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**The Relationship of Smoking and Unhealthy Alcohol Use to the HIV Care Continuum
among People with HIV in an Integrated Health Care System**

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Abstract

Introduction: Smoking tobacco and unhealthy alcohol use may negatively influence HIV care continuum outcomes but have not been examined in combination.

Methods: Participants were people with HIV (PWH) in Kaiser Permanente Northern California. Predictors included smoking status and unhealthy alcohol use (exceeding daily and/or weekly limits) reported by patients during primary care screening (index date). Outcomes were based on not achieving the following steps in the care continuum: linkage to HIV care (≥ 1 visit within 90 days of newly identified HIV diagnosis), retention (2+ in-person visits, 60+ days apart) and HIV RNA control (< 75 copies/mL). Adjusted odds ratios (ORs) were obtained from separate logistic regression models for each outcome associated with smoking and unhealthy alcohol use independently and combined.

Results: The overall sample (N=8,958) had a mean age of 48.0 years; was 91.3% male; 54.0% white, 17.6% Latino, 15.1% black, and 9.6% other race/ethnicity. Smoking was associated with higher odds of not being linked to HIV care (OR=1.60 [95% CI 1.03-2.48]), not retained (OR=1.30 [95% CI 1.13-1.50]), and HIV RNA not in control (OR=1.91 [95% CI 1.60-2.27]). Alcohol measures were not independently associated with outcomes. The combination of unhealthy alcohol use and smoking (versus neither) was associated with higher odds of not being linked to care (OR=2.83 [95% CI 1.40-5.71]), although the interaction did not reach significance ($p=0.18$).

Conclusions: In this large sample of PWH in an integrated health care system, smoking, both independently and in combination with unhealthy alcohol use, was associated with worse HIV care continuum outcomes.

Keywords: smoking; alcohol; primary care; integrated health care; HIV care continuum; viral control

1. Introduction

The HIV care continuum includes clinical goals indicative of effective identification and treatment for HIV (Centers for Disease Control and Prevention and Division of HIV/AIDS Prevention, 2019; Horberg et al., 2015). These include HIV diagnosis, linkage to care, engagement, treatment with antiretroviral therapy (ART), and achievement of viral suppression. The continuum is a valuable framework for understanding quality of care and for determining points at which treatment can be improved.

Smoking and unhealthy alcohol use have the potential to negatively impact HIV care across the continuum, both through their relationship to ART adherence and by direct effects on health (Chichetto et al., 2020). Smoking is common among people with HIV (PWH), with a meta-analysis noting 54% prevalence of current smoking, almost 2.5 times higher than the general population (Park et al., 2016). Studies in the US and elsewhere have found that PWH were also less likely to attempt quitting (De Socio et al., 2020; Mdodo et al., 2015; Shahrir et al., 2020). Unhealthy alcohol use includes a range of severity, from exceeding recommended limits on daily and/or weekly number of drinks (which puts people at risk for adverse consequences) to alcohol use disorders (AUDs) (Saitz, 2005). Unhealthy alcohol use across this spectrum is common among PWH (Cook et al., 2001; Samet et al., 2004), occurring in up to a quarter of PWH (Park et al., 2016; Williams et al., 2017). As in other populations, smoking and unhealthy alcohol use prevalence and severity are correlated among PWH (Braithwaite et al., 2016), and may have synergistic adverse effects on health (Monnig et al., 2016). Thus, it is valuable to investigate the combined and separate associations of smoking and unhealthy alcohol use with HIV care outcomes.

Several studies have examined the relationship of smoking and unhealthy alcohol use to individual outcomes. Unhealthy alcohol use and smoking both have been associated with reduced ART adherence (Azar et al., 2010; Chander et al., 2006; Cioe et al., 2017; Hendershot et al., 2009; Jaquet et al., 2010; King et al., 2012; Williams et al., 2016), and reduced HIV RNA suppression (Brown et al., 2017; Chander, 2011; Shacham et al., 2011; Winhusen et al., 2018). An investigation using data from the national Veterans Aging Cohort Study found that higher levels of alcohol use were negatively associated with engagement with care, ART treatment, and viral suppression (Williams et al., 2019). Patients drawn from Centers for AIDS Research Network of Integrated Clinical Systems with unhealthy alcohol use had worse retention (Monroe et al., 2016). To our knowledge, no prior studies have examined the association of smoking with outcomes across the continuum, nor the separate and combined relationship of smoking and unhealthy alcohol use in a single sample. We hypothesized that smoking and unhealthy alcohol use each would have adverse associations with HIV care continuum benchmarks, and that PWH with both smoking and unhealthy alcohol use would have the poorest outcomes.

2. Methods

2.1. Setting

Kaiser Permanente Northern California (KPNC) is a private not-for-profit integrated health system of 4.3 million members, covering 40% of the region's commercially insured population. Members receive coverage through employers and through government programs (e.g., Medicaid and Medicare) and individual plans. Member demographics are similar to the local Northern California population (Gordon, 2015). KPNC has a multidisciplinary team-based approach to HIV care (Horberg, 2016; Horberg et al., 2015), and has experienced growth in

enrollment of PWH following implementation of the Affordable Care Act in the U.S. (Satre et al., 2016b).

