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Predictors of Condomless Anal Intercourse in Young HIV Positive Men Who Have Sex with Men with Detectable Viral Loads

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Abstract

Purpose—A minority of young, gay, bisexual and other men who have sex with men (YGBMSM) living with HIV in the United States achieve viral suppression, thus increasing the likelihood of viral transmission during condomless anal intercourse (CAI). The purpose of this study was to explore potential risk factors for CAI and serodiscordant CAI among YGBMSM with detectable viremia.

Methods—146 YGBMSM (age 16–24) with a detectable viremia enrolled into an mHealth adherence intervention. Baseline characteristics, stratified by any CAI and any serodiscordant CAI (past 3 months), were computed. Random Forests (RF) and regression methods were used to assess factors associated with each type of CAI. Adjusted prevalence rate ratios (aPRR) and 95% confidence intervals were calculated.

Results—Half (51.9%) reported engaging in CAI; 57.1% of those reported serodiscordant CAI (SD-CAI). There was strong agreement between the RF and regression methods. Significant risk factors of CAI included marijuana use (aPRR=1.97, 95% CI: 1.21 – 3.21), problematic substance use (aPRR=1.56, 95% CI: 1.11 – 2.20) and being in a committed relationship (aPRR=1.66, 95% CI: 1.21 – 2.27). Only 47% believed they were less likely to transmit HIV through CAI when virally suppressed.

Conclusion—High rates of CAI, including engagement in SD-CAI in a population of YGBMSM with detectable viral loads poses significant concerns for onward transmission.

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Individual, dyadic and structural predictors of CAI were associated with engagement in risk in this priority population. Addressing these factors in concert with ensuring viral suppression will be key to ending the epidemic among youth.

Keywords

viral load; sexual risk; condomless sex; adolescents; young adults; HIV

Introduction

Despite a slight decline in HIV incidence from 2010 to 2016, youth (aged 13 to 24) in the United States (US) still bear a disproportionate burden (1). In 2017, youth made up 21% of all new HIV diagnoses; 87% of those were among men, most (93%) of whom were young, gay, bisexual and other men who have sex with men (YGBMSM) (1). Youth experience worse outcomes along all stages of the care continuum, most significantly, having the lowest rates of viral suppression among all age groups (1). A review of US studies, conducted between 2000–2012, found that only 62% of youth (aged 13–29) with HIV engaged in medical care within 12 months of diagnosis. Of those in care, only 43% are retained in care over 1–3 years, and among those who initiated antiretroviral therapy (ART), only 51% achieved viral suppression to less than 400 copies/ml (2). In a national study of 467 youth (aged 13–24) in care, while 77% were virally suppressed at baseline, only 59% of those initially virally suppressed maintained suppression at all follow-up points over 12 months (3).

Many youth living with HIV (YLHIV) continue to engage in condomless sex after diagnosis, including a large proportion of youth with detectable viremia (4, 5). Among 200 YGBMSM (ages 16–24 years) living with HIV recruited from 14 clinical sites, 20.5–22.5% reported condomless anal intercourse (CAI) across partner serostatus (HIV-negative/status unknown or HIV-positive) and type of CAI (receptive or insertive) (6). Among 991 YGBMSM (aged 13–24 years) in a national clinic-based sample, 688 (69.4%) had detectable viremia and 458 (46.2%) reported CAI, with 310 (31.3%) reporting serodiscordant (SD-CAI) in the past 3 months (4). Those YGBMSM with detectable viremia were more likely than those who were virally suppressed to report CAI and SD-CAI (5). Incident sexually transmitted infections (STIs) are also associated with worse viral suppression among YLHIV (7).

While there has been limited research on correlates of CAI and SD-CAI among YGBMSM living with HIV with detectable viral loads (5, 8), data from the national clinic-based sample described above identified an association between problematic substance use, greater depressive symptoms, and receiving an HIV diagnosis in the past 6 months with engagement in CAI (5). Given the high HIV transmission rates attributable to CAI among persons who are aware of their status with unsuppressed viral loads (9), and the importance of addressing the HIV epidemic among YGBMSM, the current study aims to provide a more nuanced analysis of factors associated with CAI among virologically detectable YGBMSM using multiple variable selection methods.

METHODS

Design

From October 2015 to September 2016, 146 YGBMSM living with HIV (age 16–24) were recruited into a two-arm, randomized intervention trial, Epic Allies, to test the acceptability, impact, and long-term sustainability of the Epic Allies mobile phone application (app) intervention (10). Epic Allies is a theory-based mobile app that utilizes game mechanics and social networking features to improve engagement in care, ART uptake, adherence, and viral suppression (11). Study participants were required to have a detectable viral load, defined as a viral load greater than the lower limit of detection (LLD) for the assay used. Participants were recruited from four sites within the Adolescent Trials Network for HIV Interventions (ATN) system of care; University of South Florida (Tampa, FL), Montefiore (Bronx, NY), Stroger/CORE Center (Chicago, IL), and Tulane (New Orleans, LA). A fifth (non-ATN) site, UNC Chapel Hill (Chapel Hill, NC) was also included. Chart abstraction and medical record review was completed for viral load data. Participants completed computer-assisted self-interview (CASI) surveys at baseline (prior to randomization), 13, 26 and 39 weeks (10). Baseline data were used for the analyses described below.

Primary ethical review of the study was completed by UNC Institutional Review Board. The trial is registered with clinicaltrials.gov under protocol number: [NCT02782130](https://clinicaltrials.gov/ct2/show/study/NCT02782130).

Measures

Sociodemographic items included gender, sexual identity, race/ethnicity, relationship status, education, employment status, income (past 30 days), homelessness (past 3 months) and incarceration (lifetime). Participants were classified as either new-to-care (initiation of HIV treatment within the past 12 months) or non-adherent to ART (first entered HIV care more than 12 months prior to the baseline visit).

Sexual Risk—Each participant was asked separately how many times in the past 3 months they had insertive and receptive CAI with HIV-positive, HIV-negative, and status unknown male partners. Serodiscordant CAI was defined as any CAI in which the partner(s) was HIV-negative or of unknown HIV status.

Mental Health—Depressive symptoms were assessed using the validated 20-item Center for Epidemiologic Studies Depression Scale (CES-D) with scores ranging from 0 to 60. A dichotomous variable was created using a cutoff score of 16 which suggests clinically relevant depressive symptoms (12). Generalized anxiety was measured using the validated 7-item Generalized Anxiety Disorder (GAD-7) scale (range 0–21) (13). A dichotomous variable was created using a cutoff of 10 which represents moderate to severe anxiety.

Substance Use—Patterns of substance use were established using items from the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST) (14). Of interest to this study was lifetime use of alcohol, marijuana, cocaine, amphetamines or opioids and the frequency of alcohol and marijuana use in the last 3 months. ASSIST frequency categories were collapsed into two categories: irregular use (never, once or twice, monthly or weekly),

and regular use (daily or almost daily). The 6-item Car, Relax, Alone, Forget, Friends, Trouble (CRAFFT), which measures consequences of alcohol and/or drug use among youth, was used to identify problematic substance use which was defined as endorsement of 2 or more of the 6 items (15).

