**Undetectable or Unknown? A Longitudinal Event-Level Analysis on Disclosure of HIV Serostatus and Undetectability among Gay, Bisexual, and other Men who have Sex with Men (gbMSM) in Metro Vancouver**

**Author Information:**

Jordan M. Sang 1, Nathan J. Lachowsky 1,2, Lu Wang 1, Nicanor Bacani 1, Terry Howard 3,4, Everett Blackwell 3, Allan Lal 1, Heather L. Armstrong 5, Kiffer G. Card 1,2, Richard Crosby 6, Eric A. Roth 2, Robert S. Hogg 1,7, David M. Moore1,8

1 BC Centre for Excellence in HIV/AIDS, Vancouver, Canada 2 University of Victoria, Victoria, Canada 3 Momentum Health Study Community Advisory Board 4 Glass House Consultants, Vancouver, Canada 5 University of Southampton, Southampton, United Kingdom 6 University of Kentucky, Lexington KY, United States 7 Simon Fraser University, Burnaby, Canada 8 Faculty of Medicine, University of British Columbia, Vancouver, Canada

**Abstract:** We examined temporal trends and factors associated with reporting partner’s serostatus and viral load among a sample of gay, bisexual and other men who have sex with men (gbMSM) in Vancouver, Canada. Participants were recruited using respondent-driven sampling and we collected prospective cohort data from 09/2014-02/2017 using a computer-assisted questionnaire and nurse-administered STI/HIV testing. Our study included 481 participants reporting on 3780 sexual events. Among HIV-negative/unknown gbMSM we found a trend towards decreased proportions of sexual events reporting an unknown HIV-status partner (42% to 19%; p=<0.001) and found increased proportions among gbMSM living with HIV (11% to 27%; p=0.043). More participants living with HIV reported sex with undetectable partners, compared to HIV-negative/unknown participants (14.8 % vs. 5%). Our multivariable model found that compared with unknown status partners, undetectable partners were older, were from longer sexual relationships and were more likely to engage in condomless anal sex. Findings indicate that HIV-negative gbMSM seem more aware of the serostatus of their partners over time, but knowledge of partners’ viral load over time was not significant. Further research should assess the degree to which new campaigns such as Undetectable=Untransmittable (U=U) are associated with discussions about HIV disclosure and viral load status.

**Key words:** HIV disclosure, undetectable, serostatus, gbMSM, U=U

**INTRODUCTION**

Highly active antiretroviral therapy (HAART) has changed the prognosis and the life course of those living with HIV. Scale up of HAART has improved life expectancy, quality of life, and management of HIV as a chronic disease (1). Still, gay, bisexual, and other men who have sex with men (gbMSM) remain disproportionately affected by HIV, with gbMSM accounting for more than half of all Canadians living with HIV (51.9%), despite only representing 2 to 3% of the national population (2). HAART uptake is an important factor in combatting the HIV epidemic, often referred to as Treatment as Prevention (TasP) in public health practice (3, 4). When HIV cannot be detected by standard viral load test, a person living with HIV is considered to have an undetectable viral load (often 40-50 copies of HIV per milliliter of blood (<50 copies/mL)) (5). Thus, while condoms have traditionally been considered the primary form of protection for HIV transmission/acquisition during sex between serodiscordant partners, definitions of what constitutes ‘safe’ and ‘risky sex’ are changing, and condomless anal sex (CAS) with a person living with HIV who has an undetectable viral load (VL) may not be considered risky sex (6). More recently, the PARTNER 2 study affirmed the efficacy of TasP among gbMSM (6). This study spurred community activism of the Undetectable=Untransmittable (U=U) campaign, promoting knowledge of TasP backed with scientific consensus. Literature suggests that this knowledge is transferring back to gbMSM who reported increasing endorsement of TasP over time (7).

HIV serostatus disclosure is defined as identifying partners’ HIV status and disclosing one’s own serostatus. Disclosure is important for both partners in managing risk and engaging in sexual negotiation and other preventative approaches (8). GbMSM living with HIV may be especially reluctant to share their serostatus given the pervasiveness of stigma and fear of rejection associated with being HIV-positive (9). Recent literature indicates that serostatus disclosure (at their last sexual encounter) is more common among gbMSM and their primary partners (54%) but less common for casual or secondary partners (17%) (10). Exploring how gbMSM ascertain partner’s HIV status, Horvath and colleagues found that (2010) among gbMSM in San Francisco, most men relied on disclosure on online profiles, followed by talking before sex, discussing serostatus after sex, and lastly, guessing (11). The authors conclude that guessing a partner’s HIV status was associated with higher likelihood of engaging in CAS, higher likelihood of engaging in CAS with a serodiscordant partner, and inconsistent use of strategies to ascertain partner’s serostatus; discussing serostatus before sex was associated with lower likelihood of CAS with serodiscordant partners (11).

Sexual behavior is not consistent across all partners among all sexual situations and event-level research may better reveal the nuances between proximal (substance use, HIV disclosure) and person-level (substance use, viral load) determinants of HIV transmission risk behavior (12). An event-level analysis from Australia found that among gbMSM living with and without HIV, CAS is highest when a partner’s status is known or assumed, compared with unknown status partners (13). While knowing the serostatus of partners may help HIV risk management, assumptions about partner’s serostatus may increasingly expose gbMSM to risk of HIV infection (11). Recently, among a sample of gbMSM living with HIV, Sullivan and colleagues (2019) found that gbMSM who reported using condoms inconsistently were significantly less likely to report condom use at sexual events where they disclosed their HIV status. Alternatively, gbMSM with an undetectable VL who consistently used condoms were more likely to have disclosed their HIV status than those who consistently engaged in CAS (14).

HIV serostatus disclosure between partners is key in knowing and managing HIV sexual risk and disclosure paradigms may be changing given the advent and scale up of TasP and U=U. While evidence demonstrates that there is no risk of HIV transmission during CAS with a partner who is living with HIV and undetectable (6), there is significant risk associated with non-disclosure of unknown status partners; yet no studies have assessed the implications of increasing HARRT optimism on disclosure. As such, the first goal of this study was to examine temporal trends of HIV serostatus disclosure among partners over time. We hypothesized that the proportion of sexual events where an unknown status partner is reported would decrease, while reporting an undetectable status partner would increase. Our second goal was to examine event-level factors associated with reporting an undetectable HIV status partner versus unknown status partner over time for HIV-negative/unknown gbMSM. We hypothesized that sexual behaviors such as CAS would be associated with greater odds of reporting an undetectable HIV status partner compared to unknown status partners.

**METHODS**

**Study Protocol and Participants**

Data come from the [BLINDED FOR REVIEW], a prospective longitudinal, bio-behavioral study of gbMSM in Vancouver, British Columbia. Participants were recruited from February 2012 to February 2015 using respondent-driven sampling (RDS) (15). RDS recruitment involved initial “seed” participants who were recruited through community partner agencies and online advertisements on gbMSM social networking websites and apps (16). To be eligible, participants had to gender identify as a man, be 16 years of age or older, report having sex with another man in the past six-months (P6M), currently live in Metro Vancouver, and be able to complete the questionnaire in English. We obtained written informed consent and participants completed 90-minute in-person study visits every six months over the study period (February 2012 to February 2017); however, this analysis is limited to study visits which occurred from September 2014 to February 2017 as the partner serostatus/undetectability status questions used in this analysis were added in the survey at that time. We collected information about participants’ demographics, sexual behaviors, substance use, psychosocial attributes, and details about their last sexual episode (event-level) with each of their most recent partners (up to five within the P6M) using a computer-assisted self-interview (CASI). Subsequently, participants completed a nurse-administered clinical questionnaire and blood collection for HIV, syphilis, and Hepatitis C testing. Participants received a $50 CAD honorarium for their participation at each visit and could receive an additional $10 CAD for each eligible participant they referred (maximum of six). The research protocol was approved by the research ethics boards of Simon Fraser University, the University of British Columbia, and the University of Victoria. Additional details about the study protocol, RDS networks and participant seeds have been published elsewhere (16-19).

