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Changing patterns of alcohol use and probability of unsuppressed viral load among treated patients with HIV engaged in routine care in the United States

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Abstract

We examined HIV viral load non-suppression (≥200 copies/mL) subsequent to person-periods (3-18 months) bookended by two self-reports of alcohol use on a standardized patient reported outcome assessment among adults in routine HIV care. We examined the relative risk (RR) of non-suppression associated with increases and decreases in alcohol use (relative to stable use), stratified by use at the start of the person-period. Increases in drinking from abstinence were

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associated with higher risk of viral non-suppression (low-risk without binge: RR=1.16, 95% CI 1.03, 1.32; low-risk with binge: RR=1.35, 95% CI 1.11, 1.63; high-risk: RR=1.89, 95% CI 1.16, 3.08). Decreases in drinking from high-risk drinking were weakly, and not statistically significantly associated with lower risk of viral non-suppression. Other changes in alcohol use were not associated with viral load non-suppression. Most changes in alcohol consumption among people using alcohol at baseline were not strongly associated with viral non-suppression.

Keywords

Alcohol Drinking; Drinking Behavior; HIV infections; Prospective Studies; Patient Reported Outcome Measures; Viral Load

INTRODUCTION

Over half (53-66%) of persons with HIV (PWH) engaged in clinical care report recent alcohol use, one in three report heavy episodic drinking (binge), and between one in four and one in twelve (8-29%) report hazardous alcohol use.(1-5) Most, but not all, prior studies have reported associations between hazardous or binge drinking and poor clinical outcomes including: lower probability of being retained in HIV care; higher probability of having missed visits; delayed initiation of antiretroviral therapy (ART), worse ART adherence, and lower probability of achieving viral suppression while on ART; and poor overall health.(3, 6-15)

The US Strategic Plan to End the HIV Epidemic includes one pillar to “treat HIV infection rapidly and effectively to achieve sustained viral suppression.”(16) Yet among persons successfully engaged in routine HIV care and prescribed ART, there remains a not inconsequential minority who are not consistently virally suppressed.(17, 18) If it is true that abstinence from alcohol or low-risk drinking is associated with better HIV outcomes including sustained viral suppression, the logical next question is whether we can improve viral suppression by reducing alcohol intake. Yet few studies have considered how changes in alcohol use, and in particular, changes stratified by prior alcohol use, are associated with HIV clinical outcomes.(6,19, 20) Prior alcohol use is likely to modify the effect of changes in alcohol use, if such effects exist, because a small absolute reduction in drinks/week is a large relative reduction among persons drinking rarely, but a small relative reduction among persons drinking heavily. The goal of this study was to estimate the probability viral non-suppression associated with changes in alcohol use among PWH who are prescribed ART.

METHODS

Study sample

The Centers for AIDS Research (CFAR) Network of Integrated Clinical Systems (CNICS) is a collaborative, prospective, clinical cohort of adults aged ≥18 years engaged in HIV clinical care (defined as attending at least two clinic visits) at one of eight academic medical centers across the United States who agreed to share their data. CNICS data include patient demographic and clinical characteristics including likely route of HIV acquisition,

laboratory measurements, diagnoses, and prescribed medications.(21) Additionally, all sites have implemented collection of patient-reported measures and outcomes (PROs). PROs are collected by Computer-Assisted Self-Interview Software tools on a subset of patients approximately every six months in connection with an HIV clinic visit.(22) Patient characteristics recorded on the PRO assessments include quantity and frequency of alcohol use and binge drinking on a version of the Alcohol Use Disorders Identification Test (AUDIT-C) modified such that patients were asked to provide more granular responses to how much and how often they drank alcohol;(23-25) current and past drug use on the National Institute of Drug Abuse (NIDA)-modified Alcohol, Smoking and Substance Involvement Test (ASSIST);(26, 27) panic symptoms on the Patient Health Questionnaire-Panic Disorders (PHQ-PD);(28) and depressive symptoms on the PHQ-8.(29, 30)

Because we were interested in changes in alcohol consumption, the unit of analysis in this study was a set of paired PROs (a person-period). We included all person-periods where the initial PRO (the first PRO) was collected between January 2010 and the site-specific administrative censoring date (October 2014-December 2017) and there was a subsequent PRO (the second PRO) within 3-18 months. We restricted study to person-periods where the patient had an active prescription for ART at the time of the first PRO.

