

# Tobacco Use and Sustained Viral Suppression in Youth Living with HIV

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**Abstract** Tobacco has been associated with worse HIV disease progression in adult samples of people living with HIV; however, studies have yet to examine these effects in youth living with HIV (YLWH). This study examined the association between tobacco smoking behaviors and sustained viral suppression among a sample of 820 YLWH who were recruited through the Adolescent Medicine Trials Network for HIV Interventions. Participants completed a cross-sectional survey and then staff abstracted viral suppression data from medical records for up to 26 weeks prior to enrollment. Overall, 20.4% of youth reported daily or almost daily tobacco use. In multivariable analyses, older age and daily or almost daily tobacco smoking, and ART adherence remained statistically significant in predicting sustained viral suppression over the study period. These findings underscore the need for tobacco screening and interventions in HIV care settings in order to identify youth in need of additional smoking cessation services.

**Resumen** El tabaco se ha asociado con una progresión peor de la enfermedad del VIH en muestras adultas de personas que viven con el VIH; sin embargo, los estudios todavía tienen que examinar estos efectos en los jóvenes que viven con el VIH (YLWH). Este estudio examinó la asociación entre los hábitos de fumar tabaco y la supresión viral sostenida entre una muestra de 820 YLWH que fueron reclutados a través de la Red de Investigación de Medicina del Adolescente para Intervenciones de VIH. Los participantes completaron una encuesta transversal y luego el personal extrajo los datos de supresión viral de los registros médicos hasta 26 semanas antes de la inscripción. En general, el 20,4% de los jóvenes informó un consumo diario o casi diario de tabaco. En los análisis multivariados, la edad avanzada y el tabaquismo diario o casi diario, y la adherencia a la terapia antirretroviral permanecieron estadísticamente significativas en la predicción de la supresión viral sostenida durante el período del estudio. Estos hallazgos subrayan la necesidad de evaluación del uso de tabaco e intervenciones en entornos de atención del VIH con el fin de identificar a los jóvenes que necesitan servicios adicionales para dejar de fumar.

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## Introduction

The use of antiretroviral therapy (ART) has resulted in significant improvements in morbidity and reduced mortality among people living with HIV, including youth living with HIV (YLWH) through HIV RNA viral suppression [1]. Achieving sustained viral suppression is highly dependent on success at each step of the HIV care cascade, specifically engagement and retention in care, in

order to obtain ART and maintain nearly perfect ART adherence [2, 3]. While there have been great strides in linking YLWH to HIV care, a substantial number of individuals continue to report sub-optimal ART adherence and do not maintain viral suppression [3]. A number of factors have been linked to having a detectable viral load among YLWH such as unstable housing or being homeless, a history of incarceration, and psychological distress [4, 5]. Substance use has been consistently reported to negatively impact ART adherence [6] and viral suppression [3]. Thus, YLWH who use alcohol, marijuana, and other illicit drugs are often less likely to achieve viral suppression [6].

Tobacco use is common among YLWH, with 32.9–38.7% reporting tobacco use [6, 7]. In adult samples, tobacco smoking has been associated with greater AIDS-related morbidity [8, 9], greater non-AIDS-related morbidity, including cardiovascular disease and pulmonary disease [10–15], and greater mortality [15, 16]. Smoking has been consistently shown to impact HIV disease progression and outcomes, and has been identified as the leading cause of premature mortality among adults living with HIV [17]. Findings from a few studies on the effect of tobacco use on viral suppression have been mixed. One study found that tobacco use had no significant effect on HIV viral loads [6]; however, other studies in adults living with HIV have reported that tobacco use was associated with increased odds of having an unsuppressed viral load [18].

A range of factors has been associated with tobacco use among adult samples of PLHW, including younger age, low socioeconomic status [19], co-occurring substance use [20], and psychological distress [21]. However, to our knowledge, research has yet to examine factors associated with tobacco use behaviors among YLWH. Therefore, the purpose of this study was two-fold: (1) to identify psychosocial and behavioral factors associated with tobacco use in a sample of 820 YLWH; and (2) to examine the association between tobacco smoking behaviors and sustained viral suppression among YLWH, after statistically adjusting for known psychosocial factors linked to barriers to viral suppression.

