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Intersection of alcohol use, HIV infection, and the HIV care continuum in Zambia: nationally representative survey

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Abstract

Through a nationally-representative household survey, we measured the prevalence and correlates of unhealthy alcohol use (UAU) in Zambia and its association with the HIV care continuum. Adolescent and adult (ages 15–59 years) data, including the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C), from the 2016 Zambia Population-based HIV Impact Assessment, were analyzed. UAU was defined as AUDIT-C of 3+ points for women and 4+ for men. Among 20,923 participants, 15.3% had UAU; this was 21.6% among people living with HIV (PLWH). Male sex, increasing age, being employed, urban residence, and having HIV were independent correlates of UAU (all $P<0.05$). Among PLWH, UAU was associated with reduced HIV diagnosis (adjusted odds ratio [AOR]: 0.66, 95% CI 0.50–0.88) and non-significant trends toward reduced ART use if diagnosed (AOR: 0.73, 95% CI 0.73–1.10) and reduced viral suppression (VS) if on ART (AOR: 0.91, 95% CI 0.57–1.44). Overall, UAU was linked to 25% lower odds of VS compared to abstinence. UAU in Zambia disproportionately affects certain groups including PLWH. Achieving and sustaining HIV epidemic control in Zambia will require evidence-based approaches to screen and treat UAU.

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Keywords

unhealthy alcohol use; HIV/AIDS; sub-Saharan Africa; HIV care continuum; alcohol use disorders identification test

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Introduction

Unhealthy alcohol use, a term that broadly comprises heavy and hazardous use (i.e., average drinking is more than recommended), heavy episodic drinking (i.e., binge), and alcohol use disorders (i.e., the medical diagnosis for severe chronic use despite past adverse consequences), is an emerging public health problem in sub-Saharan Africa (SSA) (UNODC, 2012). Alcohol is the most commonly consumed substance in SSA, and the prevalence of unhealthy use among people who drink in SSA is among the highest in the world (World Health Organization, 2014). The 2018 World Health Organization Global Status Report on Alcohol and Health found that the age-standardized alcohol-attributable burden of disease and injury was highest in the WHO Africa Region compared to all other regions globally. Unfortunately, treatment coverage in SSA is <10% for alcohol use problems (Lund et al., 2015; World Health Organization, 2018) and most countries lack national policies or regulations on alcohol marketing (World Health Organization, 2018).

In East and Southern Africa, where there is a high prevalence of HIV infection, alcohol and HIV commonly intersect. Unhealthy alcohol use is a major contributor to HIV transmission (Simbayi et al., 2004) and data from upper-income settings demonstrated that alcohol use can impede each step in the HIV care continuum - from diagnosis to initiation and sustained ART use ultimately resulting in viral suppression (Williams et al., 2016). In SSA where alcohol's impact on HIV outcomes is most significant, more data are needed as most previous studies either had small sample sizes, were carried out at specific clinical settings (i.e., not population representative) (O'Connell et al., 2013), and were among HIV-negative people at risk for HIV (Simbayi et al., 2004). In this paper, we used data from a nationally representative survey from Zambia, a country with 12% national adult HIV prevalence, to: 1) measure the prevalence of alcohol abstention, moderate alcohol use, and unhealthy use in the adult population; 2) identify correlates of moderate and unhealthy alcohol use, including HIV status; 3) in people with HIV, evaluate associations between moderate and unhealthy alcohol use and the HIV care continuum. We hypothesized that unhealthy but not moderate alcohol use, based on international definitions, among adults living with HIV would be associated with reduced diagnosis of HIV, lower ART use (reflecting reduced engagement in HIV care), and lower viral suppression (reflecting lower medication adherence and retention on ART).

Methods

Study design and participants:

We analyzed publicly-available data from the Zambia 2016 Population-based HIV Impact Assessment (ZAMPHIA 2016; https://phia.icap.columbia.edu), which was a nationally representative, cross-sectional survey of Zambian households conducted between March and August 2016. Data were downloaded with permission from the study team (Zambian Ministry of Health et al., 2016). Briefly, the survey utilized a two-stage cluster design, stratified by the 10 provinces of Zambia, in which 511 'enumeration areas' were selected using probability proportional to size. Within each enumeration area, households were selected with equal probability (average number of households per area was 27 with a range of 11–48). Within each selected household, adults (ages 15–59) were eligible if they slept in the household the night before the survey and were willing to provide informed consent. Following informed consent, participants were administered the survey. For the present analysis, we restricted to adults (15–59) in the *de facto* sample because this group was assessed for alcohol use. The original ZAMPHIA study was approved by Tropical Diseases Research Center Ethical Review Committee, the Columbia University IRB, the Zambia National Health Research Authority, and the Centers for Disease Control and Prevention.