2.2. *Participants*

Study participants were drawn from the KPNC HIV registry (Silverberg et al., 2009a; Silverberg et al., 2009b). The registry includes an up-to-date list of all PWH, HIV transmission risk factors, dates of known infection, AIDS diagnoses, HIV-related lab and pharmacy data and associated electronic health record (EHR) data. KPNC members are notified at enrollment that their records may be used for research. Study procedures were approved by the KPNC and University of California, San Francisco Institutional Review Boards and included waiver of informed consent to examine EHR data.

The HIV registry and EHR include information on medications, inpatient and outpatient diagnoses and visits, laboratory tests including HIV (CD4 [counts/ μ L], HIV RNA level [copies/mL]), membership dates, smoking and unhealthy alcohol use data. The eligible population included PWH ≥ 18 years of age in the HIV registry who were active KPNC members at any time between July 1st, 2013 and December 31st, 2017. The study start date of July 1st, 2013 was selected because this was the starting timepoint for systematic primary care alcohol screening in KPNC. An index date was defined for each participant as the first alcohol screening after membership began. We performed a cross-sectional examination of linkage to care, retention, and viral suppression prevalence in relation to a participant's index date. We examined outcomes occurring between the participant's index date and the end of the study follow-up window (December 31, 2017) or until they died or left the health plan. Participants were not required to have a minimum length of observation (based on enrollment in KPNC) to be

included. Because this was not a longitudinal study, follow up time was not considered in the analyses. Covariates and predictors were based on most recent measures up to one year prior to the index date, as specified below. The full study sample included 8,958 adult PWH with an alcohol screening recorded in the EHR.

2.3. Exposures

The main predictors of interest were the presence of any unhealthy alcohol use and smoking status (current tobacco smoking versus nonsmoking/not indicated), as recorded in the EHR at the time of alcohol screening. Unhealthy alcohol use was defined as either reporting any days of drinking 4+/5+ drinks in the prior 3 months or reporting an average 8+/15+ drinks in a week in the last 90 days, based on clinical guidelines. Lower limits are applied to women and men over the age of 65 and upper limits are applied to men 65 years old or younger (Silverberg et al., 2020; U.S. Department of Health and Human Services and National Institute on Alcohol Abuse and Alcoholism, 2005). Both unhealthy alcohol use and smoking status are collected during routine rooming procedures by medical assistants (MAs) (Mertens et al., 2015). MAs conduct alcohol screening using NIAAA-developed instruments embedded in the EHR, include 3 questions. Question 1: “How many times in the past 3 months have you had 5 or more drinks [for men under 65] / 4 or more drinks [for women and for men 65 and over]?” Question 2: “On average, how many days a week do you have an alcoholic drink?” Question 3: “On a typical drinking day, how many drinks do you have?”

Negative alcohol screens were categorized as no “unhealthy drinking” for analysis, and this category was further broken down into 2 categories: non-drinking and moderate drinking. Non-drinking was indicated by having no drinking activity in the last 90 days. Moderate drinking

included some level of drinking in the past 90 days but no indication of any unhealthy levels of daily or weekly drinking as described above.

Smoking status was defined as current smoking versus non-smoking (which included both never-smokers and those who had quit smoking in the past). Smoking status was determined by taking the closest smoking status prior to alcohol screening. If a smoking status was not on record prior to alcohol screening, we identified the smoking status closest within 12 months after alcohol screening. If there was no smoking status on record within that time frame (<1% of the study sample), we categorized the patient as non-smoking.

Alcohol screening is routinely conducted at least annually if the patient has a primary care visit; patients who previously exceeded unhealthy drinking limits are rescreened at every subsequent primary care visit. AUD can be diagnosed in primary care or in any other setting. Since KPNC rollout of alcohol screening in July 2013, screening rates are over 87%, and brief intervention delivery rate is 65% (Sterling et al., 2016). Similarly, tobacco screening rates are 78%, with brief intervention delivery rates (advice to quit) of 77% (National Committee for Quality Assurance (NCQA), 2016).

2.4. HIV care continuum outcomes.

Three HIV care continuum outcomes were used: linkage to care, retention, and viral suppression. Linkage was defined as having an HIV care visit within 90 days of identified HIV diagnosis (either transferred into KPNC already diagnosed or newly diagnosed). Retention was defined as having two or more visits, at least 60 days apart, within 12 months of the index date (alcohol screening). Visits used to measure linkage and retention included either in-person appointments with an HIV care provider or an HIV laboratory test (Rebeiro et al., 2015). Viral

suppression was defined as HIV RNA <75 copies/mL, as measured between 3 months prior and 12 months post-alcohol screening. In case of multiple measures, we used HIV RNA level furthest from the index date. Linkage analysis was limited to newly diagnosed PWH, i.e., those with KPNC HIV diagnosis that occurred during follow-up (n=2,077); retention analysis included the full study sample (n=8,958). Viral suppression analysis was limited to those from the full study sample with an HIV RNA result within the study time frame (n=8,677), excluding individuals with missing HIV RNA data (n=281).