## Methods

Between February 2015 and February 2016, participants were recruited from 14 different adolescent medical clinics located throughout the United States to participate in a longitudinal observational study linked with a cross-sectional survey. Adolescents were approached at one of their scheduled clinic visits by trained clinic research staff. To be eligible, youth had to be: (1) between 13 and 24 years of age; (2) living with HIV/AIDS; (3) aware they were HIV-positive; (4) engaged in HIV care in one of the Adolescent

Trial Network for HIV/AIDS Intervention (ATN) adolescent medicine clinical sites or affiliates; (5) behaviorally-infected with HIV; (6) able to understand written and/or spoken English; and (7) ability for research staff to access participant medical records throughout the duration of the study. The study was approved by the Institutional Review Boards (IRB) at each participating site as well as those of members of the protocol team.

After the initial screening process, those who were eligible went through a consent process in which research staff obtained signed informed consent or youth assent from those who agreed to participate. Participants then completed an audio-computer assisted self-interview (ACASI) which assessed multiple psychosocial and behavioral measures. Participants were compensated with an incentive which was determined by the sites' IRB for their time and effort completing the assessment. Research staff abstracted biomedical and visit appointment information from the participants' medical record including: date of initial HIV diagnosis; date of first HIV-related medical care visit; initial viral load, initial CD4 count. For participants already in care, additional data was collected for up to 26 weeks prior to enrollment which included all viral load results and CD4 counts. Subject data was then collected prospectively at 6 month intervals. Due to funding constraints the study was ended prematurely; therefore, the full-year of follow up data is not available for all youth who enrolled in the study. In total, 940 participants were enrolled in the study with 820 participants having at least 6 months of follow up data. Thus, the analytic sample included 820 participants with at least 6 months of follow data.

## Measures

### *Tobacco Use*

The Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) was used to collect data on the frequency of using ten different substances over the 3 months prior to the enrollment visit [22]. Response options included Daily/Almost Daily; Weekly; One or Two Times a Month; Never.

### *Alcohol, Marijuana, and Other Illicit Drug Use*

We also used three other indicators of substance use which were assessed with the ASSIST in our analysis, which included: (1) alcohol use (daily/almost daily; weekly; one or more times per month; never); (2) marijuana use (daily/almost daily; weekly; one or more times per month; never); and (3) endorsement of any past three-month other illicit drug use (i.e., crack, cocaine, amphetamine, inhalants, opioids, sedatives, hallucinogens).

## CRAFFT

Participants completed the 6-item CRAFFT screening tool designed to assess the consequences of alcohol and/or other drug use [23]. A score of two or greater on the CRAFFT indicates that an individual may be at risk for substance-related problems or disorders [24].

## Sociodemographic Characteristics

Participants self-reported their age (also confirmed with medical record data), sex assigned at birth, gender identity, race and ethnicity, history of incarceration, and living situation.

## Mental Health Symptoms

Participants completed three subscales from Brief Symptom Inventory (BSI), which creates Global Severity Index (GSI) [25]. The GSI combines information about the number of symptoms (i.e., Somatization, Depression, Anxiety) and intensity of distress. Items have the following response options: 0 = not at all, 1 = a little bit, 2 = moderately, 3 = quite a bit, and 4 = extremely.

## Adherence to Antiretroviral Therapy (ART)

Participants self-reported whether they were taking HIV medications. Among those who self-reported taking HIV medications, participants reported the number of pills they were told take by their doctor, as well as the number of pills they actually took per week. From the former two items, we calculated a percentage of self-reported ART adherence in a week. In total, 143 participants self-reported that they were not prescribed ART by their doctor. Self-reported ART adherence ranged from 0 to 100 ( $M = 83.50$ ,  $SD = 26.64$ ). Given the skewness of ART adherence, we recoded ART adherence into a 3-category variable (0 = Not Taking ART, 1 = Less than 80% Adherent, 2 = 80% or higher Adherent).