**Outcome Variable**

During the CASI, participants completed a “partner matrix” of a repeating set of questions about their last sexual encounter (event-level factors, see below) with up to their 5 most recent sexual partners within the past 6 months. Participants were only asked to report on one sexual event, the most recent one, with each of their recent sexual partners (to a maximum of 5 partners). The main outcome for this analysis was the HIV and viral load status of individual sexual partners as reported by the participant. This was assessed by asking participants if they knew the HIV status of their partner before sex. If participants indicated that their partner was HIV-positive they were asked if they knew their partner’s most recent HIV viral load. Responses were: 1) “No, I did not know his viral load”; 2) “Undetectable”; 3) “Detectable.” Using these questions, we created five categories: 1) HIV unknown status partners for participants that indicated “No, I did not know his HIV status” when asked about partner’s HIV status. The second category was: 2) HIV- negative partners for participants that indicated “Yes, I was certain he was HIV-negative” or “Yes, I think he was HIV-negative but I’m not 100% sure.” The third category was: 3) HIV-positive partner with unknown viral load for participants that indicated an HIV-positive partner but did not know their viral load. The fourth category was: 4) HIV-positive partner with undetectable viral load, for participants who indicated their partner’s positive HIV status and had an undetectable viral load. The last category was: 5) HIV-positive partner with a detectable viral load, for participants who indicated their partner’s positive HIV status and had a detectable viral load. We include a flow chart in the supplemental files to further illustrate our outcome variable.

**Explanatory Variables**

We assessed individual-level variables including participants’ awareness of PrEP and PEP, use of PrEP and PEP, and awareness of Treatment as Prevention. Additionally, we asked if participants had anal sex without condoms with a partner who was living with HIV who had a low viral load or was on HIV treatment, as well as sex work history (P6M). We also asked the 10-item Alcohol Use Disorders Identification Test (AUDIT) (20) which assessed alcohol dependence; responses were on a five-point Likert scale with scores ranging from 0-40. Sociodemographic variables included age, sexual orientation, ethnicity, annual income, current relationship status, educational attainment, and anal sex role preference.

At the event-level, we asked about relative age of partners (much younger/younger than me; about the same age; much older/older than me), sexual activities (including anal sex with and without condoms), receiving money/drugs/goods for sex, participant’s own substance use and partner’s substance use two hours before or during sex (alcohol, cannabis, erectile drugs, poppers, crystal methamphetamine, gamma hydroxybutyrate (GHB), ecstasy). Additionally, for each partner, we asked about time since first sex, as well as the number of times they reported sex and anal sex with each partner (P6M).

Our psychosocial measures included the Escape Motivation Scale (12 questions,study α=0.90) (21) which assessed if gbMSM used alcohol and other substances to diminish cognitive recognitions of sexual risk (e.g., “When I am high or drunk, I am more likely to have sex with people I wouldn’t ordinarily have sex with”). Each response was scored on a 4-point Likert scale ranging from strongly disagree to strongly agree, with the highest possible score of 48; higher scores indicated greater escape motivations. We also included the HIV Treatment Optimism-Skepticism Scale (12 questions, study α=0.85), which assessed sexual risk perceptions associated with treatment (e.g., “HIV/AIDS is a less serious threat than it used to be because of new treatments”) (22). Each response was scored on a 4-point Likert scale ranging from strongly disagree to strongly agree, with the highest possible score of 36; higher scores indicated greater treatment optimism.

**Analysis**

We first stratified participants by HIV status and assessed demographic differences between participants. We used repeated measuresmultilevel models (RDS recruitment chain; participant; visit; event) for our bivariate and mixed-effects model. We used 6-month calendar periods to assess temporal trends, where events were categorized into a time period based on the date they were reported to have occurred by a participant. Participants referred by the same person were considered as one cluster in the four-level mixed effects models. Repeated measures and RDS correlation were all considered in the four-level models. We used RDS clusters as opposed to RDS-II weights because the main purpose of RDS weights is to produce a more accurate population parameter estimate, which was not an aim of this analysis for individual sexual events. Instead, we considered RDS referral a cluster and accounted for this in our analysis to address issues on non-independence introduced to our data through RDS. Variables in the univariable models with a *p*-value <0.2 were included for consideration in the multivariable models (23). The final models were selected using a backward selection technique based on two criteria (Akaike Information Criterion (AIC) and Type III *p*-values), whereby the least significant (i.e., highest Type III *p*-value) variable was dropped until the final models reached the optimal (minimum) AIC. Four-level multivariable generalized mixed models compared events where participants reported their sexual partners to be “undetectable” versus events where partner’s HIV status was unknown, accounting for RDS chains. Univariable and multivariable analyses were limited to HIV-negative/unknown participants. However, as we could not determine whether participants recruited individuals who were also reported on in the event-level matrix, this poses a risk for violating the independence assumption. We conducted post-hoc analyses to test for reciprocity in our sample using participants’ relationship to their referrer as a proxy. We assessed significant differences on our outcomes by participants who were recruited by sexual partners versus others using univariable generalized linear mixed models. We also included a sensitivity analysis using RDS clustering where we excluded participants who were recruited by sexual partners. Following our original analysis, we applied univariable and multivariable generalized linear mixed models to assess the odds of reporting an undetectable versus unknown partner. Lastly, we included analyses to test if participants who were lost to follow up significantly differed than participants who remained in our study. All analyses were conducted using SAS version 9.4 (SAS, Cary, NC). Odds ratios (OR) and adjusted odds ratios (aOR) are reported and significance was assessed based on 95% confidence intervals and *p*-value less than 0.05.

**RESULTS**

**RDS, Demographic and Sexual Event Results**

The total sample for [BLINDED FOR REVIEW] was *N*=719 participants, who were recruited from 119 (16.6%) seeds and comprising 339 RDS clusters. A total of 30 seeds were initially recruited and another 89 were added later to maintain recruitment. The median number of gbMSM participants reported knowing and whom they felt comfortable giving a coupon to was 10 (Q1–Q3: 5–20). In total, 3712 coupons were distributed, of which, 708 (19%) were returned by potential study participants. A total of 50 seeds (42%) did not recruit any participants and 24 (20%) recruited only one other participant. The remaining 576 non-seeds were recruited through 45 chains, which were a median of 3 generations long, with a median total of 7 recruits per chain. The longest chain was 16 generations and recruited 77 participants. Figure 1 demonstrates the recruitment chains for the study sample.

The analytical sample for this study was limited to all cohort participants who completed a study visit where they answered the event-level question asking their partners’ viral load status. Our final sample was 481 participants who completed 1303 visits reporting on 3786 sexual events (29.7% from self-reported gbMSM living with HIV) from September 2014 to February 2017; 6 events were removed from the analysis due to small sample size. The total number of RDS clusters for all sexual events (*N*=3780) was 339. We include a brief descriptive of these 6 events, all of whom were from one participant. Of the six events excluded, four included condomless anal sex as a bottom, in five of these events partners were older than the participant, five events including using sex toys without sharing, and in five events partner marijuana use was reported.

