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Substance use predicts sustained viral suppression in a community cohort of sexual and gender minority youth living with HIV

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Abstract

Retention in care and sustained viral suppression are integral outcomes in the care continuum for people living with HIV (PLWH) and HIV prevention; however, less is known about how substance use predicts sustained viral suppression over time. This study seeks to examine the predictive effects of substance use on sustained viral suppression in a sample of cisgender sexual minority men and gender minority PLWH (n=163) drawn from a longitudinal sample in the Chicago area collected 2015- 2019. Using data from 3 visits separated by 6 months, participants were coded persistently detectable, inconsistently virally suppressed, and consistently virally suppressed (<40 copies/mL at all visits). Multinomial logistic regressions were utilized. About 40% of participants had sustained viral suppression. In multinomial logistic regressions, CUDIT-R predicted persistent detectable status and stimulant use was associated with inconsistent viral suppression. Substance use may create challenges in achieving sustained viral suppression, which has important implications for care and prevention.

Resumen

Retención en el cuidado de la salud y supresión viral sostenida son resultados integrales en la cascada del tratamiento de VIH para personas viviendo con el virus del SIDA (PVVS) y prevención del VIH. Sin embargo, no se sabe mucho acerca de cómo el uso de sustancias predice la supresión viral sostenida a través del tiempo. Este estudio busca examinar los efectos predictivos del uso de sustancias en la supresión viral sostenida en una muestra de minoría de hombres cisgéneros y minorías de género PVVS (n=163) basada en una muestra longitudinal en la región de Chicago obtenida en 2015-2019. Utilizando datos de 3 visitas con un intervalo de 6 meses, participantes fueron identificados como detectables persistentemente, inconsistentemente viralmente suprimido, y consistentemente viralmente suprimido (<40 copias/mL en todas las visitas). Regresión logística multinomial fue utilizada. Cerca de 40% de los participantes tenían

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supresión viral sostenida. En regresión logística multinomial, CUDIT-R predicho status detectable persistente y uso de estimulantes fueron asociados a la supresión viral inconsistente. Uso de sustancias crean desafíos para lograr la supresión viral sostenida, lo que tiene importante trascendencia para el cuidado y prevención.

Introduction

HIV prevalence among cisgender men who have sex with men and transgender women (MSM & TGW) remains high. In 2017, rates of new HIV diagnoses increased for ages 15-34 with the highest rates among 25-29 year olds (1). Of all diagnoses, 70% were due to male-male sexual contact (3% for both male-male sexual contact and injection drug use) (1). Moreover, transgender women in the US also have a high HIV prevalence, estimated at about 21.7% in meta-analysis (2). Research has established that viral suppression has numerous medical benefits for people living with HIV (3–6). More recently, HIV treatment has gained increasing attention as an integral part of prevention. The slogan “Undetectable = Untransmittable” (U=U) highlights evidence that people who achieve a viral load below detectable levels in standard laboratory tests cannot transmit the virus (7). This concept underscores the importance of understanding challenges to maintaining viral suppression over time. Among the suggested factors that may affect medication adherence and viral suppression achievement are alcohol and substance use, which are prevalent health concerns among MSM & TGW (8, 9). Despite existing evidence that links substance use to retention in care, adherence to medication and to achieving viral suppression, little is known about the relationship between alcohol and substance use and long-term viral suppression in young MSM and TGW or Gender Minorities (GM) more broadly representing a critical gap in our understanding of treatment as prevention (TasP) (10–14).

Treatment as Prevention (TasP) is an effective strategy in preventing HIV transmission. TasP is a concept that works within the HIV care continuum by ensuring people living with HIV adhere to antiretroviral therapy (ART) and achieve undetectable viral levels. When viral suppression is achieved and sustained, HIV transmission risk is nearly eliminated. For example, research suggests that the rate of HIV transmission among heterosexual and same-sex male serodiscordant couples is effectively zero when the partner living with HIV is virally suppressed (15–17). As a result of these and other studies observing a substantial reduction in HIV transmission with undetectable viral loads, public health organizations began adopting U=U as a prevention strategy. The World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC) and the National Institute for Allergy and Infectious Disease (NIAID) have all endorsed viral suppression as a means to preventing further HIV transmission. Although U=U and TasP are promising concepts, they are heavily dependent upon retention in care and ART adherence, and ultimately, sustained viral suppression over time. In order to be an effective prevention strategy, achieving viral suppression cannot be a singular event. Instead, it is characterized by retaining people living with HIV in care and maintaining optimal medication adherence over time in order to maintain a suppressed viral load (11–14, 18). Indeed, when HIV transmissions have occurred in studies of serodiscordant couples in which the partner living with HIV is on ART, findings indicate these transmissions have been a result of suboptimal medication

adherence and lack of sustained viral suppression (19). Although achievement of viral suppression has been the subject of research for some time, only more recently has research been conducted on sustained viral suppression within persons over time.

Sustained viral suppression is defined as maintaining a state of undetectable viral load (<40 copies/mL) over multiple doctor's visits, months, or years. Estimates of sustained viral suppression vary by study and range between 28% and 89% among adolescents worldwide, and tend to diminish over time (18, 20–22). Estimates comparing adolescents and young adults (13–24 and 24–44) with older adults (45 and older) suggest that while age-based disparities are reducing adolescents and young adults are persistently less likely to reach viral suppression (23). Given these estimates, researchers have identified a number of factors that correlate with sustained viral suppression. Foremost are lack of retention in care and low adherence to antiretroviral therapy (ART), which is associated with non-suppression (24, 25). Other studies have connected adherence and viral suppression to issues relating to existing racial and economic disparities in access to care. Black and Hispanic people living with HIV are less likely have sustained viral suppression than their white counterparts (20, 26). While the racial disparities in viral suppression have not been fully explained, possible factors that may disproportionately impact Black and Hispanic people living with HIV include access to private insurance, housing insecurity, and incarceration (20, 26–28). Black men may also be more likely to be impacted by side effects (e.g. weight gain, appetite loss, nausea, fatigue, etc.) less likely to have confidence that they can take medication as prescribed, less likely to anticipate a positive effect from medication, less likely to be retained in care, and less likely to be adherent (27, 28). Beyond these factors, alcohol and other substance use have been identified as possible factors contributing to retention in care, adherence and sustained viral suppression (10–14, 29).

Alcohol use is common among people living with HIV, with some studies documenting up to 42% of people living with HIV as having heavy drinking patterns (30). Furthermore, disparities in alcohol use in MSM and TGW populations have been documented among both adolescents and adults (31, 32). The effects of alcohol use and abuse are fairly well documented across the HIV care continuum. Alcohol use (measured in a variety of ways i.e. use, abuse) is associated with (lack of) HIV testing, lower rates of linkage to and retention in care, suboptimal medication adherence, and a lower likelihood of achieving viral suppression in systematic review (10). This includes associations between alcohol use and HIV care continuum outcomes among adolescent samples (33–35). Similar patterns have also been observed for other substances, including stimulants, cannabis, and overall drug use (12, 13, 36, 37).