Exposure

We calculated average drinks/week from the reported quantity (average number of drinks per drinking occasion) and frequency (average number of drinking days per week or month) of drinking reported on the first two questions of the modified AUDIT-C. (While there are 5 standard responses on the AUDIT-C to each question, we expanded the highest option to the first question, “How often do you have a drink containing alcohol?” from “4 or more times per week” to “4-5 times per week” and “6-7 times per week.” We also expanded options to the second question, “How many drinks do you have on a typical day when you are drinking?” from ranges, e.g., “1 or 2,” to all integer values up to “10 or more,” e.g., “1” and “2”. Thus we could get more accurate number of drinks/week than had we used the standard AUDIT-C responses.) Risk was defined according to NIAAA-defined drinking levels. Low-risk was classified as drinking on average >0 and ≤7 drinks/week for women, or >0 and <14 drinks/week for men. High-risk consumption was >7 drinks/week for women or >14 drinks/week for men. Binge drinking was defined as consuming ≥4 drinks on one occasion for women or ≥5 drinks for men.(23, 24) Patients were asked about frequency of binge drinking and we classified patients as exposed to binge drinking for a period where any binge drinking (i.e., ≥1 instance) was reported. We classified patients’ alcohol use reported on the first PRO as: non-drinking; low-risk drinking without binge; low-risk drinking with binge; and high-risk drinking.

We classified alcohol use on the second PRO, according to the same categories, but then we further categorized person-periods with alcohol use in the same category on both PROs into: person-periods in which the exact same average drinks/week was reported on both PROs (“no change”); person-periods in which drinks/week increased but stayed in the same category; and person-periods in which drinks/week decreased but stayed in the same

category. The referent condition within each stratum was maintaining the exact same number of drinks/week and presence/absence of binge drinking as was reported on the first PRO.

Outcome

Our outcome of interest was viral load non-suppression (≥200 copies/mL) in the window 2 weeks before to 6 months after the second PRO in each person-period. If there was more than one viral load measurement in that window, we analyzed the viral load measurement closest to the date of the second PRO. If there was not a viral load measurement in the window, to avoid possible selection bias due to exclusion of person-periods where patients were more stable on treatment, we multiply imputed a viral load along with all the covariates used for adjustment (see below).

Covariates

We adjusted for covariates expected to be associated with HIV viral load and alcohol consumption (i.e., potential confounders), all measured at or prior to the first PRO: sex; race/ethnicity; HIV acquisition risk factors, being a man who has sex with men (MSM), and history of injection drug use (IDU); calendar year; CNICS clinic; modified VACS index (as a summary of overall health), which is a function of age, CD4 cell count, hemoglobin, liver fibrosis as measured by FIB-4,(31) kidney function as measured by estimated glomerular filtration rate,(32) and hepatitis C viral infection (VACS index also includes viral load, but to avoid over-adjustment, we did not include viral load in our calculation of the VACS);(33) recent and prior cocaine use, opioid use, methamphetamine use, and marijuana use; panic symptoms; mild, moderate, or severe depressive symptoms; and current smoking. We adjusted for the VACs index by modeling it with a restricted quadratic spline with knots at the 5^{th}, 35^{th}, 65^{th} and 95^{th} percentiles.(34)

Statistical analyses

We estimated relative risks of viral non-suppression associated with category of alcohol consumption on the second PRO using log-binomial models, stratified according to alcohol consumption patterns reported on the first PRO. To account for repeated measurements on individuals (i.e., possibly multiple person-periods per individual), we estimated all models with generalized estimating equations (GEE) with an exchangeable working correlation matrix.(35)

We adjusted for covariates through standardization with inverse probability of exposure weighting. We estimated the weights using predicted probabilities from a set of multinomial logistic regression models (one for each strata of alcohol consumption on the first PRO) regressing category of alcohol consumption on the second PRO on all covariates listed above.

We report the frequency of missing data in tables 1 and 2. For all reported risk ratios, we accounted for missing data (on components of reported alcohol use, covariates, or viral load) by multiply imputed missing values.(36-39) We generated 20 complete datasets using multiple imputation with chained equations, conducted analyses in each of the datasets with imputed values, and combined the results using Rubin's rules.(37, 38) As is recommended,

the imputation models leveraged all covariates in table 1 (including individual components of multi-dimensional indices), the exposure (included as individual components of quantity and frequency of alcohol use and frequency of binge drinking on both the first and second PRO), the outcome, and auxiliary covariates: all available laboratory measurements available around the second PRO, depressive and panic symptoms on the second PRO, and drug use on the second PRO.