Among 335 gbMSM who self-reported as HIV-negative/unknown, there were 903 visits and 2661 sexual events reported. Among 146 gbMSM who self-reported as HIV-positive, there were 400 visits and 1125 sexual events reported. Overall, 423 (88%) identified as gay, 350 (72.8%) were over 30 years old, and 367 (76.3%) identified as White. Full demographic results are in Table 1. Among self-reported HIV-negative/unknown gbMSM’s sexual events (*N*=2261), 1798 (68%) included sex with an HIV-negative partner, 661 (25%) included sex with an HIV-unknown status partner, 68 (3%) included sex with a partner who was living with HIV with unknown viral load, and 134 (5%) included sex with a partner who was living with HIV who had an undetectable viral load. Among sexual events reported by participants living with HIV (*N*=1125), 404 (36%) included sex with an HIV-negative partner, 268 (24%) included sex with an HIV-unknown status partner, 284 (25%) included sex with a partner who was living with HIV with unknown viral load, 6 (1%) included sex with a partner who was living with HIV with known viral load and not undetectable (events removed from analysis), and 163 (14%) included sex with a partner who was living with HIV who had an undetectable viral load. Frequencies for all reported sexual events are in Table 2.

**Trend Analyses**

We assessed temporal trends for awareness of partner’s HIV status and/or viral load. There was a total of 3691 sexual events reported, excluding events with year and month missing or recent sex more than six months prior to interview. Among HIV-negative/unknown gbMSM, we found decreases in the proportion of sexual events where participants reported an unknown status partner (T1=42%, T2=27%, T3=25%, T4=22%, T5=19%; *p*<0.001) and we also found an increased reporting of sex with partners who identified as HIV-negative (T1=56%, T2=67%, T3=66%, T4=69%, T5=75%; *p*=0.002). We did not find significant trends for reporting a partner living with HIV with unknown viral load (*p*=0.722*)* or reporting a partner living with HIV with undetectable viral load (*p*=0.135). Full results are in Figure 2. Among gbMSM living with HIV, we found a trend towards increased reporting of unknown status partners (T=11%, T2=21%, T3=21%, T4=31%, T5=27%; *p*=0.043). We did not find significant trends for reporting an HIV-negative status partner (*p*=0.93), a partner living with HIV with unknown viral load (*p*=0.059*),* or a partner living with HIV with an undetectable viral load (*p*=0.71*)*. Full results are in Figure 3.

**Analytical Results**

Our multivariable model assessed odds of reporting an undetectable status partner versus an unknown status partner among HIV-negative/unknown gbMSM. Asian ethnicity (aOR=0.09; 95% CI=0.02, 0.52) and engaging in sex work (P6M) (aOR=0.05; 95% CI=0.01, 0.29) were associated with lower odds of reporting an undetectable status partner. Reporting any CAS in the past six months with a partner living with HIV with low viral load or who was on treatment (aOR=6.42; 95% CI=3.36, 12.27) was associated with greater odds of reporting an undetectable status partner. At the event-level, reporting older sexual partners (aOR=2.97; 95% CI=1.42, 6.21), reporting CAS as a top (aOR=6.12; 95% CI=3.49, 10.74) or bottom (aOR=3.25; 95% CI=1.86, 5.70), sexual activities involving shared sex toys (aOR=9.94; 95% CI=2.64, 37.50), and more months since first sex with that partner (aOR=1.01; 95% CI=1.00, 1.03) were associated with greater odds of reporting an undetectable status partner. Event-level substance use such as participant crystal methamphetamine use (aOR=5.92; 95% CI=1.87, 18.75) and partner’s GHB use (aOR=13.44; 95% CI=2.20, 82.19) were associated with increased odds of reporting an undetectable status partner. Participant event-level GHB use (aOR=0.10; 95% CI=0.02, 0.56) was associated with lower odds of reporting an undetectable status partner.

Having heard of TasP was not significantly associated with event-level partner HIV status in our univariable analysis (OR=1.49; 95% CI= 0.61, 3.63), and although HAART Treatment optimism was univariably significant (OR=1.12; 95% CI=1.06, 1.19), it was not selected for our multivariable model. Full univariable and multivariable results can be found in Table 3 and Table 4.

We conducted post-hoc loss to follow up analyses to see if participants who were lost to follow up significantly differed than our sample on reporting awareness of partner’s viral load. We did not find significant differences between events from participants reporting at the last visit (*n*=1211) compared with participants were lost to follow up (*n*=175) and did not report events at the last visit. We also examined differences between participants who were recruited into the study by sexual partners versus those who were recruited by other individuals and found participants who were recruited by sexual partners were less likely to report HIV-unknown status partners compared with participants recruited by other individuals (OR=0.75; 95% CI=0.60, 0.95) (results are reported in supplemental Table 1). We also included a sensitivity analysis, removing participants who were recruited by sexual partners and found GBM who reported having anal sex without a condom with HIV-positive partners with low viral loads or who were on HIV treatment (aOR=5.98; 95%CI=2.41, 14.87), event-level sexual activities including anal sex as a bottom without a condom (aOR=4.19; 95%CI=2.10, 8.38), anal sex as a top without a condom (aOR=7.33; 95%CI=3.01, 17.86), and months since first sex (aOR=1.01; 95%CI=1.00, 1.02) were associated with greater odds of reporting an undetectable versus unknown status partner. Full multivariable results can be found in supplemental Table 2.

**DISCUSSION**

Our first study aim was to assess the longitudinal trends of awareness of partner’s HIV serostatus from 2014 – 2017. We found significant decreases in the proportion of sexual events where HIV-negative/unknown participants reported an unknown status partner (42% to 19%) and increases in the proportion of sexual events where participants reported an HIV-negative partner (56% to 75%). Among gbMSM living with HIV, we found increases in the proportion of sexual events where an unknown status partner was reported (11% to 27%). Our second aim was to assess event-level factors associated with reporting an undetectable vs unknown status partner. We found partners tended to be older than participants, sexual relationships were of longer duration, and sexual events were more likely to include CAS. However, awareness of TasP and HAART treatment optimism scores were not significantly associated with having an undetectable versus unknown partner HIV status in our final multivariable model.

Consistent with our hypothesis, among HIV-negative/unknown gbMSM we found decreasing trends in the proportion of events which included an unknown status partner and increasing trends in the proportion of events which included an HIV-negative partner. We hypothesize these findings may be due to increased testing and awareness of HIV status in BC (24). To note, unknown-HIV status in our analysis meant unknown to participants, but the likelihood of these partners having an “unknown” HIV status is very low given the high HIV testing trends in BC (25) and low proportion of participants who self-reported as unknown-HIV status at enrollment; it is more likely that no discussion about HIV status took place. In general, the proportion of HIV-negative/unknown participants reporting sex with a partner living with HIV (undetectable or not) was relatively low. While existing literature has investigated trends of serostatus disclosure of HIV among gbMSM partners (13), our research expands on these findings by further exploring disclosure of viral load status among gbMSM living with HIV. Among gbMSM living with HIV, we found an increasing trend in the proportion of partners where HIV status was unknown. It is possible that given the high rates of viral suppression in BC (26) and awareness of TasP (7), gbMSM living with HIV may not be worried about HIV transmission. Therefore, asking about partners’ HIV status may not matter to participants living with HIV and disclosure practices may differ by serostatus. We support future research to explore associations between perceived likelihood of transmission and disclosure of HIV serostatus.