Researchers have documented elevated drug use among MSM and TGW populations compared to heterosexual and cisgender populations across drug types, including problematic use (38–42). Moreover, current drug use is common among people living with HIV, with approximately 33.6% of people living with HIV having evidence of some form of drug abuse in meta-analysis (43). Among adolescents estimates of substance use range between 4 and 37% and research suggests that substance use is elevated among MSM, TGW, and other GM youth (33, 41, 44, 45). Additionally, current drug use has been identified as a predictor of HIV medication adherence in meta-analysis such that individuals who report

current drug use are more likely to have lapses in healthcare and less likely to be adherent to ART regimens (12, 13, 36, 37). Studies have found associations between marijuana use, other illicit drug use and polysubstance use with ART nonadherence among adolescent samples while also documenting higher substance use among young MSM compared to men who have sex with women (33–35, 46). In meta-analysis of research globally, substance use was the most commonly cited predictor of retention in care for studies based in developed countries (47). Research in adult samples suggests that people who use substances are among the populations who have the highest level of attrition from HIV care (48–52). This is particularly true of injection drug use, which is associated with non-adherence and non-suppression (11–14). Stimulant use (cocaine and methamphetamines) is associated with lower likelihood of achieving viral suppression and increased risk of mortality among people living with HIV (53, 54). This includes some evidence suggesting that stimulant use is associated with lower viral suppression over time when viral suppression is measured as a time-varying outcome (55). Evidence pertaining to cannabis use is less consistent. In one study people with cannabis dependence were less likely to have consistent medication adherence than those who had non-problematic cannabis use (56). Other studies found no association with cannabis use and viral suppression (57). While studies have examined the cross-sectional relationship between substance use and viral suppression, few have used a prospective longitudinal approach, which strengthens causal arguments (9, 53, 54, 56). Moreover, few studies have examined substance use in relation to sustained viral suppression over time or across multiple forms of substance simultaneously (9, 54). Still fewer examine this relationship in samples of young adults and adolescents (58).

Current Study

The current study seeks to examine retention in care, and sustained viral suppression in a large longitudinal cohort of MSM and GM youth assigned male at birth. More specifically, this analysis examines the effects of baseline alcohol, cannabis, and stimulant use on retention in care and sustained viral suppression.

Methods

Participants and procedures

This analysis uses data from 9 waves of an ongoing longitudinal study of MSM and GM youth assigned male at birth living in the Chicago metropolitan area, called RADAR (n=1,129) (59). Data were collected between February 2015 and August 2019 using computer assisted self-interview (CASI) software as well as the collection of biological samples. The primary goal of RADAR is to examine multi-level influences on HIV and substance use. The cohort includes a sample of young MSM, TGW, and other GM youth assigned male at birth (ages 16-29 at baseline). All participants speak English, had sexual encounter with a man in the year prior or identify with a sexual minority identity. Recruitment for this study used an incentivized snowball sampling approach meaning that an initial set of participants are recruited directly who can then refer up to 5 peers. The recruitment for the initial set of participants included venue-based (e.g., community organizations) and social media advertisements (e.g., Facebook). To be included in this

analysis, the participants had to have tested HIV positive by their 6th study visit (to allow for 3 follow-up visits that collected viral load status).

Measures

Demographics included age, race, gender, and sexual orientation. Race/ethnicity was reduced to three categories for these analyses: Black, Hispanic/Latinx or “other race” due to small numbers (i.e., White, Asian, multi-racial, and other, which were combined due to small numbers.). All participants were assigned male at birth. Gender identity was reduced to two categories: cisgender man and gender minority (i.e., transgender women, non-binary individuals, and other gender identity). Sexual orientation was reduced to three categories: gay, bisexual, and other sexual orientation (i.e., queer, questioning, heterosexual, other).

HIV Status—Alere™ Determine™ 4th Generation HIV-1/HIV-2 Ab/Ag Combo rapid test was used to test for the presence of HIV-1 antibodies, HIV-2 antibodies and free HIV-1 p24 antigen. Laboratory confirmation followed the Centers for Disease Control and Prevention (CDC) guidelines for HIV testing (60). Only those who were confirmed positive were included in the sample for analysis. Participants were further classified as an “incident” case or a “prevalent” case based off of their self-report of prior exposure at baseline or their previous test results at later visits. Participants were classified as an incident case if they 1) reported a negative HIV status at baseline and received an HIV positive test at baseline or, 2) tested negative for HIV at earlier visits but then subsequently received a positive HIV test result from study staff at a later visit. Participants were classified as a prevalent case if they reported previously receiving an HIV positive test result and also received a positive HIV result at baseline.

Retention in Care and HIV Medication Adherence—Because retention in care has been linked to substance use, current use of HIV medication was used to assess retention in care. To determine if participants were currently taking ART medication participants were asked “Are you currently taking any HIV medication?” at all included time points with response options of “yes” or “no.” Those who did not consistently report currently being on HIV medication at all included time points were classified as “Inconsistent retention in care” and those who reported being on HIV medication at all included time points were classified as “Consistent retention in care.”

An additional measure of adherence was included in the survey. Participants were asked to report missed doses of HIV medication for the 7 days prior to each visit. This measure was averaged across included visits and then dichotomized as “adherent” (average of missing <1 dose in a week) and “non-adherent” (average of missing 1 or more dose per week). This dichotomization aligns with measures used in previous research (61–63).

Viral Suppression—Viral load was collected for 3–4 visits, separated by 6 months, starting at the first HIV-positive visit using RealTime HIV-1 assay results. Prevalent cases were tested at 3 consecutive times starting with their first HIV-positive visit (baseline visit), and incident cases were tested for 4 consecutive times starting at the first HIV-positive visit to allow for observation of viral load at 3 time points at which they were prevalent cases.

Viral loads that were <40 copies/mL were considered undetectable or suppressed. Viral suppression was classified using all viral loads for prevalent cases and the most recent 3 viral loads for incident cases. Participants were coded with “consistent non-suppression” if they received a detectable viral load at all 3 visits. Participants were coded with “inconsistent viral suppression” if their viral load was detectable at 1 or 2 visits. Participants were coded with “sustained suppression” if they had undetectable viral loads at all 3 visits. This means that the “sustained suppression” in this analysis is treated as a status established at the final time point.

Cannabis Use and Associated Problems—Cannabis use was measured using the Cannabis Use Disorder Identification Test (CUDIT-R) which is the sum of an 8-item screening instrument used to identify problematic cannabis use (64, 65). Questions addressed several dimensions of cannabis use including frequency, and symptoms (e.g. “How often in the past 6 months have you had a problem with your memory or concentration after using marijuana?”). Response options are on a 5-item Likert scales, ranging from “Never” to “Daily or almost daily.” The scale ranges from 0 to 32 with a score of 13 or more representing problematic use. This scale had an alpha of 0.80 in this sample. CUDIT scores are hereafter referred to as cannabis use disorder score. Cannabis use disorder score was measured at first HIV-positive visit. These data were collected at baseline.

Alcohol Use and Associated Problems—The Alcohol Use Disorders Identification Test (AUDIT) is the sum of a 10-item instrument from the World Health Organization that measures problematic drinking (66, 67). Questions addressed several dimensions of alcohol use including frequency, and symptoms (e.g. “Have you or someone else been injured because of your drinking?”). Response options are on a 5-item Likert scales, ranging from “Never” to “Daily or almost daily.” Scores ranging from 8-15 indicate moderate problematic drinking and 16+ indicates more severe problematic drinking. The scale ranges from 0 to 40 with scores ranging from 0-7 representing “low risk,” scores 8-15 representing “moderate risk, scores 16-19 representing high risk (possibly dependent), and scores 20-40 representing high risk (almost certainly dependent). This scale had an alpha of 0.80 in this sample. AUDIT scores are here after referred to as alcohol use disorder score. The alcohol use disorder score was measured at first HIV-positive visit. These data were collected at baseline.

Stimulant use—Stimulant use (specifically methamphetamine use or cocaine) was measured at first HIV-positive visit using self-report for the past 6 months. Participants were asked “In the past 6 months, have you used any of the following non-prescription drugs? - Cocaine or crack (also called Coke, Snow, Blow, Rock, or Freebase)” and “In the past 6 months, have you used any of the following non-prescription drugs? - Methamphetamines (also called Meth, Crystal Meth, Tina, parTy, or Crank).” Response options were “yes” or “no.” Participants were then classified as having any non-prescription drug use if they said yes to one or both substance. These data were collected at baseline.