Social Media Use—Participants were asked about their number of social media site accounts and past-month frequency of use. Frequency of account use was collapsed into categories of daily (once to several time per day), weekly (1 to 6 times per week), and less than weekly (less than once per week or not at all). Participants were also asked if they used the internet to search for sex partners in the last 3 months and frequency. Frequency was collapsed as described for social media.

HIV Transmission Beliefs—Attitudinal variables assessed participant beliefs regarding infectiousness and viral load (3 questions), serosorting (3 questions), and sexual positioning (1 question) using a 4-point response scale (1=strongly agree to 4=strongly disagree). An example of a viral load belief item is: “If my viral load is low or undetectable, I am less likely to infect another person with HIV if I have unprotected sex.” An example of a serosorting belief item is: “I am less concerned about using condoms with a partner who is also HIV positive.” One item: “I will have oral sex with a partner instead of either vaginal or anal sex in order to reduce the risk of infecting another person with HIV” assessed sexual positioning beliefs. All answers were dichotomized into agreement versus disagreement.

Stigma—HIV Stigma was measured using an abbreviated (10-item) scale designed for YLHIV (16) with a 5-point Likert response (1= strongly disagree to 5= strongly agree). An example item includes: “I have lost friends by telling them I have HIV.” HIV stigma was analyzed continuously (score range 10–50) with higher scores indicating more stigma.

Internalized homophobia was assessed using the Internalized Homophobia Scale-Revised (HIS-R) (17). The 5-item scale uses a 5-point Likert response (1= strongly disagree to 5= strongly agree). An example item includes, “I feel that being gay/bisexual is a personal shortcoming for me.” The upper two categories (4 and 5) were combined due to sparsity.

Perceived homophobia was quantified using the binary answer (1= agree, 2= disagree) to the question, “In the last 12 months, I have perceived a rise in homophobia/transphobia”.

Statistical Analysis

Descriptive statistics, stratified by the binary CAI behaviors of any CAI and any SD-CAI were computed, with frequency counts and percentages used for categorical variables and medians with interquartile ranges used for continuous variables. For continuous covariates, either previously validated, clinically meaningful ranges were used for values as transformed categorical variables (e.g. depression and anxiety scores), or the data were fitted via loess curves and regression fit statistics to determine if other forms of the variable, such as quadratic, log transformation, or meaningful cut offs improved the fit of the regressions.

Random Forests (RF) methods were used to determine which of the chosen covariates were most important in predicting each type of CAI behavior (18). RF is a non-parametric, data-

driven analysis that can be used for prediction, ranking variables and for variable selection, without having to make a priori assumptions about the structure of data or the relationship between the response (dependent) and predictor (independent) variables (19). Individual regression trees are constructed via binary splits in numeric predictor variables. The dataset is split into subsets that are increasingly homogeneous with regard to the response variable to form regression “trees.” The process is repeated recursively until a stopping criterion is met. To construct trees, bootstrap samples of the original data are taken repeatedly and conditional inference trees produced for each subset, in a process called bagging. A random subset of predictor variables is taken repeatedly so that one or a few variables are not able to dominate all trees. Results are summarized over all trees to provide overall inference. We used 500 trees in the bagging process, sub-selected 5 variables at a time for our regression trees, and specified nodes with fewer than five observations as a stopping criterion (18).

The relevance of each of the predictor variables in the RF was summarized by calculating the variable permutation accuracy importance (18). Any variable that had a permutation importance score greater than the absolute value of the lowest score was considered to be “important” in predicting CAI. Positive values exceeding this range are more likely to indicate a non-arbitrary level of importance in predicting the outcome (18). Each variable’s importance generated from the RF was then summarized graphically with corresponding permutation scores to provide a visual “ranking” of importance within the regression tree models. Because RF is primarily designed to optimize prediction, we computed measures of predictive accuracy by calculating the area under the curve (AUC) for each set of variables on each outcome. All RF methods were performed using the party package in R version 3.4.1 (20).

To complement the RF analysis, parametric adjusted Modified Poisson regressions were used to identify associations and to quantify the magnitude and direction of adjusted effects for each covariate on each outcome. First, regressions were run separately for each covariate that was included in RF and each regression adjusted for study site in order to ascertain a list of covariates that independently predicted CAI outcomes. Second, in order to estimate a more valid prevalence rate ratio (PRR), regressions were again run separately for each covariate of interest and adjusted for known predictors of CAI (age, ethnicity, and relationship status). All regression analyses were performed using SAS software version 9.4.

RESULTS

Sample Characteristics

Descriptive statistics stratified by CAI and SD-CAI are presented in Table 1. At baseline, 134 (91.8%) participants provided CAI information (University of South Florida (n=25), Montefiore (n=29), Stroger/CORE Center (n=21), Tulane (n=24) and UNC Chapel Hill (n=35). The sample was primarily male (94%) and gay-identified (76%). Most participants (82%) were African American; 19% identified as Hispanic or Latino. Less than half (37%) reported being in a committed relationship and 81% had at least a high school/GED level education. A majority of participants were currently employed (67%) and reported making less than \$12,000/year (73%). A quarter of the sample (28%) reported homelessness for one

night or more in the last 90 days and a similar number (27%) reported having ever been incarcerated.

Participants reported a high level of depressive symptoms, with 57% meeting the criteria for being at risk of depression. Fewer participants met criteria for moderate to severe anxiety (28%). More than half of the sample (52%) screened positive for problematic substance use. Few (7%) reported daily alcohol use, while a third (35%) reported daily marijuana use.

Standardized Cronbach's alpha computed on scales used in analysis sample indicate a sufficient level of reliability for the CES-D ($\alpha=0.891$), GAD ($\alpha=0.938$), CRAFFT ($\alpha=0.778$), Felt Stigma ($\alpha=0.866$), and internalized homophobia ($\alpha=0.906$).

Condomless Anal Intercourse

Participants reported a median of 1.0 (IQR 1.0, 3.0) male sex partner in the past 3 months. Half (52.2%, $n=70$) of the participants reported engaging in any type of CAI in the last 3 months; of those 71.4% reported any insertive CAI and 90.0% any receptive CAI. Of those reporting any CAI, 57.1% ($n=40$) reported having CAI with someone whose HIV status was either negative or unknown. Of those who had SD-CAI, 60% reported insertive and 85% reported receptive CAI.

Predictors of any CAI behavior

There was strong agreement between the RF and regression methods. Nearly all variables found to be important in predicting CAI using RF methods were also identified in regression analysis. Analysis of AUC, revealed an excellent level of discrimination for models of any CAI (AUC=0.82, 95% CI: 0.76 – 0.89), acceptable discrimination for insertive (AUC=0.71, 95% CI: 0.64 – 0.78) and receptive CAI (AUC=0.79, 95% CI: 0.72 – 0.86), and less discriminatory for serodiscordant CAI (AUC=0.65, 95% CI: 0.58 – 0.72) (Supplemental Table 1). Relationship status was the most important predictor of engaging in any CAI according to the variable selection process using RF methods (Figure 1, Panel A), with those in a committed relationship being more likely to have any CAI (Adjusted PRR=1.66, 95% CI: 1.21 – 2.27) (Supplemental Table 2). Substance use was an important RF predictor (Table 2) with those reporting ever having used marijuana almost twice as likely (PRR=1.97, 95% CI: 1.21 – 3.21) and those with problematic substance use more likely (PRR=1.56, 95% CI: 1.11 – 2.20) to report engaging in any CAI. Those who looked for sex partners online were also more likely to report any CAI (PRR=1.77, 95% CI: 1.28 – 2.47). Individuals engaging in CAI were also more likely to have reported looking for other HIV-positive individuals to have sex with (PRR=1.63; 95% CI: 1.21 – 2.19). In the crude regression analysis, individuals engaging in any CAI were less concerned about safety with HIV-positive partners, and changed very little when adjustment was made for known risk factors of CAI (PRR=1.36; 95% CI: 0.98 – 1.87). Belief that a low viral load decreased the risk of infecting a partner was an important predictor of any CAI in the RF analysis; however, there was not strong evidence for this association from the regression analysis.