## CD4 Cell Count

Participant's CD4 counts were abstracted from their medical record at the time of their enrollment in the study. We categorized CD4 counts into a 4-category variable (1 = Missing, 2 = Less than 200, 3 = 200 to 350, and 4 = Greater than 350).

## Sustained Viral Suppression

Our viral suppression outcome included participants who had 100% of viral load tests during the study period at  $< 200$  copies/ml. Because some participants ( $n = 467$ )

had viral load results for 1 year; whereas, some only had 6 months of viral load results ( $n = 353$ ), we created an additional variable for length of time in study (1 = 1 year of viral load test results vs. 0 = less than 1 year of viral load test results).

## Statistical Analyses

First, we examined descriptive statistics for tobacco use and other psychosocial and behavioral factors. Second, we conducted bivariate analyses to examine whether there were differences in psychosocial and behavioral factors by smoking patterns (i.e., daily/almost daily, weekly, monthly, and never) using Analysis of Variance (ANOVA) for continuous variables and Chi squares for categorical variables (sparse data where cell sizes were  $< 5$  utilized Fisher's exact tests to obtain exact  $p$ -values but we still reported Chi square test statistics). Next, we fit a series of bivariate logistic regression models to identify the sociodemographic, mental health, and substance use variables that were significantly associated with sustained viral suppression over the study period. Finally, we fit a multivariable logistic regression model for sustained viral suppression to determine the impact of tobacco use on viral load after statistically adjusting for sociodemographic, mental health, other substance use variables, and length of follow-up period. All analyses were conducted in SPSS 24 with a specified  $p$  value of 0.05.

## Results

### Sample Characteristics

Table 1 presents the characteristics of the study sample by tobacco smoking. Participants ranged in age from 16 to 24 ( $M = 21.48$ ,  $SD = 2.01$ ). The majority of the sample were members of racial/ethnic minority groups (73.3% Black non-Hispanic, 17.9% Latino/Hispanic, and 4.9% Other) and self-reported a male gender identity (77.8% male, 3.3% transgender woman, 18.9% female). In regards to socio-structural factors, over two-thirds (63.3%) had attained a High School degree or less, 8.7% reported unstable housing or homelessness and 39.2% reported a history of criminal justice involvement. Nearly one-quarter of the sample reported daily or almost daily tobacco use (20.4%) with an additional 7.1% reporting at least weekly tobacco use. Approximately one-quarter of the sample also reported at least weekly alcohol use (4% daily/almost daily and 20.6% weekly), with a higher percentage reporting at least weekly marijuana use (31.5% daily/almost daily and 9.8% weekly). Approximately one in four participants reported any other illicit drug use (23.4%) in the past 3 months and 61.7% screened positive on the CRAFFT (i.e.,  $\geq 2$ ). Over half of the sample self-reported