Statistical Analysis

All statistical analyses were run in SAS version 9.4 (68). Baseline measures were taken from the first HIV-positive visit (baseline) and the outcomes were composite categorical variables constructed from multiple time points. Univariate and bivariate analyses were used to examine distributions and bivariate associations. Binomial logistic regression was conducted to examine correlates of inconsistent retention in care. Multinomial logistic regression was conducted to examine substance use and alcohol use variables when controlling for demographics using “sustained suppression” as the reference group for the viral suppression outcome.

Two sensitivity analyses were conducted. One sensitivity analysis was conducted to assess the impact of excluding those participants who did not have 3 visits at which viral loads were collected. Using multiple consecutive visits to determine sustained viral suppression status resulted in participants being excluded due to too few observations (n=64). Bivariate analyses were run to assess differences between participants who were excluded due to missing observations and those who had complete data. Regressions were run to examine differences in the estimates between the sample which included participants with incomplete data and the sample with only those with complete data.

The second sensitivity analysis examined the differences in model estimates if the independent variable for retention in care was replaced with the adherence variable. This analysis was conducted to see if a more detailed measure of adherence would impact the estimated effects of substance use on sustained viral suppression.

Results

Sample Characteristics

At the time of this analysis 231 of the n=1,129 participants had received an HIV positive test before their 6th visit. A total of 64 (27.71%) participants were excluded because they had not had 3 visits with viral load results at the time of analysis. Lastly, 4 (1.73%) were excluded because they had a gap of more than a year between visits leaving a final analytic sample of n=163. The final sample is described in Table 1. TGW and other GM were combined into a broader GM category, because 14 (8.58%) identified as TGW and 1 (0.61%) participant selected “not listed” for gender without self-identifying in the open response. The “other racial identity” category included Multi-racial (n=17, 9.20%), White (n=5, 3.07%) and Asian (n=1 0.61%) as well as individuals who selected “Other” (n=2, 1.23%). The average age was 23.58 and ranged from 17.50 to 29.77.

Alcohol and Substance Use at Baseline

There was a high level of cannabis use in the 6 months prior to first HIV-positive visit in this sample (73.61% had used cannabis); however, the mean cannabis use disorder score was 7.34 (SD=6.51), which is below the threshold for problematic levels (a score of 13 or more). In this sample 87.77% reported drinking in the past 6 months. The mean for alcohol use disorder score (AUDIT score) was 5.42 (SD=5.98), which is within the “low risk category” of alcohol dependence. For alcohol, 77.91% were low risk, 17.79 % were moderate risk, and

4.29% were high risk for dependence. For cannabis, 21.47% were high risk for dependence. Other stimulant use was much less prevalent than cannabis use, at 11.66% for cocaine, and 4.91% for methamphetamines, and 14.72% for either drug. Only 1.84% reported using both cocaine and methamphetamines in the 6 months prior to their first HIV-positive visit.

Retention in care

The majority of participants reported being in care at all 3 visits with 15.95% reporting inconsistent retention in care and 2.45% reporting consistent non-retention. The latter two groups were combined for bivariate and multivariate analyses.

Viral Suppression Patterns

The largest group of participants (39.26%) had sustained viral suppression. The second largest group (35.58%) were classified with inconsistent suppression status—meaning they had at least 1 detectable viral load during the time of the study. This group was comprised of 3 sub-groups: 1) participants who began with detectable viral loads, but were trending toward sustained suppression, having reached suppression by the third visit (13.34%), 2) those who were generally inconsistent or had alternating statuses (6.75%), and 3) those who began with viral suppression, but had detectable viral loads by the third visit (15.34%). The smallest group (25.15%) had consistent non-suppression status—meaning they had a consistently detectable viral load over the course of the study.

Bivariate Associations with Retention in Care

In bivariate analyses bisexual participants had higher odds of inconsistent retention in care than gay participants (OR=3.19, 95% CI 1.35, 7.52, $p<0.01$). Black participants had higher odds of inconsistent retention in care than Hispanic/Latinx participants (OR=5.32, 95% CI 1.19, 23.74, $p=0.03$). (See Table 2)

Bivariate Associations with Suppression Category

Incident case status, race, inconsistent retention in care, and cannabis use were significantly associated with suppression status in bivariate analyses. Incident case status was associated with lower odds of consistent non-suppression compared to sustained viral suppression (OR=0.18, 95% CI 0.04, 0.85, $p=0.03$). Inconsistent retention in care was associated with inconsistent viral suppression (OR=10.81, 95% CI 2.35, 49.72, $p<0.01$), and consistent non-suppression (OR=14.39, 95% CI 3.00, 68.08, $p<0.01$). Cannabis use disorder score was associated with consistent non-suppression (OR=1.08, 95% CI 1.02, 1.15, $p=0.01$).

Multivariable model of Retention in Care

Bisexual identity, and Black identity were associated with inconsistent retention in care. People who identified as bisexual or another sexuality other than gay had higher odds of inconsistent retention in care (AOR=3.75, 95% CI 1.41, 10.00, $p<0.01$). People who identified as Black had higher odds of inconsistent retention in care (AOR=6.77, 95% CI 1.39, 33.07).

Multivariable model of Suppression Category

Cannabis use disorder score, retention in care, and being an incident case were predictive of sustained viral suppression when controlling for other variables (see Table 3). Cannabis use disorder score was associated with higher odds of consistent non-suppression vs. sustained viral suppression (AOR=1.10, 95% CI 1.02, 1.18, $p=0.01$). Those who had inconsistent retention in care had higher odds of consistent non-suppression compared to a sustained viral suppression (AOR=16.05, 95% CI 3.00, 85.79, $p<0.01$). Incident cases had higher odds of consistent non-suppression vs. sustained viral suppression (AOR=0.17 95% CI 0.03, 0.95, $p=0.04$).

Stimulant use and retention in care were predictive of inconsistent viral suppression when controlling for other variables (see Table 3). Those who reported any stimulant use at first HIV+ visit had higher odds of having an inconsistent viral suppression vs. sustained viral suppression as compared to those who reported no stimulant use (AOR=3.52, 95% CI 1.07, 11.63, $p=0.04$). Those who had inconsistent retention in care had higher odds of inconsistent viral suppression vs. sustained viral suppression as compared to those who reported retention in care at first HIV+ visit (AOR=11.16, 95% CI 2.32, 58.10, $p<0.01$).

Sensitivity Analyses

Bivariate analyses were run to assess differences between participants who were excluded due to missing observations and those who had complete data. Participants who had incomplete data were more likely to be gender minorities (21.05% compared to 9.20%, $\chi^2=4.27$ (1) $p=0.04$), more likely to report retention in care (50.00% compared to 18.40% $\chi^2=5.83$ (1) $p=0.02$), and had statistically different suppression status with a higher proportion of participants with incomplete data having consistent non-suppression (52.94% compared to 25.15%) ($\chi^2=14.45$ (2), $P<0.01$). The multivariate analyses were rerun including the participants with partial outcome data to examine if significance of relationships changed with their inclusion. The strength, direction of relationships and significance of all variables remained the same in multivariable analyses.

Additional modeling was used to examine if the inclusion of the past 7-day adherence measure altered the substance use effects on viral suppression using bivariate tests and multivariable modeling. This measure replaced the retention in care measure in multivariable models of viral suppression. Those with consistent adherence on average were compared to those who missed at least 1 dose on average. Adherence was not associated with viral suppression and the direction, strength, and statistical significance of association for substance use variables did not change in multivariable analyses.