2.5. Covariates.

Variables included race/ethnicity (white, black, Latino, other, unknown) based on EHR documentation, ICD-based depression diagnosis prior to alcohol screening (ICD9 - 296.2x, 296.3x, 296.82, 298.0x, 300.4x, 301.12x, 311x; or ICD10 – F32x, F33x, F341x), Hepatitis B and C (ever identified as antibody positive), number of outpatient care visits, HIV acquisition risk group (men who have sex with men [MSM], injection drug users [IDU], heterosexual sex, other, unknown). We included the Charlson comorbidity index (D'Hoore et al., 1993), with a score of 0, 1, or 2+, which was modified to exclude AIDS by subtracting 6 points from the total score for anyone with an AIDS diagnosis. The Charlson Comorbidity Index has been previously used in HIV studies as a covariate or predictor of interest in understanding clinical outcomes (Kilbourne et al., 2001; Silverberg et al., 2012; Sweet et al., 2014).

The neighborhood deprivation index (NDI) was used as a measure of neighborhood socioeconomic status (SES) (Messer et al., 2006) and was included as a potential confounder. Neighborhood deprivation affects multiple health conditions, so an index may have more relevance than single-item measures of SES. The NDI has been used in studies of diabetes

(Stoddard et al., 2013) and in our prior work on unhealthy alcohol use screening among people with HIV (Silverberg et al., 2020). Participants' NDI scores were divided into quartiles, with quartile 1 representing the least deprived area and quartile 4 representing the most deprived area. We also included care being received at KPNC San Francisco Medical Center (vs. all others) as a covariate due to the substantial percentage of participants (42.5%) receiving care in this facility. This is a large, high-volume clinic with potential for competing clinical demands, so we included it to control for effects of getting care in this clinic.

2.6. Analyses

We first examined demographic and clinical characteristics descriptively. Next, we independently examined the association of each HIV care continuum outcome with unhealthy alcohol use reported on the index date (exceeding daily and/or weekly limits), smoking, and the combination of both unhealthy alcohol use and smoking. The combination measure of unhealthy alcohol use and smoking status was separated into 4 groups: any unhealthy alcohol use and current smoking, any unhealthy alcohol use and non-smoking, no unhealthy alcohol use and current smoking, and no unhealthy alcohol use and non-smoking (reference group). For each continuum outcome, we fit separate logistic regression models for each exposure. We estimated the odds ratios (OR) and corresponding 95% Confidence Intervals (95% CI) in unadjusted and adjusted models. Adjusted models included sex, age at time of alcohol screening, race, HIV acquisition risk, depression diagnosis, NDI quartile, insurance type, San Francisco Medical Center, Hepatitis B/C, and modified Charlson Score. We also ran separate adjusted logistic regression models for each continuum outcome with interaction terms for unhealthy alcohol use

and smoking to estimate the change in the association of unhealthy alcohol use per each smoking status.

In three supplementary analyses we investigated the relationship of unhealthy drinking to the continuum outcomes by running three separate logistic regression models with different alcohol use measures. Specifically, to examine the potential influence of former heavy drinkers on continuum outcomes, we ran the models excluding those who reported no drinking at the time of screening yet had an AUD diagnosis recorded in the EHR (Gordon et al., 2020). Second, we ran the models using history of AUD diagnosis as the measure of alcohol use to examine effects of having a history of AUD separately. Lastly, we ran the models with alcohol use classified into 4 mutually exclusive levels (exceeded daily unhealthy alcohol use, exceeded weekly unhealthy alcohol use, moderate use, and non-drinking) to measure the role of exceeding daily limits or only weekly drinking limits. Analyses were performed with SAS (Version 9.4; Cary, North Carolina, USA).

3. Results

The overall sample (8,958) had a mean age of 48 years and was 91.3% male; 54.0% white, 17.6% Latino, 15.1% black and 9.6% other race/ethnicity; and 70.6% men who have sex with men. Participants were primarily commercially insured (76.9%), (Table 1).

Based on primary care screening, 10.0% of the overall sample reported unhealthy alcohol use, 19.1% reported smoking, 2.8% reported both smoking and unhealthy alcohol use, 16.3% reported smoking but did not report unhealthy alcohol use, 7.2% reported unhealthy alcohol use but not smoking, and 73.7% reported neither smoking nor unhealthy alcohol use. We found that 8.3% of our sample reported exceeding daily limits at least once in the prior 90 days and 1.7%

reported only exceeding weekly unhealthy drinking limits, representing the 10.0% of our sample reporting any unhealthy alcohol use. In addition, 32.3% of our sample reported moderate drinking, and 57.7% reported no drinking. In the overall sample, 11.2% had an AUD diagnosis prior to alcohol screening; and 6.5% of the overall sample reported no drinking yet also had an AUD diagnosis prior to alcohol screening (former heavy drinkers) (Table2).