We conducted secondary analyses in which the associations between alcohol use and viral non-suppression were estimated separately for men and women because men and women have been shown to have different expectancies for, reactions to and consequence of alcohol use.(7, 40-42)

RESULTS

There were 10,080 patients who contributed 41,335 person-periods to this analysis. The majority of patients were male (83%) and reported MSM as an HIV acquisition risk factor (66%). Forty-four percent identified as non-Hispanic Whites, 38% as non-Hispanic Black, and 15% as Hispanic. Median age at the first PRO was 46 (IQR: 38, 53) and median CD4 cell count was 496 cells/μL (IQR: 311, 698). Substance use, panic symptoms, and depressive symptoms were not uncommon in this sample: 36% smoked tobacco, 7% reported cocaine use in the prior 6 months, 3% reported opioid use in the prior 6 months, 25% reported panic symptoms, and 22% reported moderate to severe depressive symptoms (table 1). Patients contributed a median of 3 (interquartile range [IQR]: 1, 6) person-periods to this analysis. Median (IQR) months between the first and second PRO across all person-periods was 6.3 (5.2, 9.4).

Across person-periods, on the first PRO, patients reported not drinking 39% of the time; low-risk drinking without binge was reported 33% of the time; low-risk drinking with binge was reported 24% of the time; and high-risk drinking was reported 4% of the time. On the second PRO, patients reported not drinking 41% of the time; low-risk drinking without binge was reported 32% of the time; low-risk drinking with binge was reported 24% of the time; and high-risk drinking was reported 3% of the time. Abstinence was reported on the second PRO 15% of the time when the first PRO indicated low-risk drinking without binge; 8% of the time when the first PRO indicated low-risk drinking with binge; and 8% of the time when the first PRO indicated high-risk drinking. Increases and decreases in drinks/week between the first and second PRO while maintaining the same drinking category were relatively common (table 2). Median (IQR) increases in drinks/week within a drinking category were 1.2 (0.5, 2.2) for low-risk drinking without binge, 2.3 (1, 4) for low-risk drinking with binge, and 9 (6.5, 15) for high-risk drinking. Median (IQR) decreases in drinks/week within a drinking category were −1.2 (−2.0, −0.4) for low-risk drinking without binge, −2.4 (−4.5, −1) for low-risk drinking with binge, and −8 (−15, −6.1) for high-risk drinking.

Persons who reported abstaining from drinking across both PROs were older, more likely to be female, more likely to report IDU as an HIV acquisition risk factor, less likely to report cocaine or opioid use, and had a higher median modified VACS index (i.e. had worse

health). Persons who reported stable drinking across both PROs were more likely to report MSM as an HIV acquisition risk factor and less likely to report current tobacco smoking. Compared to persons and person-periods across which stable drinking was reported, persons who reported increasing alcohol use over the person-periods were more likely to have a history of IDU; more likely to report current tobacco smoking, cocaine, and opioid use; and slightly more likely to report panic and depressive symptoms. Characteristics of persons and person-periods across which alcohol use increased or decreased were remarkably similar (table 1).

Median time from the second PRO to the outcome viral load was 112 days (IQR: 14, 160). In the crude data, risk of unsuppressed viral load was 9.9% (4620 were missing). Overall (not stratified by prior reported drinking), there was a positive association between drinking reported on the second PRO and viral non-suppression (table 3).