This study’s second goal was to examine event-level factors associated with reporting an undetectable HIV status partner compared with an unknown HIV status partner among HIV-negative/unknown participants. Event-level factors associated with increased odds of reporting an undetectable partner as compared with an unknown HIV status partner included reporting longer sexual relationships, CAS as a top or as a bottom, and sharing sex toys. Previously, these factors have been associated with increased HIV transmission amongst sero-discordant partners (27, 28). However, reporting an undetectable status may have reassured gbMSM of the zero likelihood of HIV transmission allowing them to adjust their sexual practices and engage in previously labeled “riskier” sexual practices. We also found longer sexual relationships among serodiscordant partners was associated with increased odds of reporting an undetectable status partner. We hypothesize that conversations about HIV disclosure may be more likely among long-term partners as opposed to casual sex partners. However, as knowledge of U=U is further synthesized among gbMSM communities over time, we suspect that an individual’s knowledge of their partners’ viral load status will become a more relevant factor in sexual decision making among all partners.

Existing comparisons between event-level and individual-level sexual behaviors recall measures among gbMSM indicate weak to moderate agreement (12). We hypothesize that event-level factors such as age of partners and different substances used, will expectedly vary by different sexual encounter contexts. However, our questionnaire did not have individual-level specificity to conduct comparisons with event-level variables, especially in relation to the specific sexual activities undertaken at each sexual event. The strength of using event-level data, is the fact that we can assess variables co-occurring in the same sexual event. Our event-level findings provide valuable insight on proximal contextual factors at play in specific sexual events where viral load may be considered in sexual decision making. We support future research comparing disclosure agreement at the event-level and individual-level.

**Limitations**

This study was subject to a number of strengths and limitations. First, our study only included partner disclosure of HIV serostatus and did not include participants’ disclosure to partners. Including both measures would allow the ability to fully examine the duality of HIV disclosure such as “biomed matching” and we support future research comparing disclosure between partners. Second, based on the sensitive nature of our subject, data is vulnerable to social desirability bias. However, the use of computer-administer questionnaires to collect sensitive information may have helped mitigate this. Third, our study was based in British Columbia, which was one of the first places to implement a TasP strategy (29). As such, generalizability of findings may be limited, especially in rural or remote areas. However, our large sample size and follow up period strengthen the validity of our data. Moreover, some covariates in our model such as months since first sex and sex work may be more likely to be mediators than confounders. As such, we support future mediation analyses exploring associations with reporting an undetectable versus unknown status partner. Another limitation was that our data could not determine whether a participant’s recruits or their recruiter were the people reported in the event-level matrix or if participants reported on the same partner across multiple visits. Thus, this limitation had the potential to violate the independence assumption. To address this, we looked at the relationship to how participants were recruited into the study and found less than a quarter (23.7%) were recruited from sexual partners, while the remainder were recruited by friends or other acquaintances. Our post-hoc analysis found participants who were recruited by sexual partners were less likely to report HIV-unknown status partners compared with participants recruited by other individuals. This finding may bias our trends of unknown status partners, such that increasing trends of reporting an unknown status partner may be underestimated and decreasing trends for HIV-negative participants may be overestimated. To further explore this possible bias, we conducted a sensitivity analysis and excluded participants who were recruited by sexual partners. We found some consistency in certain variables but found event-level substance use variables were not significant. We support future research that explicitly uses a dyadic data approach to explore more direct associations between sexual partners, sexual behaviors, and substance use.

**Public Health Implications**

Given recent scale up of TasP and U=U, this research is timely and has several public health implications. We were surprised that we did not find significant trends of reporting an undetectable status partner, given that current HIV treatment cascades in British Columbia indicate high viral suppression rates among gbMSM (92%) (30). This may suggest enduring internalized stigma among gbMSM living with HIV who must disclose their HIV-positive status along with being undetectable. Therefore, health interventions and U=U campaigns should seek to directly address HIV stigma for all HIV-positive gbMSM, not just those who are undetectable. Additionally, in our multivariable model, awareness of TasP and HAART Treatment optimism scores were also non-significant. We hypothesize that our individual level predictors of TasP awareness and HAART optimism may not fully capture social/community-level changes of TasP or U=U. Public health interventions should continue to facilitate current knowledge translation of U=U to the community. Our data collection period included the start of the U=U campaign, but since then, new campaigns with related messages have emerged, including the “Can’t Pass it on” campaign (31).

**CONCLUSIONS**

Overall, our event-level data on sexual practices provide mixed evidence on the implications of community knowledge of TasP among gbMSM in Vancouver, Canada. This novel analytic approach combining longitudinal event-level analyses from a RDS sample is nascent and requires additional fundamental biostatistical research to understand the possibilities and ramifications of these design limitations for sexual health studies among a highly sexually networked population. Despite non-significant interactions between TasP awareness and HAART optimism scores in our trend analysis and multivariable model, it is evident that gbMSM are changing their behaviors around discussions about HIV status with sexual partners with significant differences by serostatus. Further research should assess the degree to which U=U and TasP campaigns promote discussions about HIV disclosure and viral load status.

**Acknowledgements**

We would like to thank the [BLIND FOR REVIEW] participants, office staff and community advisory board as well as our community partners: Health Initiative for Men, YouthCO HIV & Hep C Society, and Positive Living Society of BC. This work was supported by the National Institute on Drug Abuse (R01DA031055-01A1) and the Canadian Institutes of Health Research (MOP-107544, FDN-143342, PJT-153139). NJL was supported by a CANFAR/CTN Postdoctoral Fellowship Award. HLA was supported by a Postdoctoral Fellowship award from the Canadian Institutes of Health Research (Grant #MFE-152443). DMM and NJL are supported by Michael Smith Foundation for Health Research Scholar Awards (#5209, #16863). KGC is supported by a Canadian Institutes of Health Research Health Systems Impact Fellowship award, a Michael Smith Foundation for Health Research Trainee award, and a Canadian HIV Trials Network/Canadian Foundation for AIDS Research Postdoctoral Fellowship award.

**References**

1. Montaner JSG, Lima VD, Harrigan PR, Lourenço L, Yip B, Nosyk B, et al. Expansion of HAART coverage is associated with sustained decreases in HIV/AIDS morbidity, mortality and HIV transmission: the "HIV Treatment as Prevention" experience in a Canadian setting. PloS one. 2014;9(2):e87872.

2. Challacombe L. The epidemiology of HIV in gay, bisexual and other men who have sex with men CATIE2018 [Available from: <https://www.catie.ca/fact-sheets/epidemiology/epidemiology-hiv-gay-men-and-other-men-who-have-sex-men>.

3. Cohen J. HIV Treatment as Prevention. Science. 2011;334(6063):1628-.

4. Cohen MS, Chen YQ, McCauley M, Gamble T, Hosseinipour MC, Kumarasamy N, et al. Antiretroviral Therapy for the Prevention of HIV-1 Transmission. The New England Journal of Medicine. 2016;375(9):830-9.

5. Arkell C, Harrigan M. HIV treatment and an undetectable viral load to prevent HIV transmission CATIE2018 [Available from: <https://www.catie.ca/en/fact-sheets/transmission/hiv-viral-load-hiv-treatment-and-sexual-hiv-transmission>.