Predictors of Insertive and Receptive CAI

Both insertive and receptive CAI were most strongly associated with relationship status (Table 3, Figure 2, panels A and B), with the effect of being in a committed relationship more pronounced for insertive CAI (PRR=2.20, 95% CI: 1.40 – 3.47) versus receptive CAI (PRR=1.59, 95% CI: 1.12 – 2.26) (Supplemental Table 3). Problematic substance use (PRR=1.54, 95% CI: 1.05 – 2.28) and ever using marijuana (PRR 1.90, 95% CI: 1.11 – 3.26) were associated with higher prevalence of receptive, but not insertive CAI.

HIV transmission beliefs were associated with both insertive and receptive CAI behavior, including looking for other HIV-positive persons to have sex with (PRR=2.17, 95% CI: 1.44 – 3.26; insertive and PRR=1.94, 95% CI 1.42 – 2.65; receptive) and less concern about using condoms with HIV-positive partners (PRR=1.60, 95% CI: 1.02 – 2.52; insertive and PRR=1.41, 95% CI 0.98 – 2.02; receptive). Finding sex partners online was positively associated with receptive (PRR=1.59, 95% CI: 1.02 – 2.48) and insertive CAI (PRR=1.79, 95% CI: 1.25 – 2.56).

Predictors of Serodiscordant CAI

Similar to CAI, almost all predictors found to be important using RF methods were also identified in regression analysis. Variables strongly associated with SD-CAI, according to RF analysis (Figure 1, panel B), include problematic substance use (PRR=3.10, 95%CI: 1.63 – 5.87), and searching for sex partners online in the last 3 months (PRR=2.47, 95% CI: 1.46 – 4.18) with the rate of SD-CAI higher in those who searched for sex partners daily compared to those who searched less than weekly (PRR=2.19, 95% CI: 1.23 – 3.90). Hispanic/Latino ethnicity (PRR=2.06, 95% CI: 1.23 – 3.43), a perceived rise in homophobia (PRR=1.83, 95% CI: 1.09 – 3.06), and higher level of internalized homophobia (score of 4 vs 1) (PRR=2.50, 95% CI: 1.27 – 4.95) were also associated with a greater likelihood of SD-CAI.

DISCUSSION

A majority of virally non-suppressed YGBMSM enrolled in an mHealth treatment adherence intervention reported engaging in CAI in the last 3 months with being in a committed relationship, engaging in substance use and seeking sex online emerging as important predictors. While this echoes prior work (5), RF methods allowed for the elucidation of the relative importance of these variables, while accounting for their interdependency, in a way that is more difficult to demonstrate with standard regression modeling. Our findings can inform the development of more tailored risk reduction interventions for YGBMSM living with HIV.

Youth who reported being in a committed relationship were more likely to report CAI, aligning with prior studies among diverse MSM (21, 22) and affirming the likelihood that a significant proportion of HIV transmissions occur within the context of primary sexual relationships, particularly among YGBMSM (23). A desire to express intimacy, love and trust and to form an emotional connection are all motivating factors for CAI within relationships, however, most work to-date has focused on HIV-negative MSM (24, 25). An

important next step for understanding relationship dynamics among youth would include a deeper investigation into the emotional context in which YGBMSM living with HIV make decisions about condom use and the role of primary partner turnover, partner concurrency and sexual agreements (26). Additional work could explore relationship longevity, communication, and sexual decision-making among YGBMSM living with HIV in order to create developmentally appropriate interventions, including consideration for couples-based approaches (27).

Rates of problematic substance use were high and associated with engagement in both CAI and SD-CAI; findings that have been well-described previously (21, 28–30). For some youth, substance use may be a way to cope with the stress of living with a stigmatized illness (including both HIV as well as comorbid mental health conditions) or as a way to lower inhibitions with regard to engagement in sex with another male partner (30). Substance use can also negatively impact ART adherence (31); thus, multifaceted interventions that address the type and frequency of substances that impact YGBMSM living with HIV is critical to limit the potential for onward transmission.

Higher internalized homophobia scores were associated with more than twice the prevalence of SD-CAI. While prior studies find mixed effects of the association between internalized homophobia and engagement in sexual risk behaviors among MSM (32, 33), among a large sample of black YGBMSM, those with greater internalized homophobia were less likely to discuss prevention with sex partners and disclose same sex sexual behavior to health care providers, and more likely to report receptive CAI (34). Future interventions to address internalized homophobia might adopt a resilience lens given findings that YGBMSM with more gay-affirming attitudes may be more likely to engage in protective health behaviors (35).

Depression and anxiety were prevalent in this sample, though not associated with sexual risk. Past studies, primarily focused on older MSM, report inconsistent findings of this association (36, 37), likely indicative of the complex relationship between psychosocial factors, cognitive appraisal processes, and risk (38). Notably, Cook et al. did find an independent association of depressive symptoms and sexual risk behavior, including both CAI and SD-CAI, in a large sample of YGBMSM living with HIV (39). While our cross-sectional study could not explore pathways from depression to engagement in risk, high prevalence supports interventions aimed at addressing mental health co-morbidities among YGBMSM living with HIV.

Youth enrolled in this study after the publication of seminal results documenting the beneficial individual and population effects of HIV treatment as prevention (TasP)(40) and approval of pre-exposure prophylaxis (PrEP) (41). Thus, our analysis provides a contemporary understanding of how messages regarding transmission are impacting engagement in risk. While less than half of participants endorsed the belief that they were less likely to infect another person through CAI if they had a low or undetectable VL, this was an important predictor of CAI in the RF analysis. Further, serosorting behaviors, specifically looking for other persons living with HIV to have sex with, was more likely to be reported by YGBMSM engaging in CAI (any, insertive and receptive). It is not known if

participants had detectable viremia at the time of engaging in CAI or were even aware of their viral load results, but future work should explore if there exists any cognitive dissonance between how messages of protection are being received and their translation into behaviors among YGBMSM. While HIV transmission is not an issue among those with only positive partners, risks for acquisition of other STIs persists. In one study among adults living with HIV, participants with STIs were significantly more likely to have detectable viral loads and less likely to know their viral load than those who did not have an STI (42).