In adjusted analyses, smoking was associated with higher odds of not being linked to care (OR=1.60 [95% CI 1.03-2.48], $p=0.035$), (Table 3a), higher odds of not being retained in care (OR=1.30 [95% CI 1.13-1.50], $p<0.001$), (Table 3b), and higher odds of HIV RNA out of control (OR=1.91 [95% CI 1.60-2.27], $p<0.001$), (Table 3c). Unhealthy alcohol use measures were not independently associated with any continuum outcomes. The combination of unhealthy alcohol use and smoking was associated with greater likelihood of not being linked to care compared to patients who reported neither (OR=2.83 [95% CI 1.40 – 5.71], $p=0.004$), but the test for interaction did not reach statistical significance ($p=0.18$), (Table 3a). Interaction tests also were not significant for retention (Table 3b) and HIV RNA control (Table 3c).

Supplementary analyses did not find significant effects for unhealthy drinking once former heavy drinkers were removed from the analyses, nor effects for AUD only, nor were there significant associations between unhealthy alcohol use and continuum outcomes when alcohol use exceeding daily limits and weekly limits were examined separately (Supplementary Table 1).

4. Discussion

This study examined the relationship of smoking and unhealthy alcohol use to HIV care continuum outcomes in a large sample of PWH in an integrated health care plan with routine

screening for smoking and unhealthy drinking. After controlling for covariates, smoking had a significant adverse relationship to linkage to care, retention, and HIV RNA control. Unhealthy alcohol use was not independently associated with continuum benchmarks. To our knowledge this is the first study to examine the relationship of smoking to HIV care across the continuum as well as the combined associations of smoking status and unhealthy alcohol use with continuum outcomes.

Our results suggest an adverse relationship of smoking to three key HIV care outcomes. These findings contribute to the literature on the relationship of smoking to health among people with HIV. For example, prior studies have identified associations between smoking and common conditions in PWH including cancer and cardiovascular disease (Althoff et al., 2019). Smoking is adversely associated with ART adherence (Chichetto et al., 2020; Cioe et al., 2017). In addition, biomedical studies indicate that nicotine can have an adverse impact on ART effectiveness (Ghura et al., 2019; Steel et al., 2018; Winhusen et al., 2018). In our sample, continuum effects were found even though smoking was lower than in other studies (Hasse et al., 2015). Although we cannot draw causal conclusions regarding the relationship of smoking status to HIV care outcomes, and we were not able to measure some factors that might help to explain these relationships, e.g., lower socioeconomic status among smokers (Cioe et al., 2017) apart from the NDI effects we measured, greater social stressors, or worse self-care regarding health (Prochaska et al., 2008), our results highlight the potential value of smoking interventions. Prior studies show that smoking among PWH can be effectively treated using varenicline (Ashare et al., 2019; Mercie et al., 2018) or nicotine replacement therapy (Humfleet et al., 2013); and combined behavioral and pharmacological interventions can also be effective (Pool et al., 2016).

Analysis of VA data found that PWH were less likely than people without HIV to be offered nicotine replacement therapy (Shahrir et al., 2020). However, a study using KPNC pharmacy data found that PWH were more likely to initiate nicotine replacement than HIV-negative comparators (Lam et al., 2020), contrasting results that indicate the importance of examining how smoking cessation is managed in different health systems that serve PWH. Our findings on the relationship of smoking to poor viral control provide added urgency to address smoking among PWH.

Results regarding the relationship of unhealthy alcohol use to continuum outcomes were in contrast with our findings on smoking, and also differed from results of prior research on unhealthy alcohol use in other settings (Puryear et al., 2020; Vagenas et al., 2015; Williams et al., 2016). Notably, a recent study found that alcohol use had an adverse relationship to achieving all components of the HIV continuum among PWH in the VA Healthcare System (Williams et al., 2019). There are several reasons why our findings may have differed. The KPNC population of people with HIV is mostly MSM, is privately insured, has high levels of viral control, and has better access to health care and other resources than many other populations (Horberg et al., 2012; Satre et al., 2016a), differences which could have contributed to our contrasting results. Given that systematic alcohol screening was recently implemented in KPNC, it is possible that social desirability bias in self-report of alcohol use contributed to misclassification of participants. However, it remains essential to offer treatment and to prevent alcohol problem escalation over time and adverse health consequences among those with unhealthy drinking patterns. In recent longitudinal analysis of PWH with unhealthy drinking in KPNC, a decrease in number of days of unhealthy drinking was associated with better odds of

viral suppression, while an increase was associated with greater odds of condomless sex with HIV-negative or unknown status partners (Satre et al., 2020b). Among PWH in the VA Healthcare System, increases in unhealthy drinking were associated with decreases in viral control (Williams et al., 2018). These findings support the benefit of alcohol treatment. As with smoking, both behavioral (Satre et al., 2019) and pharmacological (Edelman et al., 2019) interventions for unhealthy alcohol use can be effective for PWH and are important components of integrated care.