Discussion

Viral suppression is an important factor in maintaining the health of people living with HIV and has growing importance in the prevention of new HIV cases. This analysis underlines the influence of baseline substance use on sustained viral suppression, finding that baseline stimulant use is associated with inconsistent viral suppression status and that cannabis use is associated with consistent non-suppression status in a cohort of MSM and GM youth

assigned male at birth. These results highlight the importance of considering substance use in the context of viral suppression and the treatment as prevention paradigm.

In this analysis, baseline stimulant use was associated with inconsistent viral suppression status. This is consistent with previous studies (a randomized control trial among adult Black MSM, and a cohort of adult MSM veterans) which suggested that stimulant use was associated with poor adherence, and achievement of viral suppression (53, 54). Interestingly, while people who reported using stimulants had 3.5 times the odds of inconsistent viral suppression status compared to sustained suppression status, there was not a significant difference in the odds of consistent non-suppression status compared to sustained viral suppression status. If stimulants are impacting viral suppression primarily through adherence, as the literature suggests, then it may be that people who use stimulants take medication inconsistently rather than discontinuing altogether. In addition, some literature suggests that stimulant use is associated with condomless sex, in that serodiscordant couples that use stimulants have 6 times the odds of condomless intercourse as non-stimulant using couples (69). These findings taken together suggest that stimulant use is an important consideration related to treatment as prevention in that it may contribute simultaneously to elevated viral loads and condomless sex. Further research may be necessary to identify specific pathways through which stimulant use impacts sustained viral suppression (70). Additional intervention may be necessary to support MSM and GM youth who are living with HIV and using stimulants to mitigate effects on access to healthcare and adherence to medication regimens. Some interventions such as mobile applications to encourage adherence have shown promise in increasing adherence among MSM and GM populations who use stimulants (71).

This study also found that higher baseline cannabis use disorder scores were associated with consistent non-suppression compared to sustained viral suppression. While the literature is inconsistent about the effects of cannabis on viral suppression, this finding may be seen as consistent with findings that cannabis dependence is associated with low adherence while general cannabis use is not (56). This may be relevant to the current analysis, because CUDIT is a measure of dependence rather than a general measure of use. The effect of cannabis use on viral suppression may be explained in part by the cognitive impact of heavy use. Research suggests that reoccurring heavy cannabis use may have effects on executive function and memory, particularly for adolescent users (72, 73). These effects may also persist in periods of abstinence (73). Simply forgetting to take medication is the most common self-reported reason for low adherence (74–76). This coincides with evidence that impaired executive and memory function are predictive of poor adherence (77–79). Thus, it may be that cognitive impairment from heavy cannabis use impacts day to day adherence. Future research about viral suppression should focus on populations who are cannabis dependent to further examine the ways that cannabis dependence influences adherence and viral suppression. This may become increasingly relevant as more states in the US legalize recreational use of marijuana including the location of this current study, though the data mostly predates this policy change.

A striking difference is that baseline stimulant use predicted inconsistent viral suppression status, while baseline cannabis use disorder scores predicted consistent non-suppression

status. It's possible that cannabis use is much more habitual in comparison to stimulants. For example, in one study of MSM 82% of methamphetamine users reported using less than once a week (80). By contrast, in another study 46% of marijuana users reported one or more times weekly use among MSM (81). It may be that use patterns and their subsequent side-effects account for different impacts on viral suppression. For example, if an individual has periodic bouts of stimulant use vs. consistent near daily use of marijuana. Future studies should examine stimulant use relative to viral suppression status using longitudinal methods.

Baseline alcohol was also not associated with viral suppression, which is not consistent with most research (77% of studies in meta-analysis found this association) (10). This finding is consistent with a subset of other studies that used AUDIT scores as the alcohol-related measure (10). The relationship between alcohol use and viral suppression is likely mediated through other factors such as use patterns, because daily use may be more disruptive to pill regimens compared to drinking alcohol several times a week (82). This is further supported by evidence that suggests that while heavy drinking is associated with detectable viral load that binge drinking is not (83). Consistent heavy drinking has been associated with more treatment interruption, and lower adherence to medication (84). So while heavy drinking and binge drinking may both be problematic drinking patterns that would be detected by alcohol use disorder scores does not necessarily differentiate between these patterns and therefore may miss this nuance in the relationship between alcohol use and viral suppression (67).

Unlike previous studies, baseline alcohol and substance use were not associated with retention in care; however, much like other studies Black participants were less likely to report retention in care (20, 26). In fact, Black participants had almost 7 times the odds of inconsistent retention in care, which underlines the need to address access to HIV medication for Black MSM and GM youth and in Black communities overall. This may be due to a number of interrelated factors relating to structural inequality and racialized experiences with healthcare. For example, neighbourhoods in Chicago with higher proportion Black inhabitants tend to be further from HIV care (85). This distance to HIV care is associated with poor retention in care (85). Other barriers related to structural inequality that disproportionately impact Black populations are access to private insurance, housing insecurity, and incarceration (20, 26, 27). Social contexts have also been identified as potential influences on Black men's engagement in care. Research suggests that Black men may experience deeper medical mistrust and HIV-related stigma, which is associated with less frequent medical visits (86). Lastly, a number of individual-level factors seem more prevalent in Black populations. Studies have suggested that Black men may also be more likely to be impacted by side effects, less likely to have confidence that they can take medication as prescribed and less likely to anticipate a positive effect from medication (27, 86).

Our data was derived from a prospective observational cohort study which included both HIV negative individuals as well as individuals living with HIV meaning that some participants represented incident cases (newly diagnosed during the course of the study), while others were prevalent cases. Previous literature that examines both prevalent and incident cases does not always consider sustained viral suppression among the incident cases (87). Among incident cases in the current analysis, approximately 92% achieved viral

suppression at some time during the study and 56% achieved sustained viral suppression, which is a similar proportion to studies examining exclusively newly diagnosed people (88, 89). A large proportion of newly diagnosed cases are expected to reach viral suppression in a year from entering care (90). In fact, the current analysis found that incident cases were more likely to achieve sustained viral suppression. This may be due to factors that may be more common in prevalent cases, such as drug resistance, which is associated with viral rebound (91). However, viral rebound becomes less likely the longer someone maintains continuous sustained suppression, so identifying and addressing factors that may contribute to inconsistent viral suppression may help reduce viral rebound in the longer term (91). And while adolescents in general are likely to have low adherence and less likely to reach viral suppression in general, few studies tease out nuances in factors contributing to sustained viral suppression in this population (18).

Limitations

This study had many strengths, including the use of longitudinal data and objective measures of viral suppression. Some limitations should also be considered. This analysis sought to examine baseline substance use on viral suppression status as established by multiple follow-up visits; however, future analyses with more available time points should employ longitudinal techniques to examine the relationship between substance use over time on long-term sustained viral suppression over time. While it was important to account for gender identity in this analysis, the sample of gender minorities was not large enough to make reliable observations by gender. It was a strength to have data from multiple time points; however, the 6 month intervals do not allow for the observation of fluctuations in medication or viral load suppression at shorter intervals. Given the age of the sample additional factors may be at play for younger participants such as parental involvement in care, insurance access, and living at home with their families, etc. which should be included in future analyses involving young MSM and GM. Lastly, this sample was restricted to one city in the U.S. and therefore cannot be fully generalized to all populations. Additionally, we are examining substance use at initial visit which doesn't account for substance use trajectories which may fluctuate over time.