In crude data, relative to no change in alcohol consumption, only an increase in alcohol consumption was associated with an increased risk of viral non-suppression (RR=1.23, 95% CI: 1.11, 1.36). A decrease in alcohol consumption was not associated with viral non-suppression (RR=0.96, 95% CI: 0.69, 1.32). After adjustment, any increase in alcohol consumption was associated with an increased risk of viral non-suppression (RR=1.22, 95% CI: 1.10, 1.36) and any decrease in alcohol consumption was associated with a decreased risk of viral non-suppression, but not statistically significantly so (RR=0.77, 95% CI: 45, 1.33). These associations differed across strata of baseline drinking (median p-value for interaction across multiple imputations was 0.04). If we excluded person-periods in which abstinence was reported on the first PRO, relative to no change in alcohol consumption there was no association between viral non-suppression and increases (RR=1.03, 95% CI: 0.91, 1.17) or decreases in alcohol use (RR=0.98, 95% CI: 0.86, 1.12). These associations did not differ across strata of baseline drinking (median p-value for interaction across multiple imputations was 0.3). After adjustment, when abstinence was reported on the first PRO, relative to stable abstinence, increases in drinking were associated with higher risk of viral non-suppression (RR for low-risk drinking without binge=1.16, 95% CI: 1.03, 1.32; RR for low-risk drinking with binge=1.35, 95% CI: 1.11, 1.63; RR for high-risk drinking=1.89, 95% CI: 1.16, 3.08). When low-risk drinking, with or without binge, was reported on the first PRO, there was essentially no association between reported drinking on the second PRO and viral load suppression. When high-risk drinking was reported on the first PRO, relative to stable, high-risk drinking, decreases in drinking were associated with lower risk of viral non-suppression, but precision for these estimates was poor and estimates were statistically indistinguishable from each other and from the null (table 4).

Abstinence was reported on the first PRO for 36% of person-periods contributed by men, and 53% of person-periods contributed by women. Men and women were similarly likely to report high-risk drinking on the first PRO (4% and 5%, respectively), men were more likely to report low-risk drinking without binge (34% versus 28% in women) and with binge (26% versus 15% in women). Despite differences in frequency and intensity of alcohol consumption, the associations between level of alcohol consumption and viral non-suppression were very similar for men and women (table 4) and there was no statistically significant interaction between sex and change in alcohol use or baseline alcohol use.

DISCUSSION

After adjustment, we observed that increases in alcohol use among persons who were initially abstinent were associated with higher risk of viral non-suppression. There was otherwise little evidence that increases or decreases in alcohol consumption were strongly associated with viral load suppression. Taken together, (initiating or) re-initiating alcohol use presented the highest risk of viral non-suppression and maintenance of abstinence was associated with the lowest risk of viral non-suppression. Our results apply to CNICS patients (persons engaged in routine HIV specialty care) who completed at least two PRO assessments 3-18 months apart. CNICS patients who were less engaged in care (and were not completing PRO assessments somewhat regularly) were excluded. Thus, if lower engagement is associated with heavier alcohol use and lower ART adherence, our conclusions may not generalize to these patients, nor to all patients engaged in care, regardless of level of engagement.

We observed a positive association between alcohol consumption and viral non-suppression in the unstratified data (not conditional on prior alcohol use). Our finding is consistent with some but not all prior studies that have looked at the association between alcohol use at a single time point and viral suppression or ART adherence.(10, 43) Alcohol may have physiologic effects on ART concentrations or HIV replication that could contribute to any observed positive associations between alcohol consumption and viral load.(44, 45) However, other studies have reported no or very weak associations between alcohol use and viral load.(46-48) Despite mixed findings for the association between alcohol use and viral suppression, alcohol use has been relatively consistently associated with lower ART adherence, poorer retention in care, and lower ART receipt.(10, 49, 50)

This study contributes to a somewhat sparse literature on changes in alcohol consumption and HIV disease progression. We found that the association between recent alcohol consumption and viral suppression depended on prior alcohol consumption, in particular, only increases in alcohol consumption from abstinence were significantly and consistently associated with viral non-suppression. While the data were consistent with a slight decrease in the risk of viral non-suppression in person-periods in which patients decreased drinking from high-risk consumption, overall, increases or decreases in alcohol use among persons using alcohol at baseline were not strongly associated with viral suppression. Our results are coherent with prior studies that have considered changes in alcohol consumption and viral load and found the highest risk of viral non-suppression among person-periods where alcohol use was increasing, and relatively modest associations overall.(6, 20, 51) Stable alcohol consumption (primarily stable abstinence) has also been associated with small improvements in the VACS index, a composite measure of HIV disease severity, while increases in alcohol consumption were associated with minimal worsening of the VACS index.(19)

A limitation of this study is that we relied on self-report of alcohol use, which may have resulted in under-reporting. In the Johns Hopkins HIV Clinical Cohort, hazardous alcohol use was associated with approximately a 4% higher absolute prevalence of viral non-suppression compared with no use and this association nearly doubled after adjusting for

under-reporting of alcohol use.(52) Without further quantitative sensitivity analyses, it is difficult to predict the direction of bias in this study.(53)