**Table 1** Characteristics of sample by tobacco use

	Total N = 820 M (SD)	Daily/almost daily N = 200 (24.4%) M (SD)	Weekly N = 58 (7.1%) M (SD)	Monthly N = 185 (22.6%) M (SD)	Never N = 377 (46.0%) M (SD)	Test statistic <sup>b</sup>
Age	21.48 (2.01)	21.69 (1.85)	21.83 (1.54)	21.41 (2.14)	21.35 (2.08)	$p = 0.129$
	N (%)	N (%)	N (%)	N (%)	N (%)	
Gender identity						$\chi^2(6) = 30.19^{***}$
Female	155 (18.9)	30 (15.0)	8 (13.8)	19 (10.3)	98 (26.0)	
Male	638 (77.8)	158 (79.0)	48 (82.8)	162 (87.6)	270 (71.6)	
Trans women	27 (3.3)	12 (6.0)	2 (3.4)	4 (2.2)	9 (2.4)	
Race/ethnicity						$p = 0.067$
White, non-Hispanic	29 (3.5)	9 (4.5)	1 (1.7)	7 (3.8)	12 (3.2)	
Black, non-Hispanic	601 (73.3)	157 (78.5)	41 (70.7)	118 (63.8)	285 (75.6)	
Hispanic/Latino	147 (17.9)	25 (12.5)	10 (17.2)	46 (24.9)	66 (17.5)	
Other, non-Hispanic	40 (4.9)	8 (4.0)	6 (10.3)	13 (7.0)	13 (3.4)	
Education						$p = 0.142$
Less than high school	179 (21.8)	56 (28.0)	11 (19.0)	48 (25.9)	64 (17.0)	
High school or GED	340 (41.5)	85 (42.5)	28 (48.3)	68 (36.8)	159 (42.2)	
College degree	231 (28.2)	47 (23.5)	16 (27.6)	48 (25.9)	120 (31.8)	
Graduate degree	69 (8.4)	12 (6.0)	3 (5.2)	20 (10.8)	34 (9.0)	
Homeless						$\chi^2(3) = 21.64^{***}$
Yes	71 (8.7)	31 (15.5)	5 (8.6)	19 (10.3)	16 (4.3)	
No	748 (91.3)	169 (84.5)	53 (91.4)	166 (89.7)	360 (95.7)	
Jail						$\chi^2(9) = 71.99^{***}$
Never	497 (60.8)	86 (43.2)	29 (50.0)	106 (57.3)	276 (73.4)	
1 time	156 (19.1)	41 (20.6)	14 (24.1)	47 (25.4)	54 (14.4)	
2–5 times	125 (15.3)	52 (26.1)	10 (17.2)	25 (13.5)	38 (10.1)	
6 or more times	40 (4.9)	20 (2.4)	5 (0.6)	7 (0.9)	8 (1.0)	
Alcohol use						$\chi^2(9) = 77.14^{***}$
Daily/almost daily	33 (4.0)	13 (6.5)	5 (8.6)	8 (4.3)	7 (1.9)	
Weekly	169 (20.6)	59 (29.5)	16 (27.6)	47 (25.4)	47 (12.5)	
Monthly	461 (56.2)	101 (50.5)	35 (60.3)	113 (61.1)	212 (56.2)	
Never	157 (19.1)	27 (13.5)	2 (3.4)	17 (9.2)	111 (29.4)	
Marijuana use						$\chi^2(9) = 215.62^{***}$
Daily/almost daily	257 (31.5)	116 (58.3)	26 (44.8)	69 (37.5)	46 (12.3)	
Weekly	80 (9.8)	20 (10.1)	10 (17.2)	31 (16.8)	19 (5.1)	
Monthly	168 (20.6)	29 (14.6)	14 (24.1)	43 (23.4)	82 (21.9)	
Never	311 (38.1)	34 (17.1)	8 (13.8)	41 (22.3)	228 (60.8)	
Any illicit drug use <sup>a</sup>	192 (23.4)	64 (32.0)	17 (29.3)	64 (34.6)	47 (12.5)	$\chi^2(3) = 47.44^{***}$
CRAFFT $\geq 2$	505 (61.7)	159 (79.5)	45 (77.6)	143 (77.7)	158 (42.0)	$\chi^2(3) = 114.64^{***}$
ART adherence						$\chi^2(6) = 21.10^{**}$
Not taking ART	186 (22.7)	58 (29.0)	16 (27.6)	41 (22.2)	71 (18.8)	
Less than 80% adherent	144 (17.6)	40 (20.0)	13 (22.4)	40 (21.6)	51 (13.5)	
80% or more adherent	490 (59.8)	102 (51.0)	50 (50.0)	104 (56.2)	255 (67.6)	
CD4 count						$p = 0.634$
Missing	67 (8.2)	16 (8.0)	4 (6.9)	19 (10.3)	28 (7.4)	
Less than 200	44 (5.4)	15 (7.5)	2 (3.5)	8 (4.3)	19 (5.0)	
200–350	81 (9.9)	25 (12.5)	4 (6.9)	17 (9.2)	35 (9.3)	
Greater than 350	628 (76.6)	144 (72.0)	48 (82.8)	141 (76.2)	295 (78.2)	
Viral suppression	410 (51.8)	72 (37.5)	30 (52.6)	97 (55.4)	221 (57.5)	$\chi^2(3) = 21.43^{***}$
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	