6. Rodger AJ, Cambiano V, Bruun T, Vernazza P, Collins S, Degen O, et al. Risk of HIV transmission through condomless sex in serodifferent gay couples with the HIV-positive partner taking suppressive antiretroviral therapy (PARTNER): final results of a multicentre, prospective, observational study. The Lancet. 2019;393(10189):2428-38.

7. Card KG, Armstrong HL, Lachowsky NJ, Cui Z, Sereda P, Carter A, et al. Belief in Treatment as Prevention and Its Relationship to HIV Status and Behavioral Risk. JAIDS Journal of Acquired Immune Deficiency Syndromes. 2018;77(1):8-16.

8. Simon Rosser BR, Horvath KJ, Hatfield LA, Peterson JL, Jacoby S, Stately A, et al. Predictors of HIV disclosure to secondary partners and sexual risk behavior among a high-risk sample of HIV-positive MSM: results from six epicenters in the US. AIDS Care. 2008;20(8):925-30.

9. Li H, Chen X, Yu B. Disclosure appraisal mediating the association between perceived stigma and HIV disclosure to casual sex partners among HIV+ MSM: a path model analysis. AIDS Care. 2016;28(6):722-5.

10. Marcus U, Schink SB, Sherriff N, Jones A-M, Gios L, Folch C, et al. HIV serostatus knowledge and serostatus disclosure with the most recent anal intercourse partner in a European MSM sample recruited in 13 cities: results from the Sialon-II study. BMC infectious diseases. 2017;17(1):730-17.

11. Horvath KJ, Nygaard K, Simon Rosser BR. Ascertaining Partner HIV Status and its Association with Sexual Risk Behavior Among Internet-Using Men Who Have Sex with Men. AIDS and Behavior. 2010;14(6):1376-83.

12. Lachowsky NJ, Card KG, Cui Z, Sereda P, Roth EA, Hogg RS, et al. Agreement between gay, bisexual and other men who have sex with men’s period prevalence and event-level recall of sexual behaviour: an observational respondent-driven sampling study. Sexual Health. 2019;16(1):84.

13. Zablotska IB, Imrie J, Prestage G, Crawford J, Rawstorne P, Grulich A, et al. Gay men's current practice of HIV seroconcordant unprotected anal intercourse: serosorting or seroguessing? AIDS Care. 2009;21(4):501-10.

14. Sullivan MC, Cruess DG, Huedo-Medina TB, Kalichman SC. Substance Use, HIV Serostatus Disclosure, and Sexual Risk Behavior in People Living with HIV: An Event-Level Analysis. Archives of sexual behavior. 2019.

15. Volz E, Heckathorn DD. Probability Based Estimation Theory for Respondent Driven Sampling. Journal of Official Statistics. 2008;24(1):79.

16. Lachowsky NJ, Lal A, Forrest JI, Card KG, Cui Z, Sereda P, et al. Including Online-Recruited Seeds: A Respondent-Driven Sample of Men Who Have Sex With Men. Journal of medical Internet research. 2016;18(3):e51.

17. Forrest JI, Lachowsky NJ, Lal A, Cui Z, Sereda P, Raymond HF, et al. Factors Associated with Productive Recruiting in a Respondent-Driven Sample of Men who Have Sex with Men in Vancouver, Canada. Journal of Urban Health. 2016;93(2):379-87.

18. Lachowsky NJ, Sorge JT, Raymond HF, Cui Z, Sereda P, Rich A, et al. Does size really matter? A sensitivity analysis of number of seeds in a respondent-driven sampling study of gay, bisexual and other men who have sex with men in Vancouver, Canada. BMC medical research methodology. 2016;16(1):157-10.

19. Moore DM, Cui Z, Lachowsky N, Raymond HF, Roth E, Rich A, et al. HIV Community Viral Load and Factors Associated With Elevated Viremia Among a Community-Based Sample of Men Who Have Sex With Men in Vancouver, Canada. Journal of acquired immune deficiency syndromes (1999). 2016;72(1):87-95.

20. Saunders JB, Aasland OG, Babor TF, De La Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption‐II. Addiction. 1993;88(6):791-804.

21. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual "escape" and sexual risk among drug and alcohol-involved gay and bisexual men. Journal of substance abuse. 2001;13(1-2):137.

22. Van de Ven P, Crawford J, Kippax S, Knox S, Prestage G. A scale of optimism-scepticism in the context of HIV treatments. AIDS care. 2000;12(2):171-6.

23. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. American journal of epidemiology. 1993;138(11):923-36.

24. BC Centre for Disease Control. HIV in British Columbia: Annual Surveillance Report 2016.

25. BC Centre for Excellence in HIV/AIDS. HIV Monitoring Quarterly Report for British Columbia. 2018.

26. BC Center for Excellence in HIV/AIDS. HIV Cascade of Care in British Columbia. 2016.

27. Card KG, Lachowsky NJ, Cui Z, Shurgold S, Armstrong HL, Rich AJ, et al. An Event-Level Analysis of the Interpersonal Factors Associated With Condomless Anal Sex Among Gay, Bisexual, and Other Men Who Have Sex With Men (MSM) With Online-Met Partners. AIDS Education and Prevention. 2017;29(2):154.

28. Mustanski BPD, Newcomb MEPD. Older Sexual Partners May Contribute to Racial Disparities in HIV Among Young Men Who Have Sex With Men. Journal of Adolescent Health. 2013;52(6):666-7.

29. British Columbia Centre for Excellence in HIV/AIDS. Treatment as Prevention 2019 [Available from: <http://www.cfenet.ubc.ca/tasp>.

30. Lourenço L, Colley G, Nosyk B, Shopin D, Montaner JSG, Lima VD, et al. High levels of heterogeneity in the HIV cascade of care across different population subgroups in British Columbia, Canada. PloS one. 2014;9(12):e115277.

31. Terrence Higgins Trust. Can't Pass It On 2019 [Available from: <https://www.tht.org.uk/our-work/our-campaigns/cant-pass-it-on>.