Conclusion

Taken together, the results of this analysis underline the importance of accounting for the effects of substance use on sustained viral suppression and subsequently treatment as prevention among young MSM and GM. This analysis highlights a number of areas that warrant additional research. Future research is needed to further understand the relationship between substance use and sustained viral suppression. One approach to achieve this is through more detailed measures and intensive longitudinal data collection (92). Using measurement that allows to differentiate between different types of problematic use may help understand nuances between heavy drinkers who drink daily versus heavy drinkers who may binge (10, 83). Through intensive longitudinal data collection, daily substance use and medication adherence can be collected prospectively along with periodic viral loads (92). This may allow for clearer understandings between substance use, daily adherence, and ultimately how this translates to viral suppression. This analysis also raises questions

about race in relation to the cascade of care. We raised many potential factors that could be contributing to our finding that Black MSM and GM were less likely to be retained in care. Future research should examine factors at multiple levels of the social ecology that may be impacting care such as access to clinics, insurance, stigma, medical mistrust, and lack of confidence in medications. Moreover, additional interventions may be needed to support the adherence and viral suppression of individuals who use stimulants and/or have cannabis dependencies, especially Black MSM and GM living with HIV.

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References

1. HIV Surveillance Report, 2018. Centers for Disease Control and Prevention; 2019.
2. Baral SD, Poteat T, Stromdahl S, Wirtz AL, Guadamuz TE, Beyrer C. Worldwide burden of HIV in transgender women: A systematic review and meta-analysis. *The Lancet infectious diseases*. 2013;13(3):214–22. [PubMed: 23260128]
3. Bartlett JA, Fath MJ, Demasi R, Hermes A, Quinn J, Mondou E, et al. An updated systematic overview of triple combination therapy in antiretroviral-naïve HIV-infected adults. *Aids*. 2006;20(16):2051–64. [PubMed: 17053351]
4. Palella FJ Jr, Delaney KM, Moorman AC, Loveless MO, Fuhrer J, Satten GA, et al. Declining morbidity and mortality among patients with advanced human immunodeficiency virus infection. *New England Journal of Medicine*. 1998;338(13):853–60.
5. Walensky RP, Paltiel AD, Losina E, Mercincavage LM, Schackman BR, Sax PE, et al. The survival benefits of AIDS treatment in the United States. *The Journal of infectious diseases*. 2006;194(1):11–9. [PubMed: 16741877]
6. Lohse N, Hansen A-BE, Pedersen G, Kronborg G, Gerstoft J, Sørensen HT, et al. Survival of persons with and without HIV infection in Denmark, 1995–2005. *Annals of internal medicine*. 2007;146(2):87–95. [PubMed: 17227932]
7. Eisinger RW, Dieffenbach CW, Fauci AS. HIV viral load and transmissibility of HIV infection: undetectable equals untransmittable. *Jama*. 2019;321(5):451–2. [PubMed: 30629090]
8. Hinkin CH, Barclay TR, Castellon SA, Levine AJ, Durvasula RS, Marion SD, et al. Drug Use and Medication Adherence among HIV-1 Infected Individuals. *AIDS and Behavior*. 2007;11(2):185–94. [PubMed: 16897351]
9. Kalichman SC, Grebler T, Amaral CM, McNeerney M, White D, Kalichman MO, et al. Viral Suppression and Antiretroviral Medication Adherence Among Alcohol Using HIV-Positive Adults. *International Journal of Behavioral Medicine*. 2014;21(5):811–20. [PubMed: 24085706]
10. Vagenas P, Azar MM, Copenhaver MM, Springer SA, Molina PE, Altice FL. The impact of alcohol use and related disorders on the HIV continuum of care: a systematic review. *Current HIV/AIDS Reports*. 2015;12(4):421–36. [PubMed: 26412084]
11. Ladak F, Socias E, Nolan S, Dong H, Kerr T, Wood E, et al. Substance use patterns and HIV-1 RNA viral load rebound among HIV-positive illicit drug users in a Canadian setting. *Antivir Ther*. 2019;24(1):19–25. [PubMed: 30230474]
12. Purkayastha T, Wasi F, Shuter J. Factors Associated with Sustained Virologic Suppression in Patients Receiving Antiretroviral Therapy in an Urban HIV Care Clinic. *AIDS Patient Care and STDs*. 2005;19(12):785–93. [PubMed: 16375610]

13. Almeida-Brasil CC, Moodie EEM, McLinden T, Hamelin A-M, Walmsley SL, Rourke SB, et al. Medication nonadherence, multitablet regimens, and food insecurity are key experiences in the pathway to incomplete HIV suppression. *AIDS*. 2018;32(10):1323–32. [PubMed: 29683846]
14. Cescon A, Cooper C, Chan K, Palmer A, Klein M, Machouf N, et al. Factors associated with virological suppression among HIV-positive individuals on highly active antiretroviral therapy in a multi-site Canadian cohort. *HIV medicine*. 2011;12(6):352–60. [PubMed: 21059167]
15. Cohen MS, Chen YQ, McCauley M, Gamble T, Hosseinipour MC, Kumarasamy N, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *New England journal of medicine*. 2011;365(6):493–505.
16. Rodger AJ, Cambiano V, Bruun T, Vernazza P, Collins S, Van Lunzen J, et al. Sexual activity without condoms and risk of HIV transmission in serodifferent couples when the HIV-positive partner is using suppressive antiretroviral therapy. *Jama*. 2016;316(2):171–81. [PubMed: 27404185]
17. Grulich AE, Bavinton BR, Jin F, Prestage G, Zablotska I, Grinsztejn B, et al., editors. HIV transmission in male serodiscordant couples in Australia, Thailand and Brazil. Seattle, Washington: 22nd Conference on Retroviruses and Opportunistic Infections; 2015.
18. Ferrand RA, Briggs D, Ferguson J, Penazzato M, Armstrong A, MacPherson P, et al. Viral suppression in adolescents on antiretroviral treatment: review of the literature and critical appraisal of methodological challenges. *Tropical Medicine & International Health*. 2016;21(3):325–33. [PubMed: 26681359]
19. Smith K, Powers KA, Kashuba AD, Cohen MS. HIV-1 treatment as prevention: the good, the bad, and the challenges. *Current Opinion in HIV and AIDS*. 2011;6(4):315. [PubMed: 21646878]
20. Yehia BR, Fleishman JA, Metlay JP, Moore RD, Gebo KA. Sustained Viral Suppression in HIV-Infected Patients Receiving Antiretroviral Therapy. *JAMA*. 2012;308(4):339–42. [PubMed: 22820781]
21. Cunningham WE, Weiss RE, Nakazono T, Malek MA, Shoptaw SJ, Ettner SL, et al. Effectiveness of a Peer Navigation Intervention to Sustain Viral Suppression Among HIV-Positive Men and Transgender Women Released From Jail: The LINK LA Randomized Clinical Trial. *JAMA Internal Medicine*. 2018;178(4):542–53. [PubMed: 29532059]
22. Nwangwu-Ike N, Frazier EL, Crepaz N, Tie Y, Sutton MY. Racial and Ethnic Differences in Viral Suppression Among HIV-Positive Women in Care. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2018;79(2):e56–e68. [PubMed: 30212433]
23. Doshi RK, Milberg J, Jumento T, Matthews T, Dempsey A, Cheever LW. For many served by the Ryan White HIV/AIDS Program, disparities in viral suppression decreased, 2010–14. *Health Affairs*. 2017;36(1):116–23. [PubMed: 28069854]
24. Glass TR, Rotger M, Telenti A, Decosterd L, Csajka C, Bucher HC, et al. Determinants of sustained viral suppression in HIV-infected patients with self-reported poor adherence to antiretroviral therapy. *PloS one*. 2012;7(1).
25. Mugavero MJ, Amico KR, Westfall AO, Crane HM, Zinski A, Willig JH, et al. Early retention in HIV care and viral load suppression: implications for a test and treat approach to HIV prevention. *Journal of acquired immune deficiency syndromes (1999)*. 2012;59(1):86. [PubMed: 21937921]
26. Sheehan DM, Fennie KP, Mauck DE, Maddox LM, Lieb S, Trepka MJ. Retention in HIV Care and Viral Suppression: Individual- and Neighborhood-Level Predictors of Racial/Ethnic Differences, Florida, 2015. *AIDS Patient Care and STDs*. 2017;31(4):167–75. [PubMed: 28414260]
27. Beer L, Mattson CL, Bradley H, Skarbinski J. Understanding cross-sectional racial, ethnic, and gender disparities in antiretroviral use and viral suppression among HIV patients in the United States. *Medicine*. 2016;95(13).
28. Millett GA, Peterson JL, Flores SA, Hart TA, Jeffries WL 4th, Wilson PA, et al. Comparisons of disparities and risks of HIV infection in black and other men who have sex with men in Canada, UK, and USA: a meta-analysis. *The Lancet*. 2012;380(9839):341–8.
29. Bulsara SM, Wainberg ML, Newton-John TR. Predictors of adult retention in HIV care: a systematic review. *AIDS and Behavior*. 2018;22(3):752–64. [PubMed: 27990582]