**Table 1** continued

	Total N = 820 M (SD)	Daily/almost daily N = 200 (24.4%) M (SD)	Weekly N = 58 (7.1%) M (SD)	Monthly N = 185 (22.6%) M (SD)	Never N = 377 (46.0%) M (SD)	Test statistic <sup>b</sup>
BSI general symptoms	18.57 (15.9)	22.59 (16.9)	22.65 (17.9)	18.72 (15.8)	15.72 (14.5)	F(3, 801) = 9.71***

<sup>a</sup>Includes cocaine, heroin, methamphetamines, hallucinogens, and other non-prescribed sedatives

<sup>b</sup>Bivariate analyses examine associations between factor in relation to the 4-category tobacco use variable (1 = never, 2 = monthly, 3 = weekly, 4 = daily/almost daily)

\* $p < 0.05$

\*\* $p < 0.01$

\*\*\* $p < 0.001$

80% or higher ART adherence within the past week (59.8%), with less than a quarter were not taking ART medications (22.7%) and over three-quarters of the sample had a CD4 count over 350 (76.6%).

As shown in Table 1, a greater proportion of participants who reported daily or almost daily tobacco use compared to non-smokers reported being homeless or unstable housing (15.5% vs. 4.3%),  $\chi^2(3) = 21.64$ ,  $p < 0.001$  and reported a history at least one time being in jail (20.6% vs. 14.4%,  $\chi^2(9) = 71.99$ ,  $p < 0.001$ ). In regards to co-occurring substance use, a greater proportion of youth who reported daily/almost daily and weekly tobacco users also reported daily/almost daily alcohol use (6.5–29.5%) compared to monthly or non-smokers (1.9–12.5%),  $\chi^2(9) = 77.14$ ,  $p < 0.001$ . Similarly, daily/almost daily smokers had a higher proportion of reporting daily or almost daily marijuana use compared to monthly or non-smokers (58.3% vs. 12.3%),  $\chi^2(9) = 215.62$ ,  $p < 0.001$ . Non-tobacco smokers (12.5%) had a lower proportion of reporting other illicit drug use compared to daily or almost daily (32.0%), weekly (29.3%), or monthly tobacco (34.6%) smokers,  $\chi^2(3) = 47.44$ ,  $p < 0.001$ . A lower proportion of non-tobacco smokers (42.0%) screened positive on the CRAFFT compared to daily or almost daily (79.5%), weekly (77.6%), or monthly tobacco (77.7%) smokers,  $\chi^2(3) = 114.64$ ,  $p < 0.001$ . A lower proportion of non-smokers (67.6%) reported 80% or higher ART adherence compared to daily/almost daily (51.0%), weekly (50.0%), and monthly (56.2%) smokers,  $\chi^2(6) = 21.10$ ,  $p < 0.01$ . A lower proportion of daily or almost daily smokers (37.5%) compared to non-smokers (57.5%) had achieved sustained viral suppression,  $\chi^2(3) = 21.43$ ,  $p < 0.001$ . Additionally, daily or almost daily smokers ( $M = 22.6$ ,  $SD = 16.9$ ) reported significantly higher BSI general symptoms compared to non-tobacco smokers ( $M = 15.7$ ,  $SD = 14.5$ ),  $F(3, 801) = 9.71$ ,  $p < 0.001$ . There were no significant bivariate differences in smoking behaviors and educational attainment or CD4 cell count.

Table 2 presents bivariate and multivariable logistic regression models examining factors associated with sustained viral suppression. In bivariate models, youth older in