**Table 1: Sociodemographic Characteristics of participants, Stratified by HIV serostatus**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall**  ***N*=481** | | | **HIV-Negative/unknown**  ***n*=335** | | **HIV-Positive *n*=146** | |
|  | **Total *N*** |  | **(%)** | ***n*** | **(%)** | ***n*** | **(%)** |
| **Individual-Level Variables** |  |  |  |  |  |  |  |
| **Sexual Identity** | 481 |  |  |  |  |  |  |
| Gay |  | 423 | (87.9) | 290 | (86.6) | 133 | (91.1) |
| Bisexual/Other |  | 58 | (12.1) | 45 | (13.4) | 13 | (8.9) |
| **Ethnicity** | 481 |  |  |  |  |  |  |
| White |  | 367 | (76.3) | 251 | (74.9) | 116 | (79.5) |
| Asian |  | 53 | (11.0) | 42 | (12.5) | 11 | (7.5) |
| Indigenous |  | 23 | (4.8) | 13 | (3.9) | 10 | (6.8) |
| Latin American/Other |  | 38 | (7.9) | 29 | (8.7) | 9 | (6.2) |
| **Age at interview date** | 481 |  |  |  |  |  |  |
| Under 30 |  | 131 | (27.2) | 123 | (36.7) | 8 | (5.5) |
| 30 and over |  | 350 | (72.8) | 212 | (63.3) | 138 | (94.5) |
| **Total annual income last year** | 480 |  |  |  |  |  |  |
| Less than $30000 |  | 235 | (49.0) | 141 | (42.1) | 94 | (64.8) |
| $30000 to $59999 |  | 159 | (33.1) | 121 | (36.1) | 38 | (26.2) |
| $60000 and over |  | 86 | (17.9) | 73 | (21.8) | 13 | (9.0) |
| **Anal Sex Preference** | 481 |  |  |  |  |  |  |
| Bottom |  | 170 | (35.3) | 116 | (34.6) | 54 | (37.0) |
| Versatile |  | 130 | (27.0) | 86 | (25.7) | 44 | (30.1) |
| Top |  | 161 | (33.5) | 121 | (36.1) | 40 | (27.4) |
| Prefer no anal |  | 20 | (4.2) | 12 | (3.6) | 8 | (5.5) |
| **Current relationship status** | 478 |  |  |  |  |  |  |
| No regular partner |  | 260 | (54.4) | 173 | (51.8) | 87 | (60.4) |
| In relationship |  | 218 | (45.6) | 161 | (48.2) | 57 | (39.6) |
| **Highest level of education** | 481 |  |  |  |  |  |  |
| High school or less |  | 70 | (14.6) | 38 | (11.3) | 32 | (21.9) |
| Greater than high school |  | 411 | (85.4) | 297 | (88.7) | 114 | (78.1) |

**A group of stars in the sky

Description automatically generated with low confidence**

**Figure 1: Recruitment chains for the [BLIND FOR REVIEW]. White = self-reported HIV-negative, black = self-reported HIV-positive, grey = other; circle = 16 to 24 years; square = 25 to 39 years, and triangle = 40+ years**

**Table 2: Frequencies for all Reported Sexual Events among gbMSM in Vancouver, Canada**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Self-reported HIV status** | | | | | | | |
|  |  | **Overall *(N*=3786)** | | **HIV- Negative/unknown (*n*=2661)** | | **HIV- Positive (*n*=1125)** | |
| **Variable** |  | ***n*** | **(%)** | ***n*** | **(%)** | ***n*** | **(%)** |
| **Awareness of Partner Viral Load** |  |  |  |  |  |  |  |
| HIV-Negative partner |  | 2202 | (58) | 1798 | (68) | 404 | (36) |
| HIV-Unknown status partner |  | 929 | (25) | 661 | (25) | 268 | (24) |
| HIV-Positive partner (Unknown viral load) |  | 352 | (9) | 68 | (3) | 284 | (25) |
| HIV-Positive partner of known detectable viral load\* |  | 6 | (0) |  |  | 6 | (1) |
| HIV-Positive partner (Undetectable viral load) |  | 297 | (8) | 134 | (5) | 163 | (14) |

*\* Not included in final analytical sample*

**Figure 2: Awareness of Partner’s HIV status and/or Viral Load (VL) over Time among HIV-Negative/Unknown gbMSM**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall Events at each Time Period** | **HIV-Negative** | | **HIV-Unknown** | | **HIV-Positive (Unknown VL)** | | **HIV-Positive (Undetectable VL)** | |
|  | **(*N*=2595)** | **(*n*= 1756)** | | **(*n*= 639)** | | **(*n*= 66)** | | **(*n*= 134)** | |
| **Time** | ***n*** | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** |
| **Sep-Feb-2015** | 90 | 50 | 56 | 38 | 42 | 2 | 2 | 0 | 0 |
| **Mar-Aug 2015** | 749 | 499 | 67 | 202 | 27 | 16 | 2 | 32 | 4 |
| **Sep-Feb 2016** | 789 | 520 | 66 | 195 | 25 | 24 | 3 | 50 | 6 |
| **Mar-Aug 2016** | 645 | 447 | 69 | 142 | 22 | 18 | 3 | 38 | 6 |
| **Sep-Feb 2017** | 322 | 240 | 75 | 62 | 19 | 6 | 2 | 14 | 4 |
| **Significance of trends over time** |  | ***p<0.001*** | | ***p=0.002*** | | *p=0.722* | | *p=0.135* | |

**Figure 3: Awareness of Partner’s HIV status and/or Viral Load (VL) over Time among HIV-Positive gbMSM**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall Events at each Time Period** | **HIV-Negative** | | **HIV-Unknown** | | **HIV-Positive (Unknown VL)** | | **HIV-Positive (Undetectable VL)** | |
|  | **(*N*=1096)** | **(*n*=394)** | | **(*n*=263)** | | **(*n*=277)** | | **(*n*=162)** | |
| **Time** | ***n*** | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** |
| **Sep-Feb 2015** | 53 | 17 | 32 | 6 | 11 | 21 | 40 | 9 | 17 |
| **Mar-Aug 2015** | 319 | 118 | 37 | 68 | 21 | 84 | 26 | 49 | 15 |
| **Sep-Feb 2016** | 259 | 97 | 37 | 54 | 21 | 76 | 29 | 32 | 12 |
| **Mar-Aug 2016** | 285 | 97 | 34 | 87 | 31 | 56 | 20 | 45 | 16 |
| **Sep-Feb 2017** | 180 | 65 | 36 | 48 | 27 | 40 | 22 | 27 | 15 |
| **Significance of trends over time** |  | *p=0.93* | | ***p=0.043*** | | *p=0.059* | | *p=0.71* | |