Although interaction effects were not statistically significant, the combined relationship of unhealthy alcohol use and smoking with higher rates of not being linked to care deserves further investigation. This finding suggests that clinicians may need to make additional effort across the care continuum to support PWH who smoke cigarettes and also have unhealthy drinking, given the clinical complexities of such patients (Braithwaite et al., 2016; Cioe et al., 2017). Our results underline the importance of outreach and linkage to care for newly diagnosed PWH who smoke and have unhealthy drinking.

4.1. Study strengths and limitations

The study used a large cohort of PWH engaged in care in an integrated health care system and included data on three continuum outcomes as well as routine self-reported alcohol and smoking screening data. However, participants were privately insured and had high levels of HIV control, and results might not generalize to public health systems or to PWH with limited access to care. We did not examine HIV diagnosis as an outcome (the first step of the care continuum), although prior studies have found that both smoking and unhealthy alcohol use may impact testing behavior (Conserve et al., 2014). We also did not examine ART initiation, because

the vast majority of PWH in KPNC are prescribed ART as soon as their diagnosis is made, KPNC members have pharmacy benefits, and pharmacies accept financial aid if a member qualifies (e.g., through the AIDS Drug Assistance Program). There is substantial overlap between the outcomes, and therefore the outcomes are not likely to be independent of each other. However, given that the outcomes are part of the same care continuum, it is expected that there would be overlap in outcomes as well as in factors predicting each step. We did not include the effects of smoking and AUD treatment in our models to keep the study focused on the potential associations of smoking and unhealthy drinking on the HIV care continuum, and since this would require lengthening the time windows associated with our outcomes. However, prior studies at KPNC have documented that relatively few PWH receive smoking treatment and AUD specialty care (Lam et al., 2020; Silverberg et al., 2020). Thus, the potential impact would likely be low in our sample.

Data on pack-years of smoking and number of years since quitting were not available. Given the potential for lasting effects on health even after patients quit, this is a limitation of our data. Alcohol use and smoking measures were based on self-report and are subject to under-reporting due to social desirability bias, which may be more likely among individuals who have experienced health problems as a result of their drinking. Retention in the health plan among PWH is high (Satre et al., 2020a). However, responses to alcohol and smoking screening questions are dependent on patients' use of primary care, since these data were collected during clinic visits. If those with unhealthy drinking or smoking were less likely to complete a visit, this would bias results toward the null; consistent with prior studies showing less use of primary care by smokers and those with unhealthy drinking (Jorm et al., 2012; Zarkin et al., 2004). We were

only partially able to account for the potential effects of former heavy drinkers on study outcomes (who may have quit drinking due to poor health) by excluding those diagnosed with an AUD. Thus, our ability to measure alcohol exposure accurately may have been limited. The sample included only those with alcohol screening recorded in the EHR, and approximately 15% were not screened. It is possible that these excluded patients either had a visit but were not screened or had KPNC membership but no primary care visit and therefore no opportunity to be screened. In either case, such individuals represent a population less engaged in HIV care than those in the sample.

5. Conclusions

This study is the first to our knowledge to examine the relationship of both smoking and unhealthy alcohol use to the HIV care continuum among PWH. In this large sample, we found that smoking had a consistent adverse association with linkage to care, retention, and HIV RNA control. There was a non-significant trend for an interaction between smoking and unhealthy alcohol use to adversely influence linkage to care. But unhealthy alcohol use did not have significant independent effects. Although we could not establish causal relationships, results support efforts to provide smoking cessation treatment for all PWH across the continuum of care and to improve linkage to HIV care for newly identified PWH who report both smoking and unhealthy alcohol use.

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Table 1**Demographic and insurance characteristics of people with HIV screened in primary care for unhealthy alcohol use (N=8,958)**

Covariates	<i>n</i>	%
Male, n (%)	8,175	91.3
Age at alcohol screen, mean (\pm SD)	48.0	\pm 12.3
Race, n (%)		
Black	1,353	15.1
Latino	1,581	17.6
White	4,834	54.0
Other	860	9.6
Unknown	330	3.7
Risk Status, n (%)		
Heterosexual	1,181	13.2
Injection Drug Use	656	7.3
Men who have sex with men	6,326	70.6
Other	80	0.9
Unknown	715	8.0
Neighborhood Deprivation Index Quartile, n (%)		
Quartile 1	2,630	29.4
Quartile 2	1,914	21.4
Quartile 3	2,047	22.9
Quartile 4	2,367	26.4
Insurance, n (%)		
Commercial/Private	6,888	76.9
Medicare	1,736	19.4
Medicaid	229	2.6
Other	105	1.2
San Francisco Medical Center member, n (%)	3,836	42.8

Notes: Participants with both Medicare and Medicaid were classified as having Medicare, to obtain mutually exclusive insurance categories.