A strength of this study was our ability to adjust for many covariates that could confound this association, including a multi-dimensional measure of overall health (VACS index), mental health symptoms, and other substance use. However, we have described associations between observed changes in alcohol consumption and viral suppression, and our results may be due to unmeasured confounders. That is, the precipitating factors that cause someone to increase or decrease their alcohol intake may also cause increased or decreased ART adherence, and the associations (or lack thereof) we see may be the result of these precipitating factors rather than the result of changing alcohol consumption. In particular, the lack of any improvements in viral suppression associated with a switch to alcohol abstinence could be the result of the “sick quitter” phenomenon.(54)

If this is the case, interventions to reduce alcohol consumption may have different effects on ART adherence and viral suppression than seen here.(50, 55-58) In particular, interventions that prompt decreases in alcohol consumption may have greater effects on viral suppression than we observed in our cohort in the absence of a specific intervention aimed at alcohol use. (59) An 8-session motivational interviewing intervention for alcohol use was associated with improvements in ART adherence and viral load, but not decreases in alcohol consumption. (55) In contrast, a different, 2-session brief intervention targeting hazardous alcohol use was associated with slight reductions drinking frequency but not improvements in viral load suppression.(60) Among youth living with HIV, a motivational interviewing intervention targeting multiple risk behaviors including substance use, sexual risk, and ART adherence was associated with significant declines in viral load at 6 months post-intervention, but not at 9 months.(61, 62) Extended-release naltrexone among incarcerated individuals transitioning to the community was associated with both reductions in alcohol consumption and increased odds of viral suppression.(57)

While there are reasons, detailed above, why the associations described in this study are explainable by unmeasured confounding or why they may not equal the effect of *interventions* to reduce alcohol use, it is also possible that these associations *are* equal to the effect of changes in alcohol use on viral load. Specifically, we now detail some reasons that we might expect that only increases in use from abstinence are associated with viral non-suppression, and that decreases in alcohol use do not meaningfully improve the probability of viral suppression, nor do increases in alcohol use among persons who are already drinking meaningfully decrease the probability of viral suppression. Changing drinking behavior (including decreasing alcohol consumption) can have wide-reaching effects on one’s life, including disrupting social support,(54) changing mental health symptoms,(63) or changing other patterns of drug use. Even if alcohol use is negatively associated with ART adherence, the level of adherence required for viral suppression is dropping as ART regimens improve(64, 65) (and perhaps also as the duration of ART use increases).(66) Although ≥95% adherence was required to maintain viral suppression on unboosted protease inhibitor regimens, that dropped to approximately 80% on boosted protease inhibitors,(67) and even lower on nonnucleoside reverse transcriptase inhibitors (adherence levels of 54-100% were associated with high levels of viral suppression).(68) There is some

consensus that 80-90% adherence on newer regimens is associated with high levels of viral suppression.(65, 69) As regimens containing integrase inhibitors become more widely used, the level of adherence required for viral suppression may drop even further,(70) and thus the potential range of influence of alcohol use on viral suppression (through modest changes in ART adherence) may be limited.

In conclusion, although in general, higher levels of alcohol consumption were associated with worse viral suppression, this association was modified by prior alcohol consumption. Increasing alcohol use following a period of abstinence was strongly associated with higher risk of unsuppressed viral load. Decreasing alcohol use following a period of high-risk drinking was possibly weakly and not statistically significantly associated with decreased risk of unsuppressed viral load. Other changes in alcohol use (i.e., following a period of low-risk drinking) were not strongly associated with viral load suppression. It is important to consider patterns of alcohol use, beyond just prevalent consumption patterns, when estimating the impact of alcohol use on HIV disease progression and severity.

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TABLE 1.