30. Williams EC, Hahn JA, Saitz R, Bryant K, Lira MC, Samet JH. Alcohol use and human immunodeficiency virus (HIV) infection: current knowledge, implications, and future directions. *Alcoholism: Clinical and Experimental Research*. 2016;40(10):2056–72.
31. Gilbert PA, Pass LE, Keuroghlian AS, Greenfield TK, Reisner SL. Alcohol research with transgender populations: A systematic review and recommendations to strengthen future studies. *Drug and alcohol dependence*. 2018;186:138–46. [PubMed: 29571076]
32. Talley AE, Hughes TL, Aranda F, Birkett M, Marshal MP. Exploring alcohol-use behaviors among heterosexual and sexual minority adolescents: intersections with sex, age, and race/ethnicity. *American journal of public health*. 2014;104(2):295–303. [PubMed: 24328614]
33. Evangelini M. Mental health and substance use in HIV-infected adolescents. *Current Opinion in HIV and AIDS*. 2018;13(3):204–11. [PubMed: 29401120]
34. Gamarel KE, Brown L, Kahler CW, Fernandez MI, Bruce D, Nichols S, et al. Prevalence and correlates of substance use among youth living with HIV in clinical settings. *Drug and alcohol dependence*. 2016;169:11–8. [PubMed: 27750182]
35. Gamarel KE, Nelson KM, Brown L, Fernandez MI, Nichols S, Intervention AMTnHA. The usefulness of the CRAFFT in screening for problematic drug and alcohol use among youth living with HIV. *AIDS and Behavior*. 2017;21(7):1868–77. [PubMed: 27981399]
36. Langebeek N, Gisolf EH, Reiss P, Vervoort SC, Hafsteinsdóttir TB, Richter C, et al. Predictors and correlates of adherence to combination antiretroviral therapy (ART) for chronic HIV infection: a meta-analysis. *BMC medicine*. 2014;12(1):142. [PubMed: 25145556]
37. Westergaard RP, Hess T, Astemborski J, Mehta SH, Kirk GD. Longitudinal changes in engagement in care and viral suppression for HIV-infected injection drug users. *AIDS (London, England)*. 2013;27(16):2559–66.
38. McCabe SE, Hughes TL, Bostwick WB, West BT, Boyd CJ. Sexual orientation, substance use behaviors and substance dependence in the United States. *Addiction*. 2009;104(8):1333–45. [PubMed: 19438839]
39. Drabble LA, Trocki KF, Korcha RA, Klinger JL, Veldhuis CB, Hughes TL. Comparing substance use and mental health outcomes among sexual minority and heterosexual women in probability and non-probability samples. *Drug and alcohol dependence*. 2018;185:285–92. [PubMed: 29482053]
40. Marshal MP, Friedman MS, Stall R, King KM, Miles J, Gold MA, et al. Sexual orientation and adolescent substance use: a meta-analysis and methodological review. *Addiction*. 2008;103(4):546–56. [PubMed: 18339100]
41. Newcomb ME, Hill R, Buehler K, Ryan DT, Whitton SW, Mustanski B. High Burden of Mental Health Problems, Substance Use, Violence, and Related Psychosocial Factors in Transgender, Non-Binary, and Gender Diverse Youth and Young Adults. *Archives of sexual behavior*. 2019:1–15. [PubMed: 30635817]
42. Becasen JS, Denard CL, Mullins MM, Higa DH, Sipe TA. Estimating the prevalence of HIV and sexual behaviors among the US transgender population: A systematic review and meta-analysis, 2006–2017. *American journal of public health*. 2019;109(1):e1–e8.
43. Nduka C, Uthman O, Kimani P, Stranges S. Drug abuse in people living with HIV in the era of highly active antiretroviral therapy: a systematic review and meta-analysis. *J Addict Res Ther*. 2015;6(255):2.
44. Newcomb ME, Ryan DT, Greene GJ, Garofalo R, Mustanski B. Prevalence and patterns of smoking, alcohol use, and illicit drug use in young men who have sex with men. *Drug and alcohol dependence*. 2014;141:65–71. [PubMed: 24907774]
45. Kidd JD, Jackman KB, Wolff M, Veldhuis CB, Hughes TL. Risk and protective factors for substance use among sexual and gender minority youth: A scoping review. *Current addiction reports*. 2018;5(2):158–73. [PubMed: 30393591]
46. Starks TJ, MacDonell KK, Pennar AL, Dinaj-Koci V, Millar BM, Naar S. Drug Use Among Adolescents and Young Adults with Unsuppressed HIV Who Use Alcohol: Identifying Patterns of Comorbid Drug Use and Associations with Mental Health. *AIDS and Behavior*. 2020:1–9. [PubMed: 30903450]