Table 2

Clinical characteristics of people with HIV screened in primary care for unhealthy alcohol use (N=8,958).

<i>Primary Measures</i>	<i>n</i>	<i>%</i>
Unhealthy alcohol use (exceeds daily and/or weekly limits)		
Unhealthy alcohol use	894	10.0
No unhealthy alcohol use	8,064	90.0
Smoking status		
Current smoking	1,712	19.1
Non-smoking	7,246	80.9
Combined unhealthy alcohol use and smoking		
Smoking + unhealthy alcohol use	248	2.8
Smoking + no unhealthy alcohol use	1,464	16.3
Non-smoking + unhealthy alcohol use	646	7.2
Non-smoking + no unhealthy alcohol use	6,600	73.7
<i>Supplementary Alcohol Measures</i>	<i>n</i>	<i>%</i>
Former heavy drinking status		
No unhealthy alcohol use, without prior AUD diagnosis	7,483	83.5
No unhealthy alcohol use, with prior AUD diagnosis	581	6.5
Alcohol screening results		
Non-drinking	5,168	57.7
Moderate drinking	2,896	32.3
Unhealthy alcohol use (exceeded daily limit)	740	8.3
Unhealthy alcohol use (exceeded weekly limit)	154	1.7
AUD diagnosis in EHR prior to alcohol screening		
AUD diagnosis	996	11.1
No AUD diagnosis	7,962	88.9
<i>HIV Care Continuum Outcomes</i>	<i>n</i>	<i>%</i>
Retention in care		
Yes	7,564	84.4
No	1,394	15.6
RNA control* (n=8,677)		
< 75 Copies	7,960	91.7
≥ 75 Copies	717	8.3
Linked to care* (n=2,077)		
Yes	1,962	94.5
No	115	5.5
<i>Covariates</i>	<i>n</i>	<i>%</i>
Charlson Score (excludes AIDS), n (%)		
0	7,057	78.8
1	893	10.0
2+	1,008	11.3
Depression, n (%)	2,958	33.0
HBV/HCV coinfectd, n (%)	3,145	35.1

*RNA control based on latest lab date, with lab values between 3 months prior and 12 months post alcohol screening (n=8,677). Linkage to care includes data for subjects with new KPNC HIV diagnosis after observation start date and alcohol screening within 90 days of HIV diagnosis date (n=2,077). AUD = alcohol use disorder; EHR = electronic health record. See Appendix for summary of how measures were defined.

Table 3a

Linkage to care by unhealthy alcohol use and current smoking status among people with incident HIV diagnoses (n=2,077)

Unhealthy alcohol use and smoking	Linked to Care		Odds Ratio (Adjusted)	p
	Not linked, n (%)	Linked, n (%)	Adj. (95% CL)	
	115 (5.5%)	1,962 (94.4%)		
Unhealthy Drinking				
Unhealthy alcohol use	22 (8.0%)	253 (92.0%)	1.40 (0.82-2.37)	0.218
No unhealthy alcohol use (ref)	93 (5.2%)	1,709 (94.8%)	(ref)	
Smoking Status				
Smoking	39 (7.5%)	483 (92.5%)	1.60 (1.03-2.48)	0.035
Non-smoking (ref)	76 (4.9%)	1,479 (95.1%)	(ref)	
Smoking and unhealthy alcohol use				
Smoking + unhealthy alcohol use	13 (13.1%)	86 (86.9%)	2.83 (1.40-5.71)	0.004
Smoking + no unhealthy alcohol use	26 (6.1%)	397 (93.9%)	1.37 (0.83-2.27)	0.217
No smoking + unhealthy alcohol use	9 (5.1%)	167 (94.9%)	1.00 (0.47-2.14)	0.991
No smoking + no unhealthy alcohol use (ref)	67 (4.9%)	1,312 (95.1%)	(ref)	

*p-interaction = 0.18

Linkage to Care includes data for subjects with new KP HIV Diagnosis after observation start date and alcohol screening within 90 days of HIV Diagnosis date (n=2,077). Smoking was adjusted for drinking and drinking was adjusted for smoking in respective models. The combination of drinking and smoking was not adjusted for smoking or drinking independently. Odds ratios adjusted for the following terms: race, HIV infection risk category, gender, age, Neighborhood Deprivation Index score, depression diagnosis, San Francisco facility, HBV/HCV, insurance status, and modified Charlson score.