Demographic and clinical characteristics of ART-experienced people living with HIV across all included person-periods, 2010-2018, stratified by change in alcohol consumption from first patient-reported outcomes assessment to second patient-reported outcomes assessment 3-18 months later

	Persons	Observations				
		Total	Stable, abstaining	Stable, drinking	Increasing	Decreasing
N	10080	41335	12335	5969	9672	9849
Male[a]	8339 (82.7)	33640 (81.4)	9263 (75.1)	5127 (85.9)	8157 (84.3)	8369 (85.0)
Age[b]	46 (38, 53)	49 (41, 55)	51 (44, 57)	48 (40, 55)	47 (38, 53)	47 (38, 53)
Race/ethnicity						
Black	3789 (37.7)	16871 (41.0)	5701 (46.3)	1958 (33.0)	3785 (39.3)	3765 (38.4)
White	4394 (43.8)	17511 (42.5)	4525 (36.8)	3271 (55.1)	4170 (43.3)	4355 (44.4)
Hispanic	1452 (14.5)	5591 (13.6)	1717 (14.0)	559 (9.4)	1395 (14.5)	1376 (14.0)
Other	406 (4.0)	1205 (2.9)	369 (3.0)	154 (2.6)	281 (2.9)	308 (3.0)
Missing	39	157	23	27	41	45
MSM	6535 (65.8)	26279 (64.2)	6460 (53.1)	4439 (74.9)	6616 (69.0)	6825 (69.9)
IDU	1233 (12.4)	4967 (12.1)	2044 (16.8)	401 (6.8)	1020 (10.6)	1020 (10.4)
Missing	144	407	164	40	87	88
CD4 cells/μL[b]	496 (311, 698)	545 (356, 758)	543 (350, 759)	568 (381, 764)	546 (358, 758)	542 (355, 752)
Missing	165	822	222	113	215	207
Recent						
Tobacco smoking	3524 (36.0)	13192 (32.9)	3847 (31.5)	1601 (26.9)	3381 (35.2)	3460 (35.4)
Missing	292	1240	104	26	66	77
Cocaine use	617 (6.8)	2066 (5.4)	262 (2.3)	238 (4.1)	771 (8.3)	600 (6.3)
Missing	1014	3023	869	147	369	268
Opioid use	225 (2.6)	739 (2.1)	152 (1.5)	69 (1.2)	245 (2.8)	212 (2.4)
Missing	1583	5893	2192	318	999	1004
Methamphetamine use	745 (8.3)	2197 (5.8)	408 (3.6)	334 (5.8)	676 (7.3)	643 (6.9)
Missing	1091	3416	1033	167	431	490
Marijuana use	2798 (31.1)	10296 (27.0)	1577 (13.8)	1750 (30.1)	3309 (35.7)	3000 (31.8)
Missing	1086	3146	906	156	413	402
Panic						
Disorder	1190 (12.1)	4601 (11.4)	1224 (10.1)	584 (9.9)	1177 (12.3)	1186 (12.2)
Symptoms	1300 (13.2)	4683 (11.6)	1225 (10.1)	680 (11.5)	1185 (12.4)	1155 (11.9)
Missing	215	931	177	65	128	120
Depression						
Severe	1005 (10.7)	3497 (8.8)	979 (8.4)	367 (6.2)	862 (9.2)	809 (8.4)
Moderate	1094 (11.7)	4186 (10.5)	1193 (10.3)	514 (8.7)	986 (10.5)	1034 (10.8)
Mild	2159 (23.1)	8620 (21.6)	2378 (20.5)	1225 (20.8)	2128 (22.6)	2101 (21.9)
Missing	721	1437	714	84	257	268
VACS index[b,c]	17 (6, 29)	18 (7, 28)	22 (12, 34)	16 (6, 24)	16 (6, 27)	16 (6, 27)

	Persons	Observations				
		Total	Stable, abstaining	Stable, drinking	Increasing	Decreasing
Missing	614	2705	764	387	670	662

[a] Number (%) unless otherwise specified

[b] Median (IQR)

[c] Modified to exclude contributions of viral load

TABLE 2.

Number (percent) of person-periods according to first patient-reported outcomes assessment (rows) and second patient-reported outcomes assessment (columns, with row percentages in parentheses) alcohol use[a], 2010-2018, N=41,335

		Decrease in alcohol consumption				No change	Increase in alcohol consumption			Missing
	Total, column %	**Non-drinker**	**Low-risk, no binge**	**Low-risk, binge**	**High-risk**		**Low-risk, no binge**	**Low-risk, binge**	**High-risk**	
Non-drinking	15501 (39.2)					12335 (83.1)	1753 (11.8)	679 (4.6)	84 (0.6)	650
Low-risk, no binge	12863 (32.5)	1808 (14.7)	2091 (17.0)			4124 (33.5)	2141 (17.4)	2015 (16.4)	132 (1.1)	552
Low-risk, binge	9600 (24.3)	686 (7.5)	2108 (23.0)	2152 (23.5)		1610 (17.6)		2111 (23.0)	497 (5.4)	436
High-risk	1585 (4.0)	123 (8.2)	120 (8.0)	537 (35.8)	224 (14.9)	235 (15.7)			260 (17.3)	86
Missing	1786	575[a]	-[b]	-[b]	-[b]	-[b]	477[b]	379[b]	79[b]	276

[a]NIAAA-defined risk drinking levels and binge drinking

[b]Cannot be determined whether these were indeed increases or decreases in drinking since they were missing drinking on the first patient-reported outcomes assessment

TABLE 3.