47. Buller AM, Devries KM, Howard LM, Bacchus LJ. Associations between intimate partner violence and health among men who have sex with men: a systematic review and meta-analysis. *PLoS medicine*. 2014;11(3):e1001609. [PubMed: 24594975]
48. Lourenço L, Colley G, Nosyk B, Shopin D, Montaner JS, 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).
49. Giordano TP, Hartman C, Gifford AL, Backus LI, Morgan RO. Predictors of retention in HIV care among a national cohort of US veterans. *HIV clinical trials*. 2009;10(5):299–305. [PubMed: 19906622]
50. Nosyk B, Lourenço L, Min JE, Shopin D, Lima VD, Montaner JS. Characterizing retention in HAART as a recurrent event process: insights into ‘cascade churn’. *AIDS (London, England)*. 2015;29(13):1681.
51. Rebeiro P, Althoff KN, Buchacz K, Gill MJ, Horberg M, Krentz H, et al. Retention among North American HIV-infected persons in clinical care, 2000–2008. *Journal of acquired immune deficiency syndromes (1999)*. 2013;62(3):356. [PubMed: 23242158]
52. Tobias CR, Cunningham W, Cabral HD, Cunningham CO, Eldred L, Naar-King S, et al. Living with HIV but without medical care: barriers to engagement. *AIDS patient care and STDs*. 2007;21(6):426–34. [PubMed: 17594252]
53. Menza TW, Choi S-K, LeGrand S, Muessig K, Hightow-Weidman L. Correlates of self-reported viral suppression among HIV-positive, young, black men who have sex with men participating in a randomized controlled trial of an internet-based HIV prevention intervention. *Sexually transmitted diseases*. 2018;45(2):118–26. [PubMed: 28876283]
54. Adams JW, Bryant KJ, Edelman JE, Fiellin DA, Gaither JR, Gordon AJ, et al. Association of cannabis, stimulant, and alcohol use with mortality prognosis among HIV-infected men. *AIDS and Behavior*. 2018;22(4):1341–51. [PubMed: 28887669]
55. Carrico AW, Hunt PW, Neilands TB, Dilworth SE, Martin JN, Deeks SG, et al. Stimulant use and viral suppression in the era of universal antiretroviral therapy. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2019;80(1):89–93. [PubMed: 30272634]
56. Bonn-Miller MO, Oser ML, Bucossi MM, Trafton JA. Cannabis use and HIV antiretroviral therapy adherence and HIV-related symptoms. *Journal of Behavioral Medicine*. 2014;37(1):1–10. [PubMed: 23054178]
57. Okafor CN, Zhou Z, Burrell LE, Kelso NE, Whitehead NE, Harman JS, et al. Marijuana use and viral suppression in persons receiving medical care for HIV-infection. *The American journal of drug and alcohol abuse*. 2017;43(1):103–10. [PubMed: 27398989]
58. Wood SM, Lowenthal E, Lee S, Ratcliffe SJ, Dowshen N. Longitudinal viral suppression among a cohort of adolescents and young adults with behaviorally acquired human immunodeficiency virus. *AIDS patient care and STDs*. 2017;31(9):377–83. [PubMed: 28891717]
59. Mustanski B, Morgan E, D’aquila R, Birkett M, Janulis P, Newcomb ME. Individual and network factors associated with racial disparities in HIV among young men who have sex with men: Results from the RADAR cohort study. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2019;80(1):24–30. [PubMed: 30365451]
60. Centers for Disease Control and Prevention and Association of Public Health Laboratories. Technical update on HIV-1/2 differentiation assays 2016 [Available from: <https://stacks.cdc.gov/view/cdc/40790>].
61. Mustanski B, Ryan DT, Remble TA, Richard T, Newcomb ME, Morgan E. Discordance of self-report and laboratory measures of HIV viral load among young men who have sex with men and transgender women in Chicago: Implications for epidemiology, care, and prevention. *AIDS and Behavior*. 2018;22(7):2360–7. [PubMed: 29637386]
62. Olowookere S, Fatiregun A, Ladipo M, Abioye-Kuteyi E, Adewole I. Effects of adherence to antiretroviral therapy on body mass index, immunological and virological status of Nigerians living with HIV/AIDS. *Alexandria Journal of Medicine*. 2016;52(1):51–4.
63. Iroh PA, Mayo H, Nijhawan AE. The HIV care cascade before, during, and after incarceration: a systematic review and data synthesis. *American journal of public health*. 2015;105(7):e5–e16.

64. Adamson SJ, Sellman JD. A prototype screening instrument for cannabis use disorder: the Cannabis Use Disorders Identification Test (CUDIT) in an alcohol-dependent clinical sample. *Drug and alcohol review*. 2003;22(3):309–15. [PubMed: 15385225]
65. Adamson SJ, Kay-Lambkin FJ, Baker AL, Lewin TJ, Thornton L, Kelly BJ, et al. An improved brief measure of cannabis misuse: the Cannabis Use Disorders Identification Test-Revised (CUDIT-R). *Drug and alcohol dependence*. 2010;110(1):137–43. [PubMed: 20347232]
66. 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. [PubMed: 8329970]
67. Organization WH. AUDIT: The alcohol use disorders identification test: Guidelines for use in primary health care. Geneva: World Health Organization; 2001.
68. Inc SI. SAS 9.4 [Computer software]. Author Cary, NC; 2013.
69. Gamarel KE, Woolf-King SE, Carrico AW, Neilands TB, Johnson MO. Stimulant use patterns and HIV transmission risk among HIV serodiscordant male couples. *Journal of acquired immune deficiency syndromes (1999)*. 2015;68(2):147. [PubMed: 25590269]
70. Parsons JT, Kowalczyk WJ, Botsko M, Tomassilli J, Golub SA. Aggregate versus day level association between methamphetamine use and HIV medication non-adherence among gay and bisexual men. *AIDS and Behavior*. 2013;17(4):1478–87. [PubMed: 23553345]
71. Horvath KJ, Lammert S, MacLehose RF, Danh T, Baker JV, Carrico AW. A pilot study of a mobile app to support HIV antiretroviral therapy adherence among men who have sex with men who use stimulants. *AIDS and Behavior*. 2019;23(11):3184–98. [PubMed: 31309348]
72. Schoeler T, Bhattacharyya S. The effect of cannabis use on memory function: an update. *Substance abuse and rehabilitation*. 2013;4:11. [PubMed: 24648785]
73. Ganzer F, Bröning S, Kraft S, Sack P-M, Thomasius R. Weighing the evidence: a systematic review on long-term neurocognitive effects of cannabis use in abstinent adolescents and adults. *Neuropsychology review*. 2016;26(2):186–222. [PubMed: 27125202]
74. Blackstone K, Woods S, Weber E, Grant I, Moore D, Group H. Memory-based strategies for antiretroviral medication management: an evaluation of clinical predictors, adherence behavior awareness, and effectiveness. *AIDS and Behavior*. 2013;17(1):74–85. [PubMed: 22968399]
75. Kalichman SC, Cain D, Cherry C, Kalichman M, Pope H. Pillboxes and antiretroviral adherence: prevalence of use, perceived benefits, and implications for electronic medication monitoring devices. *AIDS Patient Care & STDs*. 2005;19(12):833–9. [PubMed: 16375615]
76. Miller W, Hecht F. Adherence to HIV treatment. *Clinical Care of AIDS Patients*. 1997.
77. Babson KA, Heinz AJ, Bonn-Miller MO. HIV medication adherence and HIV symptom severity: the roles of sleep quality and memory. *AIDS patient care and STDs*. 2013;27(10):544–52. [PubMed: 24032625]
78. Woods SP, Dawson MS, Weber E, Gibson S, Grant I, Atkinson JH, et al. Timing is everything: Antiretroviral nonadherence is associated with impairment in time-based prospective memory. *Journal of the International Neuropsychological Society*. 2009;15(1):42–52. [PubMed: 19128527]
79. Hinkin C, Castellon S, Durvasula R, Hardy D, Lam M, Mason K, et al. Medication adherence among HIV+ adults: effects of cognitive dysfunction and regimen complexity. *Neurology*. 2002;59(12):1944–50. [PubMed: 12499488]
80. Colfax G, Coates TJ, Husnik MJ, Huang Y, Buchbinder S, Koblin B, et al. Longitudinal patterns of methamphetamine, popper (amyl nitrite), and cocaine use and high-risk sexual behavior among a cohort of San Francisco men who have sex with men. *Journal of Urban Health*. 2005;82(1):i62. [PubMed: 15738319]
81. McCarty-Caplan D, Jantz I, Swartz J. MSM and drug use: A latent class analysis of drug use and related sexual risk behaviors. *AIDS and Behavior*. 2014;18(7):1339–51. [PubMed: 24065437]
82. Wu ES, Metzger DS, Lynch KG, Douglas SD. Association between alcohol use and HIV viral load. *Journal of acquired immune deficiency syndromes (1999)*. 2011;56(5):e129. [PubMed: 21532918]
83. Cook R, Zhou Z, Kelso-Chichetto N, Janelle J, Morano J, Somboonwit C, et al. Alcohol consumption patterns and HIV viral suppression among persons receiving HIV care in Florida: an observational study. *Addiction science & clinical practice*. 2017;12(1):22. [PubMed: 28950912]