**Table 3: Univariable Generalized Linear Mixed-Models Assessing Factors Associated with Having an Undetectable versus Unknown HIV status partner (Based on First Visit)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **HIV-Unknown Status Partner** | | **HIV-Positive partner (Undetectable)** | | **Reporting sex with HIV-Positive (Undetectable) vs HIV-Unknown status partners** | | | |
|  | **N=266** | | **N=40** | |  | | | |
|  | ***n*** | **(%)** | ***n*** | **(%)** | **OR** | **95% CI** | | ***p*-value** |
| **Individual-Level Factors** |  |  |  |  |  |  |  |  |
| **Sexual Identity** |  |  |  |  |  |  |  |  |
| Gay | 226 | (85.0) | 33 | (82.5) | REF |  |  |  |
| Bisexual/Other | 40 | (15.0) | 7 | (17.5) | 1.06 | 0.34 | 3.32 | 0.922 |
| **Ethnicity** |  |  |  |  |  |  |  |  |
| White | 199 | (74.8) | 36 | (90.0) | REF |  |  |  |
| Asian | 37 | (13.9) | 2 | (5.0) | 0.12 | 0.02 | 0.58 | **0.009** |
| Indigenous | 9 | (3.4) | 1 | (2.5) | 0.34 | 0.02 | 7.60 | 0.496 |
| Latin American/Other | 21 | (7.9) | 1 | (2.5) | 0.73 | 0.28 | 1.92 | 0.526 |
| **Age at interview date** |  |  |  |  |  |  |  |  |
| Under 30 | 100 | (37.6) | 8 | (20.0) | REF |  |  |  |
| 30 and over | 166 | (62.4) | 32 | (80.0) | 0.88 | 0.37 | 2.13 | 0.782 |
| **Total annual income last year** |  |  |  |  |  |  |  |  |
| Less than $30000 | 105 | (39.5) | 18 | (45.0) | REF |  |  |  |
| $30000 to $59999 | 112 | (42.1) | 17 | (42.5) | 0.86 | 0.37 | 2.01 | 0.734 |
| $60000 and over | 49 | (18.4) | 5 | (12.5) | 0.67 | 0.23 | 1.89 | 0.445 |
| **Anal Sex Preference** |  |  |  |  |  |  |  |  |
| Bottom | 86 | (32.3) | 12 | (30.0) | REF |  |  |  |
| Versatile | 69 | (25.9) | 10 | (25.0) | 2.67 | 1.12 | 6.36 | **0.026** |
| Top | 91 | (34.2) | 16 | (40.0) | 1.50 | 0.67 | 3.38 | 0.324 |
| Prefer no anal | 20 | (7.5) | 2 | (5.0) | 1.33 | 0.22 | 8.15 | 0.757 |
| **Current relationship status** |  |  |  |  |  |  |  |  |
| No regular partner | 167 | (62.8) | 20 | (50.0) | REF |  |  |  |
| In relationship | 99 | (37.2) | 20 | (50.0) | 1.34 | 0.76 | 2.37 | 0.313 |
| **Reporting condomless anal sex with HIV positive partner who has low viral load or is on HIV treatment (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 38 | (14.3) | 24 | (60.0) | 9.56 | 5.17 | 17.66 | **<0.001** |
| **Highest level of education** |  |  |  |  |  |  |  |  |
| High school or less | 31 | (11.7) | 6 | (15.0) | REF |  |  |  |
| Greater than high school | 235 | (88.3) | 34 | (85.0) | 2.10 | 0.60 | 7.34 | 0.245 |
| **Ever heard of treatment as prevention (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 210 | (78.9) | 35 | (87.5) | 1.49 | 0.61 | 3.63 | 0.377 |
| **Ever heard of PEP (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 240 | (90.2) | 39 | (97.5) | 1.83 | 0.51 | 6.57 | 0.351 |
| **Used PEP (P6M) (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 14 | (5.3) | 1 | (2.5) | 0.88 | 0.25 | 3.09 | 0.842 |
| **Ever heard of (PrEP) (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 220 | (82.7) | 38 | (95.0) | 2.38 | 0.57 | 9.91 | 0.233 |
| **Used PrEP (P6M) (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 5 | (1.9) | 6 | (15.0) | 3.39 | 1.44 | 7.96 | **0.005** |
| **Sex Work (P6M) (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 14 | (5.3) | 0 | (0) | 0.26 | 0.06 | 1.18 | 0.081 |
| **AUDIT Zone** |  |  |  |  |  |  |  |  |
| Low risk (scores 0 to 7) | 144 | (54.1) | 24 | (61.5) | REF |  |  |  |
| Medium risk (scores 8 to 15) | 81 | (30.5) | 10 | (25.6) | 0.73 | 0.37 | 1.42 | 0.351 |
| Harmful/Possible dependence (scores 16 and over) | 41 | (15.4) | 5 | (12.8) | 1.18 | 0.41 | 3.45 | 0.760 |
| **Event-Level Sexual Activities** |  |  |  |  |  |  |  |  |
| **Where partner was first met** |  |  |  |  |  |  |  |  |
| Internet or Smart phone app | 125 | (47.2) | 23 | (57.5) | REF |  |  |  |
| Others | 140 | (52.8) | 17 | (42.5) | 0.82 | 0.46 | 1.45 | 0.485 |
| **Relative age of partner** |  |  |  |  |  |  |  |  |
| Much younger/younger than me | 94 | (35.3) | 9 | (22.5) | REF |  |  |  |
| About the same age as me | 81 | (30.5) | 12 | (30.5) | 1.21 | 0.71 | 2.07 | 0.493 |
| Much older/older than me | 91 | (34.2) | 19 | (47.5) | 2.61 | 1.33 | 5.11 | **0.005** |
| **Anal sex as a bottom with condom (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 45 | (16.9) | 3 | (7.5) | 0.52 | 0.25 | 1.09 | 0.083 |
| **Anal sex as a bottom without condom (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 37 | (13.9) | 16 | (40.0) | 4.84 | 3.02 | 7.76 | **<0.001** |
| **Anal sex as a top with condom (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 36 | (13.5) | 3 | (7.5) | 0.64 | 0.21 | 1.90 | 0.417 |
| **Anal sex as a top without condom (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 34 | (12.8) | 17 | (42.5) | 6.06 | 3.38 | 10.86 | **<0.001** |
| **He gave me a blowjob (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 167 | (62.8) | 23 | (57.5) | 1.45 | 0.88 | 2.41 | 0.146 |
| **I gave him a blowjob (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 191 | (71.8) | 28 | (70.0) | 1.56 | 0.85 | 2.88 | 0.155 |
| **Rimming (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 84 | (31.6) | 17 | (42.5) | 2.71 | 1.79 | 4.09 | **<0.001** |
| **Masturbation (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 149 | (56.0) | 19 | (47.5) | 1.30 | 0.86 | 1.96 | 0.207 |
| **Fisting (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 5 | (1.9) | 2 | (5.0) | 9.24 | 3.08 | 27.72 | **<0.001** |
| **Used sex toys but did not share (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 13 | (4.9) | 5 | (12.5) | 2.96 | 1.17 | 7.50 | **0.023** |
| **Shared sex toys (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 1 | (0.4) | 0 | (0) | 23.42 | 5.10 | 107.65 | **<0.001** |
| **Received money/drugs/goods for sex (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 3 | (1.1) | NA\* |  |  |  |  | NA\* |
| **Event-Level Substance Use (Self)** |  |  |  |  |  |  |  |  |
| **Alcohol (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 108 | (40.6) | 9 | (22.5) | 0.61 | 0.31 | 1.19 | 0.147 |
| **Marijuana (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 47 | (17.7) | 9 | (22.5) | 1.02 | 0.53 | 1.98 | 0.944 |
| **Erectile Drugs (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 26 | (9.8) | 6 | (15.0) | 1.39 | 0.60 | 3.22 | 0.441 |
| **Poppers (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 24 | (9.1) | 12 | (30.0) | 1.93 | 0.92 | 4.04 | 0.080 |
| **Crystal Methamphetamine (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 16 | (6.0) | 4 | (10.0) | 7.44 | 2.38 | 23.27 | **0.001** |
| **GHB (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 7 | (2.6) | 1 | (2.5) | 2.89 | 1.39 | 6.00 | **0.005** |
| **Ecstasy (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 14 | (5.3) | 4 | (10.0) | 2.59 | 1.16 | 5.76 | **0.020** |
| **Event-Level Substance Use (Partner)** |  |  |  |  |  |  |  |  |
| **Alcohol (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 82 | (30.8) | 7 | (17.5) | 0.45 | 0.22 | 0.92 | **0.030** |
| **Marijuana (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 23 | (8.6) | 11 | (27.5) | 2.24 | 1.18 | 4.26 | **0.014** |
| **Erectile Drugs (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 5 | (1.9) | 3 | (7.5) | 3.40 | 1.34 | 8.64 | **0.010** |
| **Poppers (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 20 | (7.5) | 9 | (22.5) | 2.62 | 1.38 | 4.99 | **0.003** |
| **Crystal Methamphetamine (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 10 | (3.8) | 3 | (7.5) | 5.03 | 2.17 | 11.63 | **<0.001** |
| **GHB (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 7 | (2.6) | 2 | (5.0) | 6.18 | 2.89 | 13.20 | **<0.001** |
| **Ecstasy (Ref: No)** |  |  |  |  |  |  |  |  |
| Yes | 12 | (4.5) | 4 | (10.) | 5.46 | 1.97 | 15.09 | **0.001** |
| **Individual-Level Continuous Variables** | **Median** | **(Q1-Q3)** | **Median** | **(Q1-Q3)** | **OR** | **95% CI** | | ***p*-value** |
| **HAART Treatment Optimism-Skepticism Scale** | 27 | (24-30) | 30 | (27-34) | 1.12 | 1.06 | 1.19 | **<0.001** |
| **Cognitive Escape Scale** | 30 | (26-34) | 28 | (23-32) | 1.00 | 0.95 | 1.05 | 0.921 |
| **Event-Level Continuous Variables** |  |  |  |  |  |  |  |  |
| **Months since first sex** | 2 | (1-6) | 10 | (1-29) | 1.01 | 1.00 | 1.03 | **0.023** |
| **Number of times of sex (P6M)** | 1 | (1-2) | 4 | (1-27) | 1.10 | 0.95 | 1.26 | 0.196 |
| **Number of times of anal sex (P6M)** | 1 | (0-1) | 3 | (1-18) | 1.13 | 0.96 | 1.32 | 0.141 |