Risk ratios (crude and adjusted[a]) for the association between self-reported drinking on the second patient-reported outcomes assessment and viral non-suppression, across 41,335 person-periods contributed by 10,080 unique patients engaged in care in CNICS, 2010-2018

	Non-drinker	Low-risk, no binge	Low-risk, binge	High-risk
Crude				
Overall	1.	1.03 (0.95, 1.11)	1.09 (1.00, 1.19)	1.26 (1.09, 1.44)
Men	1.	1.02 (0.94, 1.12)	1.09 (0.99, 1.20)	1.24 (1.05, 1.47)
Women	1.	1.08 (0.93, 1.26)	1.16 (0.98, 1.38)	1.30 (1.01, 1.69)
Adjusted[a]				
Overall	1.	1.09 (1.01, 1.18)	1.17 (1.07, 1.28)	1.24 (1.04, 1.49)
Men	1.	1.08 (0.99, 1.18)	1.17 (1.06, 1.29)	1.22 (1.00, 1.50)
Women	1.	1.11 (0.94, 1.32)	1.19 (0.98, 1.44)	1.33 (0.95, 1.87)

[*] Abbreviations: CNICS, Centers for AIDS Research Network of Integrated Clinical Systems; eGFR, estimated glomerular filtration rate; FIB-4, Fibrosis-4 Index for Liver Fibrosis; IDU, injection drug use; MSM, men who have sex with men; VACS, Veterans Aging Cohort Study

[a] Adjustment for sex; race/ethnicity; MSM, IDU; calendar year; CNICS clinic; modified VACS index (a function of age, CD4 cell count, hemoglobin, FIB-4, eGFR, and hepatitis C viral infection); recent and prior cocaine and opioid use; panic symptoms; depressive symptoms; and current smoking

TABLE 4.

Risk ratios (crude and adjusted[a]) for the association between self-reported drinking at second patient-reported outcomes assessment (columns) and viral non-suppression, stratified by self-reported drinking at first patient-reported outcomes assessment (rows), across 41,335 person-periods contributed by 10,080 unique patients engaged in care in CNICS, 2010-2018