84. Deiss RG, Mesner O, Agan BK, Ganesan A, Okulicz JF, Bavaro M, et al. Characterizing the association between alcohol and HIV virologic failure in a military cohort on antiretroviral therapy. *Alcoholism: Clinical and Experimental Research*. 2016;40(3):529–35.
85. Ridgway JP, Almirol EA, Schmitt J, Schuble T, Schneider JA. Travel time to Clinic but not Neighborhood Crime Rate is associated with Retention in Care among HIV-positive Patients. *AIDS and Behavior*. 2018;22(9):3003–8. [PubMed: 29600423]
86. Eaton LA, Driffin DD, Kegler C, Smith H, Conway-Washington C, White D, et al. The role of stigma and medical mistrust in the routine health care engagement of black men who have sex with men. *American journal of public health*. 2015;105(2):e75–e82.
87. Willis S, Castel AD, Ahmed T, Olejemeh C, Frison L, Kharfen M. Linkage, engagement, and viral suppression rates among HIV-infected persons receiving care at medical case management programs in Washington, DC. *Journal of acquired immune deficiency syndromes (1999)*. 2013;64(0 1).
88. Torian LV, Xia Q. Achievement and maintenance of viral suppression in persons newly diagnosed with HIV, New York City, 2006–2009: Using population surveillance data to measure the treatment part of “test and treat”. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2013;63(3):379–86. [PubMed: 23535295]
89. Hoenigl M, Chaillon A, Moore DJ, Morris SR, Mehta SR, Gianella S, et al. Rapid HIV viral load suppression in those initiating antiretroviral therapy at first visit after HIV diagnosis. *Scientific reports*. 2016;6(1):1–5. [PubMed: 28442746]
90. Toren KG, Buskin SE, Dombrowski JC, Cassels SL, Golden MR. Time from HIV diagnosis to viral load suppression: 2007–2013. *Sexually transmitted diseases*. 2016;43(1):34. [PubMed: 26650994]
91. Lima VD, Bangsberg DR, Harrigan PR, Deeks SG, Yip B, Hogg RS, et al. Risk of viral failure declines with duration of suppression on HAART, irrespective of adherence level. *Journal of acquired immune deficiency syndromes (1999)*. 2010;55(4):460. [PubMed: 20838225]
92. Wray TB, Kahler CW, Monti PM. Using ecological momentary assessment (EMA) to study sex events among very high-risk men who have sex with men (MSM). *AIDS and Behavior*. 2016;20(10):2231–42. [PubMed: 26746212]

Table 1.

Univariate demographics, substance use, and viral suppression for HIV-positive cohort participants (n=163)

Variable	N (%)	Mean (SD)
Age		23.58 (2.74)
Race		
Black	103 (63.19%)	
Hispanic/Latinx	37 (22.70%)	
Other racial identity	23 (14.11%)	
White	5 (3.07%)	
Asian	1 (0.61%)	
Multi-racial/Mixed	15 (9.20%)	
Other race	2 (1.23%)	
Gender		
Male	148 (90.80%)	
Gender minority	15 (9.20%)	
Sexual Orientation		
Gay	128 (78.53%)	
Bisexual, Other	35 (21.47%)	
Inconsistent retention in care	30 (18.40%)	
Alcohol use disorder score (AUDIT score at baseline)		5.42 (5.98)
Cannabis use disorder score (CUDIT score at baseline)		7.34 (6.51)
Stimulant use at baseline		
Methamphetamine (use in past 6 months)	8 (4.91%)	
Cocaine (use in past 6 month)	19 (11.66%)	
Any meth or cocaine (use in past 6 months)	24 (14.72%)	
HIV Status		
Incident Case	25 (15.34%)	
Prevalent Case	138 (84.66%)	
Viral Suppression		
Sustained suppression	64 (39.26%)	
Inconsistent suppression	58 (35.58%)	
<i>Trending toward sustained suppression</i>	22 (13.34%)	
<i>Generally Inconsistent/alternating</i>	11 (6.75%)	
<i>Trending toward consistent non-suppression</i>	25 (15.34%)	
Consistent non-suppression	41 (25.15%)	

Unadjusted logistic regressions predicting non-adherence, and predicting viral suppression category (ref = sustained viral suppression) (n=163)

Table 2.

Variables	Binary Logistic Regression		Multinomial Logistic Regression (ref=sustained viral suppression)	
	Inconsistent retention in care	Inconsistent viral suppression	Inconsistent viral suppression	Consistent non-suppression
Type of Case				
Prevalent Case (ref)	-	-	Unadjusted OR (95% CI)	Unadjusted OR (95% CI)
Incident Case	0.34 (0.08, 1.54)	0.66 (0.26, 1.66)		0.18 (0.04, 0.85) *
Sexual Orientation				
Gay (ref)	-	-		-
Bi or other	3.19 (1.35, 7.52) **	1.07 (0.45, 2.56)		1.00 (0.39, 2.57)
Age				
	0.98 (0.85, 1.14)	0.98 (0.86, 1.11)		1.03 (0.89, 1.19)
Gender				
Cis gender man (ref)	-	-		-
Gender minority	1.12 (0.3, 4.25)	0.73 (0.21, 2.55)		0.78 (0.2, 3.11)
Race				
Hispanic/Latinx (ref)	-	-		-
Black	5.32 (1.19, 23.74) *	1.55 (0.66, 3.61)		3.69 (1.23, 11.03) *
Other racial identity (White, Asian, multiracial)	3.68 (0.62, 22)	1.2 (0.39, 3.70)		1.04 (0.21, 5.2)
Inconsistent Retention in Care	-	10.81 (2.35, 49.72) **		14.39 (3.04, 68.08) ***
Alcohol Use Disorder Score (AUDIT Score) at baseline	0.92 (0.83, 1.02)	0.95 (0.89, 1.02)		1.02 (0.96, 1.08)
Cannabis Use Disorder Score (CUDIT Score) at baseline	0.99 (0.93, 1.05)	1.02 (0.96, 1.08)		1.08 (1.02, 1.15) *
Any Stimulant Use in the past 6 months (yes vs. no) at baseline	1.6 (0.57, 4.44)	2.79 (0.98, 7.92)		1.34 (0.38, 4.72)

* p<0.05,

** p<0.01,

*** p<0.001

Table 3.

Adjusted logistic regressions predicting non-adherence, and predicting viral suppression category (ref = sustained viral suppression) (n=163)

Variables	Binary Logistic Regression		Multinomial Logistic Regression (ref=sustained viral suppression)	
	Inconsistent Retention in Care		Inconsistent viral suppression	Consistent non-suppression
Type of Case	AOR (95% CI)		AOR (95% CI)	AOR (95% CI)
Prevalent Case (ref)	-		-	-
Incident Case	3.95 (0.74, 21.21)		0.7 (0.24, 2.06)	0.17 (0.03, 0.95) *
Sexual Orientation				
Gay (ref)	-		-	-
Bi or other	3.75 (1.41, 10.00) **		0.5 (0.17, 1.45)	0.68 (0.2, 2.31)
Age	0.96 (0.81, 1.15)		0.94 (0.81, 1.1)	0.99 (0.83, 1.19)
Gender				
Cis gender man (ref)	-		-	-
Gender minority	0.66 (0.16, 2.81)		1.84 (0.44, 7.73)	1.52 (0.31, 7.41)
Race				
Hispanic/Latinx (ref)	-		-	-
Black	6.77 (1.39, 33.03) **		1.1 (0.44, 2.75)	3.02 (0.9, 10.19)
Other racial identity (White, Asian, multiracial)	3.24 (0.51, 20.74)		0.92 (0.27, 3.06)	0.92 (0.16, 5.33)
Inconsistent Retention in Care	-		11.16 (2.32, 58.10) **	16.05 (3.00, 85.79) **
Alcohol Use Disorder Score (AUDIT Score)	0.91 (0.81, 1.02)		0.94 (0.86, 1.02)	1.01 (0.95, 1.09)
Cannabis Use Disorder Score (CUDIT Score)	0.98 (0.91, 1.06)		1.01 (0.95, 1.08)	1.10 (1.02, 1.18) *
Any Stimulant Use in the past 6 months (yes vs. no)	1.67 (0.48, 5.74)		3.52 (1.07, 11.63) *	0.75 (0.18, 3.22)

* p<0.05,

** p<0.01,

*** p<0.001