age had an increased odds of sustained viral suppression (OR = 1.11, 95% CI 1.04, 1.19). Participants who reported unstable housing or homelessness (OR = 0.54, 95% CI 0.32, 0.89) and those who reported at least one time in jail (OR = 0.63, 95% CI 0.44, 0.92) had a decreased odds of sustained viral suppression. Participants who reported weekly alcohol use had a reduced odds of sustained viral suppression compared to youth who reported no alcohol use in the past 3 months (OR = 0.70, 95% CI 0.49, 1.00). Participants who reported daily or almost daily cigarette smoking (OR = 0.47, 95% CI 0.32, 0.73), any illicit drug use (OR = 0.66, 95% CI 0.47, 0.92), screened positive on the CRAFFT (OR = 0.74, 95% CI 0.56, 0.99) and reported greater BSI scores (OR = 0.99, 95% CI 0.98, 0.99) had a decreased odds of sustained viral suppression. Additionally, participants who self-reported less than 80% ART adherence (OR = 5.04, 95% CI 3.04, 8.37) and those who reported 80% or greater ART adherence (OR = 7.51 (95% CI 5.03, 11.81) had an increased odds of sustained viral suppression compared to those who were not taking ART medications. In the multivariable model, older age was associated with an increased odds of viral suppression (AOR = 1.22, 95% CI 1.06, 1.39). Compared to participants not taking ART medications, those who self-reported less than 80% adherence (AOR = 5.59, 95% CI 2.41, 12.97) and those who self-reported 80% or greater ART adherence (AOR = 8.62, 95% CI 4.08, 12.21) had an increased odds of sustained viral suppression. Finally, participants who reported daily or almost daily tobacco smoking had a reduced odds of sustained viral suppression (AOR = 0.55, 95% CI 0.32, 0.96).

## Discussion

In this sample of YLWH who were engaged in care, we found that daily or almost daily tobacco use in the past 3 months was significantly associated with a decreased odds of durable viral suppression even after adjusting for possible covariates and confounders. These findings are

**Table 2** Bivariate and multivariable associations between tobacco use and sustained 100% viral suppression

	Durable viral suppression ( $\leq 200$ copies/ml)			
	Bivariate models		Multivariable model	
	OR (95% CI)	<i>p</i> -value	AOR (95% CI)	<i>p</i> -value
Age	1.11 (1.04, 1.19)	0.004	1.22 (1.06, 1.39)	0.004
Gender (vs. female)				
Male	0.96 (0.67, 1.38)	0.825	1.22 (0.49, 3.07)	0.669
Trans woman	0.83 (0.36, 1.95)	0.664	1.84 (0.27, 12.61)	0.533
Race/ethnicity (vs. white)				
Black, non-Hispanic	1.06 (0.74, 1.53)	0.737	1.34 (0.72, 2.49)	0.364
Hispanic/Latino	1.08 (0.47, 2.45)	0.860	0.17 (0.02, 1.14)	0.068
Other, non-Hispanic	1.65 (0.61, 4.47)	0.324	0.25 (0.03, 2.00)	0.193
Homeless (vs. no)				
Yes	0.54 (0.32, 0.89)	0.016	0.91 (0.42, 1.98)	0.808
Jail (vs. never)				
1 time	0.63 (0.44, 0.92)	0.015	0.73 (0.39, 1.35)	0.315
2–5 times	0.53 (0.35, 0.80)	0.002	0.58 (0.30, 1.12)	0.103
6 or more times	0.39 (0.19, 0.77)	0.007	0.33 (0.10, 1.14)	0.080
Alcohol use (vs. none)				
Daily/almost daily	0.81 (0.39, 1.66)	0.561	1.38 (0.50, 3.78)	0.535
Weekly	0.70 (0.49, 1.00)	0.050	0.70 (0.41, 1.19)	0.185
Monthly	0.52 (0.32, 1.77)	0.672	0.62 (0.75, 2.13)	0.372
Marijuana use (vs. none)				
Daily/almost daily	0.68 (0.46, 1.02)	0.059	0.96 (0.41, 3.78)	0.535
Weekly	0.80 (0.47, 1.37)	0.416	1.02 (0.47, 2.21)	0.882
Monthly	0.92 (0.31, 1.40)	0.521	1.12 (0.62, 2.01)	0.711
Cigarette use (vs. none)				
Daily/almost daily	0.48 (0.32, 0.73)	0.001	0.55 (0.32, 0.96)	0.039
Weekly	0.89 (0.49, 1.63)	0.713	0.80 (0.38, 1.65)	0.538
Monthly	0.93 (0.42, 1.72)	0.729	0.72 (0.07, 2.94)	0.984
Any illicit drug use <sup>a</sup>	0.66 (0.47, 0.92)	0.013	0.65 (0.38, 1.11)	0.114
CRAFFT $\geq 2$	0.74 (0.56, 0.99)	0.041	0.88 (0.43, 1.81)	0.736
ART adherence (vs. none)				
Less than 80% adherence	5.04 (3.04, 8.37)	0.000	5.59 (2.41, 12.97)	0.000
80% or greater adherence	7.71 (5.03, 11.81)	0.000	8.62 (4.08, 12.21)	0.000
BSI general symptoms	0.99 (0.98, 0.99)	0.013	0.99 (0.98, 1.01)	0.994

