly disagree

PBP_15. I was having sex with someone else.

1, Yes | 2, No

PBP_16. How old was [Initials_P1] when you first started having sex with him/her?

1, He/she was more than 2 years younger than you | 2, He/she was about 1 year younger than you | 3, You were the same age | 4, 1 to 2 years older than you | 5, 3 to 4 years older than you | 6, 5 or more years older than you | 7, I don't know how old he/she is

PBP_17. Has [Initials_P1] ever hit, slapped, punched, or hurt you?

1, Yes | 2, No

PBP_18. Did [Initials_P1] ever force you to have sex when you didn't want to? ("Force" includes physical and non-physical pressure, such as pushing you, arguing with you or threatening you in order to have sex).

1, Yes | 2, No

If PBP_18 = 1: PBP_19. Did [Initials_P1] ever force you to have unprotected sex when you didn't want to?

1, Yes | 2, No

PBP_19. Have you ever hit, slapped, punched, or hurt [Initials_P1] in a physical way?

1, Yes | 2, No

PBP_20. Did you ever force [Initials_P1] to have sex when he/she didn't want to? ("Force" includes physical and non-physical pressure, such as pushing, arguing or threatening your partner in order to have sex).

1, Yes | 2, No

If PBP_20 = 1: PBP_21. Did you ever force [Initials_P1] to have unprotected sex when he/she didn't want to?

1, Yes | 2, No

PBP_22. How frequently did you drink alcohol within two hours of having sex with [Initials_P1]?

1, Never | 2, Less than half the time | 3, About half the time | 4, More than half the time | 5, Always

PBP_23. How frequently did you use drugs within two hours before having sex with [name_]?

1, Never | 2, Less than half the time | 3, About half the time | 4, More than half the time | 5, Always

If PBP_1 = 2 OR 4: PBP_24. How many times did you have vaginal sex with [Initials_P1] during the PAST 6 MONTHS? [numerical response]

If PBP_24 > 0: PBP_25. How many times did you have vaginal sex without using a condom with [Initials_P1]? [numerical response]

PBP_26. How many times did you have anal sex with [Initials_P1] during the PAST 6 MONTHS? [numerical response]

If PBP_26 > 0: PBP_27. How many times did you have anal sex without using a condom with [Initials_P1]? [numerical response]

If PBP_27 > 0: PBP_28. How often did you use have sex without a condom during anal sex where you were the top with [Initials_P1]? [numerical response]

If PBP_37 > 0: PBP_29. How often did you have sex without a condom during anal sex where you were the bottom with [Initials_P1]?

PBP_30. How many times did you have oral sex with [Initials_P1] during the PAST 6 MONTHS? [numerical response]

If PBP_30 > 0: PBP_31. How many times did you use a condom during oral sex with [Initials_P1]? [numerical response]

Repeat for Partner 2 and Partner 3 as needed.

Figure 1.
The basic APIM model.

Figure 2.
The APIM with Distinguishable Dyads

Table 1

Example APIM Dataset with Exchangeable Dyads

Subject	Couple	x	x _p	y	y _p
1001	101	0	1	1	4
1002	101	1	0	4	1
1003	102	1	1	2	3
1004	102	1	1	3	2
1005	103	1	0	5	2
1006	103	0	1	2	5