Overall, only 70% of participants were more concerned with using condoms with HIV negative/unknown status partners when their viral load was detectable. As TasP messaging appears to impact engagement in CAI (6), future qualitative work must take into account how youth are understanding and adapting their behaviors in the context of these scientific advances. Additional social and structural drivers of condom use and sexual risk including serostatus disclosure, social support and sexual network characteristics that impact both adherence and CAI among YGBMSM should be explored (39, 43, 44).

Use of geospatial apps and online sites to find sex partners was common in this study and among YGBMSM in general (45). While those who looked for sex partners online in the past 3 months were more likely to report any CAI, this finding should be interpreted cautiously given that other venues for meeting sex partners were not assessed. The stronger association between more frequent online partner searching and SD-CAI is similar to findings among an online sample of MSM (46). As such, continued development of online interventions, including consideration of delivery through sex seeking apps, is warranted.

The results of this research should be considered in light of its methodological limitations. The statistical methods were exploratory and not meant to provide confirmatory evidence of causal associations. The large number of null hypothesis tests performed make our results prone to Type I error, and thus, inference on any specific result should be interpreted with caution. All data analyzed were cross-sectional, and, therefore, interpretation of estimated prevalence ratios as risk ratios are subject to temporal bias, as well as point prevalence complement ratio bias. Specifically, all CAI outcomes were common (>20%) in most exposure strata, making the estimated prevalence ratio a conservative estimate of the risk ratio. Furthermore, like many randomized trials, our study sample was a convenience sample and our findings may not be generalizable to the broader YGBMSM population. Despite these limitations, many of our results align with previous findings and predictors of CAI, a positive sign of the external validity of our results. In addition, using two distinct methods of ascertaining risk factors and having those methods largely agree is a strong indication of internal validity.

Conclusion

High rates of CAI, including engagement in SD-CAI in a population of YGBMSM with detectable viral loads poses significant concerns for onward HIV transmission. Using multiple methods - both non-parametric (RF) and parametric (modified Poisson regression) approaches - to determine the most important predictors of CAI provides a more nuanced understanding of the multiple psychosocial individual and structural factors that are

associated with engagement in risk in this priority population. Addressing these factors in concert with ensuring viral suppression will be key to ending the epidemic among youth in the US.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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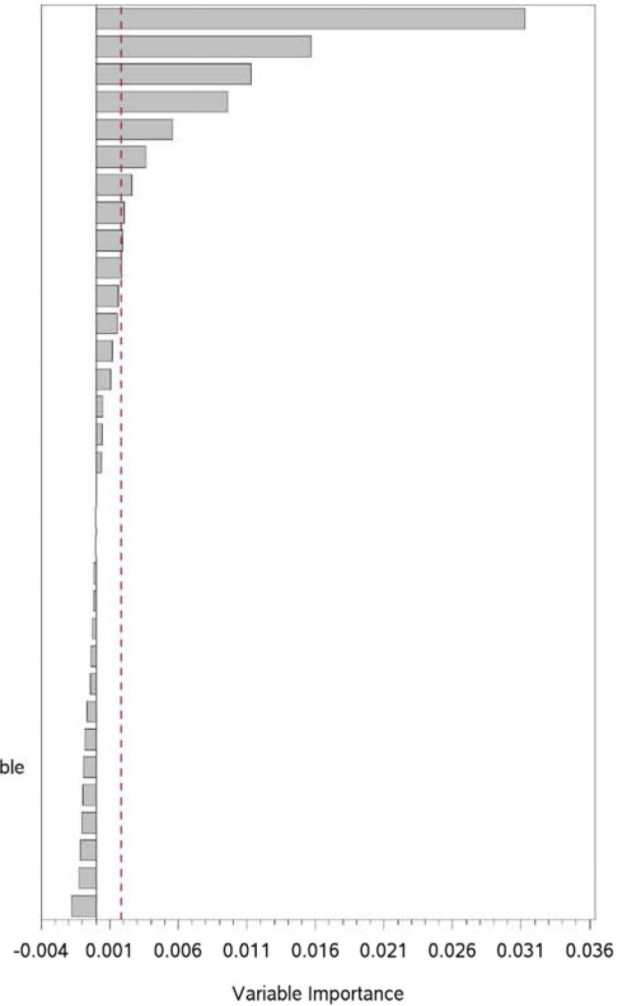
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Implications and Contribution

Findings indicate that half of all virally non-suppressed young, gay, bisexual and other men who have sex with men (YGBMSM) enrolled in an adherence intervention reported engaging in condomless anal intercourse (CAI) in the last 3 months. Predictors of CAI included individual, dyadic and structural level variables. This suggests the need for multifaceted interventions for YGBMSM living with HIV to stem onward transmission.

Panel A

- In a committed relationship
- Internet use to find sex partners (past 3 months)
- Marijuana use (ever)
- Problematic substance use
- Look for HIV+ partners to have sex with
- Less concerned about condom use with HIV+ partners
- Age (yrs)
- Cocaine, amphetamine, opioid use (ever)
- Belief that low VL decreases transmission risk
- Frequency of internet use to find sex partners (daily, weekly, or < than weekly)
- Perceived rise in homophobia
- Sexual identity (gay, bisexual or other)
- Moderate/severe anxiety
- Belief that partners not interested in using condoms are probably HIV+
- Alcohol use (ever)
- Hispanic/Latino
- HIV Stigma
- Gender identity
- Frequency of alcohol use (daily or almost daily)
- Income
- Race (black, white, or other)
- Housing instability (past 3 months)
- Use of social media (daily, weekly, or < than weekly)
- New to care or ART non-adherent
- Internalized homophobia
- Belief in less need for condom use because of availability of ART
- Engages in only oral sex to reduce risk of HIV transmission
- Belief in need to use condoms with HIV-/unknown status partners when VL is detectable
- Incarceration (ever)
- Educational level
- Employment
- Depression
- Frequency marijuana use (daily or almost daily)



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Panel B

- Problematic substance use
- Hispanic/Latino
- Internet use to find sex partners (past 3 months)
- Perceived rise in homophobia
- Frequency marijuana use (daily or almost daily)
- Internalized homophobia
- Frequency of internet use to find sex partners (daily, weekly, or < than weekly)
- Engages in only oral sex to reduce risk of HIV transmission
- HIV Stigma
- Moderate/severe anxiety
- Cocaine, amphetamine, opioid use (ever)
- Marijuana use (ever)
- Depression
- Employment
- Alcohol use (ever)
- Frequency of alcohol use (daily or almost daily)
- Gender identity
- Housing instability (past 3 months)
- Look for HIV+ partners to have sex with
- Less concerned about condom use with HIV+ partners
- Belief in less need for condom use because of availability of ART
- Belief that low VL decreases transmission risk
- New to care or ART non-adherent
- Use of social media (daily, weekly, or < than weekly)
- Belief in need to use condoms with HIV-/unknown status partners when VL is detectable
- Age (yrs)
- Educational level
- Race (black, white, or other)
- Income
- Sexual identity (gay, bisexual or other)
- In a committed relationship
- Incarceration (ever)
- Belief that partners not interested in using condoms are probably HIV+