<sup>a</sup>Includes cocaine, heroin, methamphetamines, hallucinogens, and other non-prescribed sedatives; multivariable model adjusted for length of follow up

consistent with prior studies with adult populations that also detect a significant association between tobacco smoking and biomarkers of HIV disease progression [7]. While studies on these associations have been mixed, our finding provides important information on smoking among YLWH.

A higher proportion of YLHW who reported being a daily or almost daily smoker compared to non-smokers, also reported weekly or more frequent alcohol use and marijuana use, as well as any other illicit drug use in the past 3 months and screened positive on the CRAFFT. In bivariate analyses illicit drug use and screening positive on

the CRAFFT were both significantly associated with a decreased odds of having a sustained viral load. Although these factors did not remain significant in the multivariable model, our findings demonstrate that YLHW who smoke tobacco daily or almost daily may also use other substances, which may make them vulnerable to sub-optimal ART adherence [6]. However, given that ART adherence was based on a self-report measure which is subject to social desirability, our findings may also support the hypothesis that tobacco smoking may have direct physiological effects on HIV disease progression, such that nicotine may suppress immune functioning [26, 27].

Notably, a greater proportion of YLWH who reported unstable housing or homelessness or criminal justice involvement were daily or almost daily smokers compared to non-smokers, and these structural factors were also associated with a lower odds of achieving durable viral suppression. While we did not find significant associations between educational attainment and smoking behaviors, many YLWH frequently experience social and environmental distress including exposure to violence, limited economic resources, and family problems including parental substance abuse [28]. Thus, youth with a history of homelessness and incarceration may particularly benefit from tobacco screening and interventions in HIV care settings. Furthermore, individual and structural interventions which address both tobacco use and ART adherence are urgently needed for YLWH.

Our study sample was predominately African American and identified as male gender. Studies have demonstrated that African Americans have about the same prevalence of smoking as their white counterparts but may have more difficulty quitting smoking. As a result of low socioeconomic status and limited resources, African American men living with HIV may be less likely to receive tobacco prevention and smoking cessation counseling and treatment [29]. Thus, future research is needed to create sustained smoking cessation programs which includes access to pharmacological treatments within HIV care settings.

## Limitations

Study findings must be interpreted within several limitations. First, the observational design of the study precludes us from making causal inferences. Although ACASI technology was used to mitigate social desirability bias, self-report data is still subject to social desirability and recall bias. Additionally, we did not formally adjust for numerous tests; therefore, study findings with marginal *p*-values, such as the association between weekly alcohol use and sustained viral suppression, should be interpreted with caution. Furthermore, this is a non-probability sample of youth who were aware of their HIV status and linked to medical services which limits generalizability to the broader population of YLWH. Finally, we did not assess known correlates of smoking among PLWH, such as social networks [30], which is an important area for future research with youth.

## Conclusion

Despite these limitations, our study findings highlight the need for future research and programming to intervene on tobacco smoking among YLWH. Future research is

warranted to better understand the link between tobacco smoking and HIV disease progression. Additionally, the important association between other substance use and structural factors merits further investigation and points to the importance of multi-level interventions in HIV care settings. Given the high prevalence of tobacco smoking and its potential link with not achieving sustained viral suppression, clinicians should be trained in tobacco screening and interventions in order to identify youth in need of additional smoking cessation services.

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## Compliance with Ethical Standards

**Conflict of interest** Each of the authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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