	Decrease in alcohol consumption					Increase in alcohol consumption		
	Non-drinker	**Low-risk, no binge**	**Low-risk, binge**	**High-risk**	**No change**	**Low-risk, no binge**	**Low-risk, binge**	**High-risk**
Crude								
Overall								
Non-drinker	-	-	-	-	1.	1.16 (1.02, 1.31)	1.38 (1.16, 1.64)	1.89 (1.24, 2.90)
Low-risk, no binge	1.21 (1.05, 1.40)	1.06 (0.91, 1.22)			1.	1.05 (0.92, 1.21)	1.21 (1.05, 1.40)	1.05 (0.67, 1.66)
Low-risk, binge	1.26 (0.99, 1.60)	1.18 (0.98, 1.41)	1.18 (0.98, 1.41)		1.		1.14 (0.96, 1.35)	1.28 (1.00, 1.65)
High-risk	1.15 (0.67, 1.98)	0.98 (0.57, 1.69)	0.89 (0.63, 1.27)	1.01 (0.67, 1.51)	1.			1.14 (0.78, 1.67)
Men								
Non-drinker					1.	1.21 (1.05, 1.40)	1.36 (1.11, 1.67)	1.95 (1.15, 3.31)
Low-risk, no binge	1.29 (1.10, 1.52)	1.11 (0.95, 1.29)			1.	1.12 (0.96, 1.30)	1.26 (1.08, 1.47)	0.81 (0.40, 1.62)
Low-risk, binge	1.26 (0.98, 1.62)	1.15 (0.95, 1.40)	1.18 (0.98, 1.43)		1.		1.14 (0.96, 1.37)	1.27 (0.96, 1.68)
High-risk	1.13 (0.58, 2.21)	0.93 (0.47, 1.83)	0.93 (0.62, 1.40)	0.97 (0.61, 1.56)	1.			1.15 (0.73, 1.80)
Women								
Non-drinker					1.	1.01 (0.80, 1.29)	1.49 (1.09, 2.03)	1.75 (0.87, 3.49)
Low-risk, no binge	0.93 (0.69, 1.25)	0.90 (0.64, 1.26)			1.	0.83 (0.59, 1.15)	1.03 (0.74, 1.44)	1.15 (0.60, 2.19)
Low-risk, binge	1.14 (0.64, 2.04)	1.22 (0.75, 1.98)	1.13 (0.71, 1.81)		1.		1.05 (0.63, 1.76)	1.17 (0.67, 2.04)
High-risk	1.38 (0.48, 3.95)	1.13 (0.41, 3.15)	1.09 (0.49, 2.44)	1.12 (0.46, 2.72)	1.			1.26 (0.55, 2.87)
Adjusted[a]								
Overall								
Non-drinker					1.	1.16 (1.03, 1.32)	1.35 (1.11, 1.63)	1.89 (1.16, 3.08)
Low-risk, no binge	1.00 (0.85, 1.17)	0.99 (0.85, 1.16)			1.	1.00 (0.86, 1.15)	1.11 (0.95, 1.30)	0.67 (0.34, 1.32)
Low-risk, binge	0.95 (0.73, 1.24)	0.98 (0.81, 1.19)	1.03 (0.85, 1.24)		1.		1.01 (0.85, 1.22)	0.96 (0.72, 1.26)
High-risk	0.79 (0.36, 1.73)	0.65 (0.28, 1.49)	0.77 (0.43, 1.37)	0.78 (0.41, 1.47)	1.			0.93 (0.51, 1.68)

	Decrease in alcohol consumption					Increase in alcohol consumption		
	Non-drinker	Low-risk, no binge	Low-risk, binge	High-risk	No change	Low-risk, no binge	Low-risk, binge	High-risk
Men								
Non-drinker					1.	1.21 (1.04, 1.41)	1.33 (1.06, 1.67)	1.68 (0.87, 3.23)
Low-risk, no binge	1.05 (0.88, 1.26)	1.03 (0.87, 1.21)			1.	1.05 (0.89, 1.24)	1.14 (0.96, 1.36)	0.58 (0.21, 1.62)
Low-risk, binge	0.95 (0.71, 1.26)	0.97 (0.79, 1.18)	1.03 (0.85, 1.26)		1.		1.02 (0.85, 1.23)	0.96 (0.70, 1.30)
High-risk	0.96 (0.42, 2.19)	0.70 (0.28, 1.76)	0.88 (0.52, 1.49)	0.88 (0.48, 1.60)	1.			1.05 (0.60, 1.82)
Women								
Non-drinker					1.	1.06 (0.82, 1.36)	1.39 (0.95, 2.05)	1.95 (0.72, 5.32)
Low-risk, no binge	0.83 (0.59, 1.16)	0.86 (0.60, 1.23)			1.	0.77 (0.53, 1.10)	0.97 (0.68, 1.38)	1.10 (0.44, 2.74)
Low-risk, binge	1.00 (0.49, 2.02)	1.05 (0.60, 1.86)	0.98 (0.55, 1.75)		1.		0.96 (0.52, 1.75)	0.96 (0.50, 1.85)
High-risk	1.57 (0.21, 11.66)	0.81 (0.12, 5.53)	0.88 (0.16, 4.71)	1.03 (0.19, 5.62)	1.			1.18 (0.22, 6.48)

*Abbreviations: CNICS, Center for AIDS Research Network of Integrated Clinical Systems; eGFR, estimated glomerular filtration rate; FIB-4, Fibrosis-4 Index for Liver Fibrosis; IDU, injection drug use; MSM, men who have sex with men; VACS, Veterans Aging Cohort Study

[a]Adjustment for sex; race/ethnicity; MSM, IDU; calendar year; CNICS clinic; modified VACS index (a function of age, CD4 cell count, hemoglobin, FIB-4, eGFR, and hepatitis C viral infection); recent and prior cocaine and opioid use; panic symptoms; depressive symptoms; and current smoking