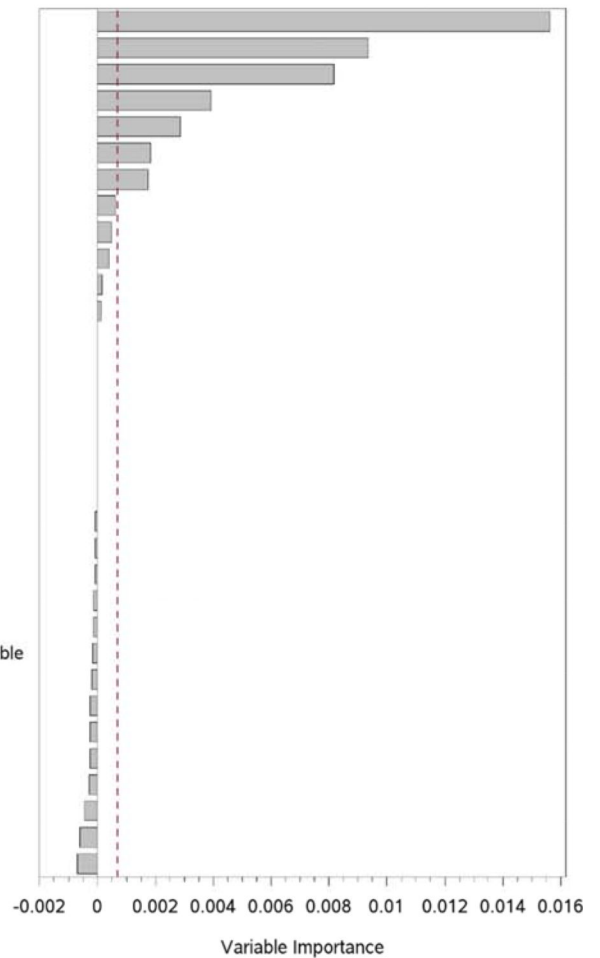
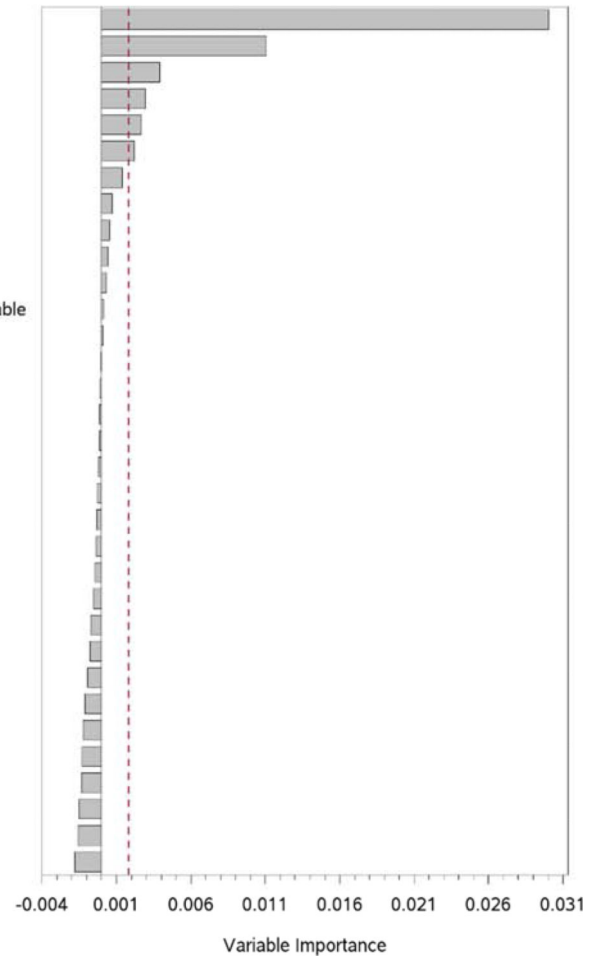


Figure 1. Random Forest Variable Importance for Predictors of Any CAI (Panel A) and Serodiscordant CAI (Panel B). Dotted line at absolute value of minimum variable importance score.

Panel A

- In a committed relationship
- Look for HIV+ partners to have sex with
- Less concerned about condom use with HIV+ partners
- Belief that low VL decreases transmission risk
- Internet use to find sex partners (past 3 months)
- Use of social media (daily, weekly, or < than weekly)
- Belief that partners not interested in using condoms are probably HIV+
- Marijuana use (ever)
- Internalized homophobia
- Alcohol use (ever)
- Frequency of alcohol use (daily or almost daily)
- Belief in need to use condoms with HIV-/unknown status partners when VL is detectable
- Frequency marijuana use (daily or almost daily)
- Employment
- Gender identity
- Age (yrs)
- New to care or ART non-adherent
- Sexual identity (gay, bisexual or other)
- Frequency of internet use to find sex partners (daily, weekly, or < than weekly)
- Educational level
- Race (black, white, or other)
- Problematic substance use
- Perceived rise in homophobia
- Cocaine, amphetamine, opioid use (ever)
- Depression
- Income
- Moderate/severe anxiety
- Engages in only oral sex to reduce risk of HIV transmission
- HIV Stigma
- Housing instability (past 3 months)
- Hispanic/Latino
- Incarceration (ever)
- Belief in less need for condom use because of availability of ART



Panel B

- In a committed relationship
- Look for HIV+ partners to have sex with
- Problematic substance use
- Marijuana use (ever)
- Internet use to find sex partners (past 3 months)
- Age (yrs)
- Belief that partners not interested in using condoms are probably HIV+
- Less concerned about condom use with HIV+ partners
- Perceived rise in homophobia
- Cocaine, amphetamine, opioid use (ever)
- Belief in less need for condom use because of availability of ART
- Sexual identity (gay, bisexual or other)
- Alcohol use (ever)
- Race (black, white, or other)
- HIV Stigma
- Use of social media (daily, weekly, or < than weekly)
- Belief in need to use condoms with HIV-/unknown status partners when VL is detectable
- Educational level
- Belief that low VL decreases transmission risk
- Gender identity
- Internalized homophobia
- Frequency of alcohol use (daily or almost daily)
- Depression
- Frequency of internet use to find sex partners (daily, weekly, or < than weekly)
- Employment
- New to care or ART non-adherent
- Frequency marijuana use (daily or almost daily)
- Hispanic/Latino
- Moderate/severe anxiety
- Income
- Engages in only oral sex to reduce risk of HIV transmission
- Housing instability (past 3 months)
- Incarceration (ever)