Table 3b

Retention in HIV care by unhealthy alcohol use and current smoking status (n=8,958)

Unhealthy alcohol use and smoking	Retention Outcome		Odds Ratio (Adjusted)	p
	Not retained, n (%)	Retained, n (%)	Adj. (95% CL)	
	1,394 (15.6%)	7,564 (84.4%)		
Unhealthy Drinking				
Unhealthy alcohol use	164 (18.3%)	730 (81.7%)	0.96 (0.80-1.16)	0.704
No unhealthy alcohol use (ref)	1,230 (15.3%)	6,834 (84.7%)	(ref)	
Smoking Status				
Smoking	334 (19.5%)	1,378 (80.5%)	1.30 (1.13-1.50)	<.001
Non-smoking (ref)	1,060 (14.6%)	6,186 (85.4%)	(ref)	
Smoking and unhealthy alcohol use				
Smoking + unhealthy alcohol use	52 (21.0%)	196 (79.0%)	1.13 (0.82-1.56)	0.469
Smoking + no unhealthy alcohol use	282 (19.3%)	1,182 (80.7%)	1.33 (1.15-1.55)	<.001
No smoking + unhealthy alcohol use	112 (17.3%)	534 (82.7%)	1.02 (0.82-1.27)	0.850
No smoking + no unhealthy alcohol use (ref)	948 (14.4%)	5,652 (85.6%)	(ref)	

*p-interaction = 0.35

Retention in care is defined as when a patient has 2 or more HIV primary care visits within 12 months of alcohol screen, at least 60 days apart. Smoking was adjusted for drinking and drinking was adjusted for smoking in respective models. The combination of drinking and smoking was not adjusted for smoking or drinking independently. Odds ratios adjusted for the following terms: race, HIV infection risk category, gender, age, Neighborhood Deprivation Index score, depression diagnosis, San Francisco facility, HBV/HCV, insurance status, and modified Charlson score.

Table 3c**HIV RNA Control by unhealthy alcohol use and current smoking status (n=8,677)**

Unhealthy alcohol use and smoking	HIV RNA Control		Odds Ratio (Adjusted)	p
	≥ 75 Copies, n (%)	< 75 Copies, n (%)	Adj. (95% CL)	
	717 (8.3%)	7,960 (91.7%)		
Unhealthy Drinking				
Unhealthy alcohol use	71 (8.2%)	792 (91.8%)	0.83 (0.64-1.09)	0.179
No unhealthy alcohol use (ref)	646 (8.3%)	7,168 (91.7%)	(ref)	
Smoking Status				
Smoking	230 (14.1%)	1,405 (85.9%)	1.91 (1.60-2.27)	<.001
Non-smoking (ref)	487 (6.9%)	6,555 (93.1%)	(ref)	
Smoking and unhealthy alcohol use				
Smoking + unhealthy alcohol use	29 (12.2%)	209 (87.8%)	1.44 (0.95-2.17)	0.084
Smoking + no unhealthy alcohol use	201 (14.4%)	1,196 (85.6%)	1.95 (1.62-2.34)	<.001
No smoking + unhealthy alcohol use	42 (6.7%)	583 (93.3%)	0.90 (0.64-1.26)	0.541
No smoking + no unhealthy alcohol use (ref)	445 (6.9%)	5,972 (93.1%)	(ref)	

*p-interaction = 0.48

RNA control indicates status as of latest lab date for subjects with lab values between 3 months prior and 12 months post alcohol screening (n=8,677). Smoking was adjusted for drinking and drinking was adjusted for smoking in respective models. The combination of drinking and smoking was not adjusted for smoking or drinking independently. Odds ratios adjusted for the following terms: race, HIV infection risk category, gender, age, Neighborhood Deprivation Index score, depression diagnosis, San Francisco facility, HBV/HCV, insurance status, and modified Charlson score.