*NA\* =No data longitudinally*

*(P6M) = Past six months*

**Table 4: Multivariable Generalized Linear Mixed-Models Assessing Factors Associated with Having an Undetectable versus Unknown HIV status (Among all Sexual Events)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reporting sex with HIV-Positive (Undetectable) vs HIV-Unknown Status Partners** | | | | |
| **Individual-Level Variables** | **aOR** | **95% CI** | | ***p*-value** |
| **Ethnicity** |  |  |  |  |
| White | REF |  |  |  |
| Asian | 0.09 | 0.02 | 0.52 | **0.007** |
| Indigenous | 0.07 | 0.00 | 61.52 | 0.438 |
| Latin American/Other | 0.47 | 0.19 | 1.20 | 0.116 |
| **Having anal sex without condoms with HIV-positive guys who have low viral loads or are on HIV treatment (Ref: No)** |  |  |  |  |
| Yes | 6.42 | 3.36 | 12.27 | **<0.001** |
| **Sex Work (P6M) (Ref: No)** |  |  |  |  |
| Yes | 0.05 | 0.01 | 0.29 | **0.001** |
| **Event-Level Sexual Activity** |  |  |  |  |
| **Relative age of partner** |  |  |  |  |
| Much younger/younger than me |  |  |  |  |
| About the same age as me | 1.62 | 0.82 | 3.23 | 0.166 |
| Much older/older than me | 2.97 | 1.42 | 6.21 | **0.004** |
| **Anal sex as a bottom with condom (Ref: No)** |  |  |  |  |
| Yes | 3.25 | 1.86 | 5.70 | **<0.001** |
| **Anal sex as a top with condom (Ref: No)** |  |  |  |  |
| Yes | 6.12 | 3.49 | 10.74 | **<0.001** |
| **Rimming (Ref: No)** |  |  |  |  |
| Yes | 1.92 | 0.98 | 3.75 | 0.056 |
| **Shared sex toys (Ref: No)** |  |  |  |  |
| Yes | 9.94 | 2.64 | 37.50 | **0.001** |
| **Event-Level Substance Use (Self)** |  |  |  |  |
| **Crystal Methamphetamine (Ref: No)** |  |  |  |  |
| Yes | 5.92 | 1.87 | 18.75 | **0.003** |
| **GHB (Ref: No)** |  |  |  |  |
| Yes | 0.10 | 0.02 | 0.56 | **0.009** |
| **Event-Level Substance Use (Partner)** |  |  |  |  |
| **Alcohol (Ref: No)** |  |  |  |  |
| Yes | 0.41 | 0.16 | 1.06 | 0.067 |
| **GHB (Ref: No)** |  |  |  |  |
| Yes | 13.44 | 2.20 | 82.19 | **0.005** |
| **Event-Level Continuous Variables** | **aOR** | **95% CI** | | ***p*-value** |
| **Months since first sex** | 1.01 | 1.00 | 1.03 | **0.030** |

*(P6M) = Past six months*

**Supplemental Post Hoc Analyses and Figures**

**Figure 1: Flow chart for Outcome Variable**

Diagram

Description automatically generated

**Table 1: Univariable Generalized Linear Mixed Model Between Awareness of Partner’s Viral load and Participant Referral**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** |  | **Relationship to the referrer** | | | | **Univariable Glimmix** | | | |
|  |  | **Other** | | **Sexual partner** | | **Sexual partner vs Other** | | | |
|  |  | **(N=2749)** | | **(N=1036)** | |  |  |  |  |
|  | **Total N** | **N** | **(%)** | **N** | **(%)** | **OR** | **95% CI** | | ***p*-value** |
| **Awareness of Partner Viral Load (Main Outcome)** | 3786 |  |  |  |  |  |  |  |  |
| HIV negative partner |  | 1564 | (56.9) | 638 | (61.6) | Ref |  |  |  |
| HIV unknown status partner |  | 727 | (26.4) | 201 | (19.4) | 0.757 | 0.601 | 0.954 | **0.018** |
| HIV positive partner of unknown viral load |  | 261 | (9.5) | 91 | (8.8) | 0.875 | 0.611 | 1.254 | 0.468 |
| HIV positive partner of known viral load not undetectable\* |  | 6 | (0.2) | 0 | (0.0) |  |  |  | NA |
| HIV positive partner of undetectable viral load |  | 191 | (6.9) | 106 | (10.2) | 1.040 | 0.781 | 1.386 | 0.788 |

*\*Could not be calculated due to small sample size*

**Table 2: Multivariable Generalized Linear Mixed-Models Assessing Factors Associated with Having an Undetectable versus Unknown HIV status, among HIV-Negative/Unknown gbMSM not referred into the study by a Sexual Partner**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reporting sex with HIV-Positive (Undetectable) vs HIV-Unknown Status Partners** | | | | |
| **Individual-Level Variables** | **aOR** | **95% CI** | | ***p*-value** |
| **Having anal sex without condoms with HIV-positive guys who have low viral loads or are on HIV treatment (Ref: No)** |  |  |  |  |
| Yes | 5.98 | 2.41 | 14.87 | **<0.001** |
| **Event-Level Sexual Activity** |  |  |  |  |
| **Anal sex as a bottom without a condom (Ref: No)** |  |  |  |  |
| Yes | 4.19 | 2.10 | 8.38 | **<0.001** |
| **Anal sex as a top without a condom (Ref: No)** |  |  |  |  |
| Yes | 7.33 | 3.01 | 17.86 | **<0.001** |
| **Event-Level Substance Use (Partner)** |  |  |  |  |
| **Alcohol (Ref: No)** |  |  |  |  |
| Yes | 0.33 | 0.10 | 1.01 | 0.052 |
| **Poppers (Ref: No)** |  |  |  |  |
| Yes | 1.90 | 0.91 | 3.99 | 0.087 |
| **GHB (Ref: No)** |  |  |  |  |
| Yes | 5.80 | 0.98 | 34.35 | 0.053 |
| **Ecstasy (Ref: No)** |  |  |  |  |
| Yes | 2.98 | 0.80 | 11.14 | 0.105 |
| **Event-Level Continuous Variables** | **aOR** | **95% CI** | | ***p*-value** |
| **Months since first sex** | 1.01 | 1.00 | 1.02 | **0.047** |

*(P6M) = Past six months*