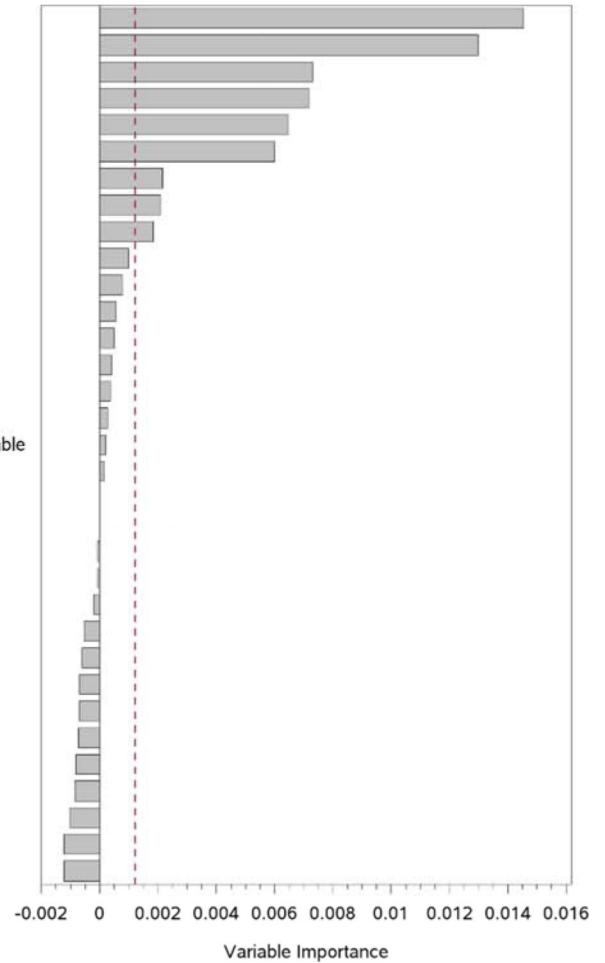


Figure 2. Random Forest Variable Importance for Predictors of Any Inceptive Condomless Anal Intercourse (CAI) (Panel A) and Receptive CAI (Panel B). Dotted line represents absolute value of minimum variable importance score

Table 1.

Sample characteristics of YGBMSM¹ (n=134) overall and by differences in sexual risk behavior.

Variable	Total (N=134)	Type of CAI Behavior			
		Any CAI ²		Serodiscordant CAI	
		No (N=64)	Yes (N=70)	No (N=94)	Yes (N=40)
Demographics					
Age, Median (IQR)	22 (20, 23)	21 (20, 23)	22 (20, 23)	22.0 (20, 23)	22 (20, 23)
Current Gender Identity					
Male	126 (94%)	59 (92%)	67 (96%)	89 (95%)	37 (93%)
Female, transgender female, other	8 (6%)	5 (8%)	3 (4%)	5 (5%)	3 (7%)
Sexual Identity					
Gay	102 (76%)	45 (70%)	57 (81%)	70 (74%)	32 (80%)
Bisexual	26 (19%)	14 (22%)	12 (17%)	18 (19%)	8 (20%)
Other	6 (4%)	5 (8%)	1 (1%)	6 (6%)	0 (0%)
Hispanic/Latino	26 (19%)	9 (14%)	17 (24%)	12 (13%)	14 (35%)
Racial Identification					
White	8 (6%)	4 (7%)	4 (6%)	6 (7%)	2 (6%)
African American/Black	102 (82%)	52 (85%)	50 (79%)	76 (84%)	26 (79%)
Other	14 (11%)	5 (8%)	9 (14%)	9 (10%)	5 (15%)
In a committed relationship	50 (37%)	15 (23%)	35 (50%)	35 (37%)	15 (38%)
Highest Education					
< 12th grade	25 (19%)	14 (22%)	11 (16%)	20 (21%)	5 (13%)
Completed high school/GED, some technical/college	97 (72%)	46 (72%)	51 (73%)	67 (71%)	30 (75%)
College/technical degree or more	12 (9%)	4 (6%)	8 (11%)	7 (7%)	5 (13%)
Economic					
Currently employed	90 (67%)	44 (69%)	46 (66%)	62 (66%)	28 (70%)
Approximate yearly income					
< \$11,999	98 (73%)	46 (72%)	52 (74%)	70 (74%)	28 (70%)
\$12,000+	23 (17%)	9 (14%)	14 (20%)	14 (15%)	9 (23%)
Don't know/Refuse	13 (10%)	9 (14%)	4 (6%)	10 (11%)	3 (8%)
Life Stressors					
Homeless for one night or more (3 mo.)	38 (28%)	17 (27%)	21 (30%)	27 (29%)	11 (28%)
Ever incarcerated	36 (27%)	17 (27%)	19 (27%)	29 (31%)	7 (18%)
Male Sex partners Median (IQR)	1.0 (1.0, 3.0)	0 (0.0, 1.0)	2.0 (1.0, 4.0)	1.0 (0.0, 2.0)	3.0 (1.5, 5.0)
Social Media Use					
Number of social media accounts					
None	9 (7%)	5 (8%)	4 (6%)	7 (7%)	2 (5%)
1 to 3	48 (36%)	24 (38%)	24 (34%)	37 (39%)	11 (28%)

Variable	Total (N=134)	Type of CAI Behavior			
		Any CAI ²		Serodiscordant CAI	
		No (N=64)	Yes (N=70)	No (N=94)	Yes (N=40)
4 to 6	66 (49%)	31 (48%)	35 (50%)	43 (46%)	23 (58%)
7 to 9	11 (8%)	4 (6%)	7 (10%)	7 (7%)	4 (10%)
Frequency of visit to social media accounts (3 mo.)					
Less than weekly	11 (8%)	7 (11%)	4 (6%)	9 (10%)	2 (5%)
Weekly	12 (9%)	3 (5%)	9 (13%)	7 (7%)	5 (13%)
Daily	111 (83%)	54 (84%)	57 (81%)	78 (83%)	33 (83%)
Used internet to search for a sex partner (3 mo.)	55 (41%)	19 (30%)	36 (51%)	30 (32%)	25 (63%)
How often looked online for sex partner					
Less than weekly	104 (78%)	54 (84%)	50 (72%)	79 (84%)	25 (64%)
Weekly	15 (11%)	6 (9%)	9 (13%)	9 (10%)	6 (15%)
Daily	14 (11%)	4 (6%)	10 (14%)	6 (6%)	8 (21%)
Mental Health					
Depressive symptoms	76 (57%)	36 (56%)	40 (57%)	50 (53%)	26 (65%)
Moderate/Severe Anxiety	38 (28%)	15 (23%)	23 (33%)	25 (27%)	13 (33%)
Substance Use					
Problematic substance use	69 (52%)	24 (39%)	45 (64%)	38 (41%)	31 (78%)
Ever used alcohol	116 (87%)	52 (83%)	64 (91%)	80 (86%)	36 (90%)
Alcohol daily/almost daily	9 (7%)	4 (6%)	5 (7%)	6 (6%)	3 (8%)
Ever used marijuana	97 (73%)	38 (60%)	59 (84%)	63 (68%)	34 (85%)
Marijuana daily/almost daily	46 (35%)	19 (30%)	27 (39%)	33 (35%)	13 (33%)
Ever used Cocaine/ Amphetamines/Opioids	23 (17%)	7 (11%)	16 (23%)	14 (15%)	9 (23%)
HIV Health and Medication Adherence					
Non-adherent	68 (51%)	34 (53%)	34 (49%)	50 (53%)	18 (45%)
New-to-care	66 (49%)	30 (47%)	36 (51%)	44 (47%)	22 (55%)
HIV Transmission Beliefs					
If VL ³ is low/undetectable I'm less likely to infect someone w/ HIV	62 (48%)	25 (41%)	37 (54%)	40 (44%)	22 (56%)
I practice safer sex less often because new medical treatments for HIV/AIDS have come along	55 (42%)	23 (38%)	32 (46%)	40 (44%)	15 (38%)
I am less concerned about using condoms w/ a partner who is also HIV+	31 (24%)	10 (16%)	21 (30%)	22 (24%)	9 (23%)
I am more concerned about using condoms with HIV- or unknown status partners when VL is detectable	92 (71%)	43 (70%)	49 (71%)	62 (68%)	30 (77%)
A partner who doesn't seem interested in using condoms is probably also HIV+	53 (41%)	20 (33%)	33 (48%)	37 (41%)	16 (41%)
I look for other HIV+ people to have sex with	26 (20%)	7 (11%)	19 (28%)	19 (21%)	7 (18%)
I will have oral sex w/ /partner to reduce risk of infecting someone	40 (31%)	16 (26%)	24 (35%)	25 (27%)	15 (39%)
Stigma					