Supplementary Table 1

HIV care continuum outcomes by alcohol measurement subgroups

Alcohol use subgroups	Continuum Outcome		Odds Ratio (Adjusted)	
	Not Linked, n (%)	Linked, n (%)	Adj. (95% CL)	p
<i>Linkage to Care (N=2,077)</i>				
Unhealthy alcohol use (excl. former heavy drinkers)*				
Unhealthy alcohol use	22 (8.0%)	253 (92.0%)	1.41 (0.83-2.40)	0.205
No unhealthy alcohol use (ref)	91 (5.1%)	1,677 (94.9%)	(ref)	
History of alcohol use disorder (AUD)				
AUD diagnosis	4 (5.3%)	72 (94.7%)	1.04 (0.34-3.24)	0.943
No AUD diagnosis (ref)	111 (5.5%)	1,890 (94.5%)	(ref)	
Drinking Levels				
Non-drinking	50 (5.0%)	959 (95.0%)	0.94 (0.60-1.47)	0.772
Unhealthy alcohol use (exceeded daily limit)	16 (7.0%)	211 (93.0%)	1.39 (0.72-2.69)	0.323
Unhealthy alcohol use (exceeded weekly limit)	6 (12.5%)	42 (87.5%)	1.26 (0.51-3.08)	0.614
Moderate (ref)	43 (5.4%)	750 (94.6%)	(ref)	
<i>Retention in HIV care (N=8,958)</i>				
Unhealthy alcohol use (excl. former heavy drinkers)*				
Unhealthy alcohol use	164 (18.3%)	730 (81.7%)	0.83 (0.64-1.08)	0.170
No unhealthy alcohol use (ref)	1,170 (15.6%)	6,313 (84.4%)	(ref)	
History of alcohol use disorder (AUD)				
AUD diagnosis	125 (12.6%)	871 (87.4%)	1.16 (0.91-1.48)	0.242
No AUD diagnosis (ref)	1,269 (15.9%)	6,693 (84.1%)	(ref)	
Drinking Levels				
Non-drinking	734 (14.2%)	4,434 (85.8%)	0.99 (0.83-1.18)	0.921
Unhealthy alcohol use (exceeded daily limit)	135 (18.2%)	605 (81.8%)	0.86 (0.61-1.19)	0.360
Unhealthy alcohol use (exceeded weekly limit)	29 (18.8%)	125 (81.2%)	0.78 (0.49-1.23)	0.279
Moderate (ref)	496 (17.1%)	2,400 (82.9%)	(ref)	
<i>HIV RNA Control (N=8,677)</i>				
	≥ 75 Copies, n (%)	< 75 Copies, n (%)	Adj. (95% CL)	p
Unhealthy alcohol use (excl. former heavy drinkers)*				
Unhealthy alcohol use	71 (8.2%)	792 (91.8%)	0.95 (0.79-1.15)	0.612
No unhealthy alcohol use (ref)	600 (8.3%)	7,096 (91.9%)	(ref)	
History of alcohol use disorder (AUD)				
AUD diagnosis	95 (9.9%)	864 (90.1%)	0.90 (0.73-1.10)	0.305
No AUD diagnosis (ref)	622 (8.1%)	7,096 (91.9%)	(ref)	
Drinking Levels				
Non-drinking	413 (8.2%)	4,598 (91.8%)	0.91 (0.80-1.03)	0.132
Unhealthy alcohol use (exceeded daily limit)	58 (8.1%)	656 (91.9%)	0.87 (0.68-1.10)	0.244
Unhealthy alcohol use (exceeded weekly limit)	13 (8.7%)	136 (91.3%)	1.00 (0.73-1.36)	0.993
Moderate (ref)	233 (8.3%)	2,570 (91.7%)	(ref)	

*Those with former heavy drinking were defined as those reporting no drinking in the prior 90 days yet having an AUD diagnosis recorded in the EHR. Smoking was adjusted for in drinking models. Odds ratios adjusted for the following terms: race, HIV infection risk category, gender, age, Neighborhood Deprivation Index score, depression diagnosis, San Francisco facility, HBV/HCV, insurance status, and modified Charlson score.

APPENDIX. Study alcohol use, smoking, and continuum of care definitions.

Alcohol use

Drinking levels (based on primary care alcohol screening)

- Unhealthy alcohol use: Indicated 4+/5+ drinks in a day or average 8+/15+ drinks in a week in the last 90 days for women/men 66+ and men under 66, respectively.
 - Daily unhealthy drinking: Indicated 4+/5+ drinks in a day in the last 90 days for women/men 66+ and men under 66, respectively.
 - Weekly unhealthy drinking only: Indicated an average 8+/15+ drinks in a week but did not indicate 4+/5+ drinks in a day in the last 90 days for women/men 66+ and men under 66, respectively.¹
- Moderate drinking: Indicated more than 0 drinks over the past 90 days but less than 4+/5+ drinks in a day and averaged less than 8+/15+ drinks in a week for women/men.
- Non-drinking: Indicated an average of 0 drinks over the past 90 days for women/men.

Smoking

- Smoking status was determined by taking the closest smoking status (current, never, or former smoking) prior to the alcohol screening completion. Former smokers were categorized as non-smoking for analysis.
- If no smoking status was recorded prior to alcohol screen (<1%) participant was categorized as a non-smoker.

Linkage to care

- Linkage to care was defined as having at least 1 visit within 90 days of a new HIV diagnosis (transferred into Kaiser Permanente already diagnosed or newly diagnosed).
- Visit was defined as in-person visit with an HIV provider, CD4 lab test, or viral load test.
- Kaiser Permanente HIV diagnosis must occur after the start of observation and alcohol screening must occur within 90 days of HIV diagnosis.

Retention in care

- Retention in care was defined as when a patient has 2 or more HIV primary care visits within 12 months of alcohol screening completion, at least 60 days apart.
- HIV primary care visit was defined as an in-person visit with an HIV provider, CD4 lab test, or viral load lab test.

Viral control

- Viral control was defined as having a viral load laboratory result of <75 copies as of the latest lab date for subjects with lab values between 3 months prior and 12 months post alcohol screening.
- If no laboratory result occurred in this period, the participant was not included in analysis.

— Note: ¹Age group differentiation of alcohol limits for men were based on NIAAA clinician guidelines from 2005/2016 (Silverberg et al., 2020; U.S. Department of Health and Human Services and National Institute on Alcohol Abuse and Alcoholism, 2005). More recent limits based on the 2015-2020 US. Dietary Guidelines make no distinction by age group for men (i.e., no more than 2 drinks for men of legal drinking age)(National Institute on Alcohol Abuse and Alcoholism).”