Variable	Total (N=134)	Type of CAI Behavior			
		Any CAI ²		Serodiscordant CAI	
		No (N=64)	Yes (N=70)	No (N=94)	Yes (N=40)
HIV Stigma Median (IQR)	21 (16.0, 28.0)	20 (14, 27)	22 (17, 28)	20 (14, 25)	23 (18, 30)
Internalized Homophobia Scale					
1	54 (40%)	28 (44%)	26 (37%)	42 (45%)	12 (30%)
2	29 (22%)	11 (17%)	18 (26%)	17 (18%)	12 (30%)
3	33 (25%)	21 (33%)	12 (17%)	27 (29%)	6 (15%)
4 or 5	18 (13%)	4 (6%)	14 (20%)	8 (9%)	10 (25%)
Perceived a rise in homophobia/transphobia (12 mo.)	46 (34%)	17 (27%)	29 (41%)	25 (27%)	21 (53%)

¹ Young gay, bisexual or other men who have sex with men

² Condomless anal intercourse

³ Viral load

Table 2.

Characteristics associated with prevalence of any CAI and any serodiscordant CAI among YGBMSM

Variable	Level	Type of CAI Behavior			
		Any CAI		Serodiscordant CAI	
		Estimate (95% CI)	P-value	Estimate (95% CI)	P-value
Demographics					
Age (years)	-	1.08 (1.00,1.18)	.065	1.08 (0.94,1.25)	.256
Current Gender Identity (ref: Male)	Female, trans female	0.55 (0.18,1.71)	.304	0.94 (0.30,2.95)	.922
	Other	0.88 (0.15,5.14)	.889	1.55 (0.22,10.7)	.657
Sexual Identity (ref: Gay)	Bisexual	0.27 (0.05,1.50)	.134		
	Other	0.86 (0.56,1.33)	.499		
Hispanic/Latino	Yes	1.24 (0.87,1.77)	.227	2.07 (1.23,3.49)	.006
Racial Identification (ref: White)	African American/Black	1.20 (0.56,2.59)	.637	1.32 (0.33,5.29)	.691
	Other	0.83 (0.41,1.67)	.593	0.85 (0.23,3.06)	.801
In a committed relationship	Yes	1.61 (1.18,2.20)	.003	0.94 (0.55,1.61)	.832
Highest Education (ref: < 12 th grade)	Completed high school/GED, some technical/college	1.17 (0.73,1.89)	.510	1.47 (0.62,3.45)	.382
	College/technical degree or more	1.55 (0.85,2.81)	.152	2.10 (0.76,5.81)	.152
Economic					
Currently employed	Yes	1.17 (0.73,1.89)	.510	1.47 (0.62,3.45)	.382
Yearly income (ref: <\$11,999)	\$12,000+	1.15 (0.78,1.69)	.474	1.38 (0.78,2.44)	.269
	Don't know/Refuse	0.57 (0.24,1.35)	.199	0.78 (0.27,2.22)	.637
Life Stressors					
Homeless for one night or more (3 mo.)	Yes	1.11 (0.78,1.57)	.559	0.99 (0.55,1.78)	.965
Ever been incarcerated?	Yes	1.06 (0.73,1.53)	.755	0.58 (0.28,1.20)	.143
Social Media Use					
Number of social media accounts (ref: none)	1–3	1.17 (0.53,2.58)	.696	1.03 (0.27,3.92)	.962
	4–6	1.23 (0.57,2.65)	.595	1.58 (0.45,5.53)	.478
	7–9	1.45 (0.59,3.54)	.420	1.57 (0.34,7.27)	.561
Frequency of visit to social media accounts (in last month) (ref: less than weekly)	Weekly	2.10 (0.92,4.83)	.079	2.28 (0.56,9.24)	.248
	Daily	1.43 (0.64,3.15)	.381	1.60 (0.45,5.66)	.465
Used internet to search for a sex partner (3 mo)?	Yes	1.49 (1.08,2.06)	.016	2.30 (1.35,3.91)	.002
Frequency going online for sex partners (past month)? (ref: less than weekly)	Weekly	1.23 (0.78,1.96)	.375	1.62 (0.79,3.30)	.186
	Daily	1.39 (0.93,2.08)	.106	2.16 (1.20,3.90)	.011
Mental Health					
Depressed	Yes	2.10 (0.92,4.83)	.079	2.28 (0.56,9.24)	.248
Moderate/Severe Anxiety	Yes	1.43 (0.64,3.15)	.381	1.60 (0.45,5.66)	.465

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		Type of CAI Behavior			
		Any CAI		Serodiscordant CAI	
Variable	Level	Estimate (95% CI)	P-value	Estimate (95% CI)	P-value
Substance Use					
Problematic Substance Use	Yes	1.60 (1.12,2.29)	.009	3.13 (1.62,6.07)	.001
Ever used alcohol	Yes	1.51 (0.80,2.85)	.202	1.23 (0.52,2.93)	.636
Alcohol daily/almost daily	Yes	1.27 (0.68,2.40)	.452	1.43 (0.52,3.95)	.488
Ever used marijuana	Yes	1.92 (1.16,3.18)	.011	2.00 (0.92,4.35)	.081
Marijuana daily/almost daily	Yes	1.15 (0.83,1.58)	.395	0.86 (0.50,1.50)	.597
Ever used Cocaine/Amphetamines/Opioids	Yes	1.46 (1.03,2.07)	.035	1.42 (0.76,2.65)	.269
HIV Health and Medication Adherence					
New-to-care vs. Non-adherent	New-to-care	1.21 (0.87,1.70)	.257	1.54 (0.89,2.67)	.123
HIV Transmission Beliefs					
If VL is low/undetectable I'm less likely to infect someone w/ HIV	Yes	1.22 (0.89,1.69)	.219	1.33 (0.78,2.27)	.296
I practice safer sex less often because new medical treatments for HIV/AIDS have come along	Yes	1.18 (0.86,1.62)	.314	0.85 (0.50,1.43)	.533
I am less concerned about using condoms w/ a partner who is also HIV+	Yes	1.38 (1.00,1.91)	.047	0.96 (0.50,1.84)	.899
I am more concerned about using condoms with HIV- or unknown status partners when VL is detectable	Yes	1.03 (0.73,1.46)	.865	1.40 (0.75,2.64)	.293
A partner who doesn't seem interested in using condoms is probably also HIV+	Yes	1.33 (0.97,1.83)	.078	0.98 (0.58,1.66)	.953
I look for other HIV+ people to have sex with	Yes	1.55 (1.14,2.10)	.005	0.91 (0.46,1.83)	.796
I will have oral sex w/ /partner to reduce risk of infecting someone	Yes	1.16 (0.83,1.62)	.386	1.37 (0.79,2.39)	.257
Stigma					
Internalized Homophobia	2	1.27 (0.83,1.92)	.269	1.77 (0.91,3.45)	.093
	3	0.77 (0.46,1.30)	.327	0.83 (0.35,1.98)	.679
	4+	1.55 (1.06,2.27)	.023	2.34 (1.21,4.51)	.012
Rise in homophobia/transphobia (12mo).	Agree	1.28 (0.93,1.76)	.135	1.96 (1.16,3.33)	.012
HIV Stigma (Range: 0-50)	--	1.01 (0.99,1.03)	.447	1.03 (1.00,1.06)	.048

All regressions adjusted for study site

Estimates found "important" by Random Forests analysis in **bold**

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Table 3.

Characteristics associated with prevalence of insertive and receptive CAI among YGBMSM

Variable	Level	Any Insertive CAI		Any Receptive CAI	
		Estimate (95% CI)	P-value	Estimate (95% CI)	P-value
Demographics					
Age		1.03 (0.92,1.14)	.636	1.11 (1.01,1.22)	.035
Current Gender Identity (ref: Male)	Female, trans female			0.95 (0.16,5.74)	.957
	Other			0.60 (0.19,1.84)	.369
Sexual Identity (ref: Gay)	Bisexual	0.96 (0.54,1.70)	.880	0.79 (0.47,1.31)	.360
	Other	0.37 (0.07,2.15)	.270	0.28 (0.05,1.58)	.150
Hispanic/Latino	Yes	0.98 (0.56,1.72)	.938	1.18 (0.78,1.78)	.425
Racial Identification (ref: White)	African American/Black	0.52 (0.20,1.38)	.188	1.15 (0.53,2.49)	.722
	Other	0.57 (0.28,1.15)	.116	0.67 (0.33,1.35)	.262
In a committed relationship	Yes	2.19 (1.39,3.44)	.001	1.55 (1.09,2.19)	.014
Highest Education (ref: <12 th grade)	Completed high school/GED, some technical/college	0.96 (0.54,1.72)	.898	1.10 (0.66,1.83)	.716
	College/technical degree or more	1.19 (0.53,2.71)	.673	1.69 (0.90,3.17)	.099
Economic					
Currently employed	Yes	0.81 (0.52,1.25)	.341	0.85 (0.59,1.22)	.375
Yearly income (ref: <\$11,999)	\$12,000+	0.95 (0.52,1.73)	.864	0.87 (0.53,1.45)	.602
	Don't know/Refuse	0.80 (0.33,1.95)	.628	0.60 (0.25,1.42)	.242
Life Stressors					
Homeless for one night or more (3 mo)?	Yes	0.87 (0.52,1.46)	.595	1.12 (0.76,1.64)	.574
Ever been incarcerated?	Yes	1.03 (0.61,1.74)	.913	1.25 (0.85,1.83)	.251
Social Media Use					
Number of social media accounts (ref: none)	1–3	0.93 (0.41,2.07)	.850	1.41 (0.53,3.70)	.490
	4–6	0.84 (0.38,1.85)	.668	1.44 (0.56,3.72)	.448
	7–9	0.79 (0.26,2.36)	.674	1.87 (0.65,5.42)	.249
Frequency of visit to social media accounts (in last month) (ref: less than weekly)	Weekly	2.14 (0.94,4.87)	.070	2.48 (0.89,6.87)	.081
	Daily	0.95 (0.42,2.14)	.906	1.72 (0.66,4.51)	.268
Used internet to search for a sex partner (3 mo.)?	Yes	1.22 (0.78,1.90)	.381	1.53 (1.07,2.19)	.021
Frequency going online for sex partners (past month)? (ref: less than weekly)	Weekly	1.34 (0.72,2.50)	.351	1.21 (0.73,2.00)	.463
	Daily	1.16 (0.61,2.20)	.656	1.37 (0.87,2.15)	.173
Mental Health					
Depressed	Yes	0.98 (0.63,1.53)	.935	0.93 (0.64,1.34)	.690
Moderate/Severe Anxiety	Yes	1.15 (0.72,1.85)	.556	1.26 (0.88,1.80)	.212
Substance Use					

Variable	Level	Any Insertive CAI		Any Receptive CAI	
		Estimate (95% CI)	P-value	Estimate (95% CI)	P-value
Problematic Substance Use	Yes	1.31 (0.82,2.07)	.257	1.54 (1.05,2.28)	.028
Ever used alcohol	Yes	1.60 (0.67,3.86)	.291	1.62 (0.80,3.28)	.183
Alcohol daily/almost daily	Yes	0.33 (0.05,2.06)	.235	1.47 (0.78,2.77)	.239
Ever used marijuana	Yes	1.45 (0.82,2.57)	.196	1.90 (1.11,3.26)	.020
Marijuana daily/almost daily	Yes	1.01 (0.64,1.59)	.977	1.27 (0.90,1.80)	.167
Ever used Cocaine/ Amphetamines/Opioids	Yes	0.91 (0.49,1.67)	.749	1.54 (1.04,2.28)	.031
HIV Health and Medication Adherence					
New-to-care vs. Non-adherent	New-to-care	1.31 (0.82,2.07)	.257	1.54 (1.05,2.28)	.028
HIV Transmission Beliefs					
If VL is low/undetectable I'm less likely to infect someone w/ HIV	Yes	1.53 (0.96,2.41)	.071	1.19 (0.83,1.70)	.353
I practice safer sex less often because new medical treatments for HIV/AIDS have come along	Yes	1.06 (0.68,1.66)	.789	1.36 (0.95,1.94)	.090
I am less concerned about using condoms w/ a partner who is also HIV+	Yes	1.71 (1.10,2.64)	.017	1.42 (1.00,2.03)	.052
I am more concerned about using condoms with HIV- or unknown status partners when VL is detectable	Yes	0.96 (0.60,1.53)	.861	1.03 (0.70,1.51)	.891
A partner who doesn't seem interested in using condoms is probably also HIV+	Yes	1.59 (1.02,2.49)	.041	1.43 (1.00,2.03)	.048
I look for other HIV+ people to have sex with	Yes	2.00 (1.33,3.01)	.001	1.82 (1.32,2.52)	.000
I will have oral sex w/ partner to reduce risk of infecting someone	Yes	1.33 (0.84,2.10)	.220	1.18 (0.82,1.70)	.375
Stigma					
Internalized Homophobia	2	0.97 (0.54,1.75)	.917	1.47 (0.94,2.30)	.094
	3	0.81 (0.43,1.50)	.499	0.75 (0.41,1.36)	.339
	4+	1.23 (0.68,2.22)	.489	1.67 (1.10,2.55)	.017
Rise in homophobia/transphobia (12mo).	Agree	1.11 (0.70,1.75)	.657	1.26 (0.88,1.80)	.209
HIV Stigma (Range: 0–50)	--	1.01 (0.99,1.04)	.279	1.00 (0.98,1.02)	.938

All regressions adjusted for study site

Estimates found "important" by Random Forests analysis in **bold**