Procedures:

Participants were administered the survey by an in-person interviewer using a mobile tablet. The survey consisted of sections covering: demographics, sexual and reproductive health, gender norms, HIV/AIDS knowledge and attitudes, HIV testing and treatment, other physical health conditions, and alcohol use. Alcohol use was evaluated with the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C) measure (Bradley et al., 2007). The three items assessed average frequency of use (0=never, 1=monthly or less, 2=2–4 times/month, 3=2–3 times/week, 4=4 or more times/week), quantity of use when drinking on a typical day (0=1 or 2 drinks, 1=3 or 4 drinks, 2=5 or 6 drinks, 3=7 to 9 drinks, 4=10 or more drinks) and average frequency of heavy episodic drinking, defined as having six or more drinks on one occasion (0=never, 1=less than monthly, 2=monthly, 3=weekly, 4=daily or almost daily). A total score was calculated by summing the three items with a possible range of 0–12.

Rapid HIV home-based testing was performed using finger prick sampling and PLWH were asked whether they were already aware of their HIV status, and if they reported prior diagnosis, whether they were currently taking ART. PLWH also received a rapid CD4 test (Pima, Alere). For those adults with HIV who consented for biomarker testing, a 14 ml blood sample was collected via venipuncture. Samples were used to assess HIV viral load (Abbott RealTime HIV-1 assay, Abbott Molecular, Germany) and the presence of ART, a marker of adherence. Of note, ART testing was limited to 3 common first- and second-line drugs (efavirenz, atazanavir, and lopinavir); hence it was anticipated that some reported use would not be confirmable. PLWH were referred to their local facility for follow-up of HIV viral load results.

Statistical Analysis:

We categorized participants as abstinent (i.e., total AUDIT-C score of 0), having moderate alcohol use (i.e., score of 1–2 among women and 1–3 among men), or having unhealthy alcohol use (i.e., score of ≥3 among women and ≥4 among men). HIV status was defined, based on test results, using the ZAMPHIA variable *hivstatusfinal*. HIV cascade indicators were defined as dichotomous variables. Among PLWH (based on HIV testing), prior diagnosis of HIV was 'yes' when self-reported by the participant or when ART was detected in the blood sample (i.e., the person reports being undiagnosed but is ingesting HIV medication). Current use of ART was also ‘yes’ when self-reported or when ART was detected in blood. VS was defined as <1,000 copies/ml, per Zambian guidelines.

Among the overall *de facto* sample, we estimated prevalence and corresponding 95% confidence intervals for alcohol use (abstention, moderate use, unhealthy use) disaggregated by key background characteristics including HIV status. We used multinomial logit regression (using the *mlogit* command in Stata) to identify correlates of moderate and unhealthy alcohol use (abstention as reference category; Model 1). Variables of interest in the model were HIV status and demographic characteristics. We present exponentiated coefficients from the model, which are interpreted as relative risk ratios (RRR).

We examined the association between alcohol use (abstention as the reference category) and the HIV cascade indicators using multiple logistic regression models (Models 2–4), adjusted for demographic characteristics. We also tested interactions of the alcohol variables with age and sex, respectively, in each model. Coefficients presented from these models are adjusted odds ratios (AOR). We analyzed the overall association of alcohol use with successful navigation of the care continuum resulting in VS among *all* PLWH. Interactions between alcohol with age and sex, important demographic factors that may alter the association of unhealthy alcohol use and HIV, were also tested in these models.

All analyses were performed in Stata 15 (StataCorp, College Station, TX, USA) using the *svyset:* and *svy:* commands for survey data. For all analyses, we adjusted for survey characteristics including sampling weights, clustering, and stratification. Jackknife repeated replication was used as a variance estimator in all analyses.

Results

Prevalence and correlates of alcohol use in Zambia:

The analysis sample included N=21,280 adolescents and adults who completed the survey (the *de facto* population), which includes N=19,115 (89.8%) who also provided blood samples for biomarker testing. Among the *de facto* population, 20,923 (98.3%) had complete AUDIT-C data. Table 1 displays respondent demographic characteristics and HIV status overall and by level of alcohol use. HIV prevalence was 12.8% (95% CI 12.4–13.3), 74.1% (95% CI 73.0–75.1) reported current abstinence, 10.6% (95% CI 10.0–11.3) had moderate alcohol use, and 15.3% (95% CI 14.6–16.1) had unhealthy use. Among those with any alcohol use, 59.1% reported unhealthy use (95% CI 47.3–60.9).

Among PLWH, 64.2% (95% CI 61.9–66.4) abstained from alcohol, 14.2% (95% CI 12.8–15.8) had moderate use, and 21.6% (95% CI 19.5–23.8) had unhealthy use. Comparatively, among participants without HIV, 75.4% abstained (95% CI 74.3–76.5), 10.1% (95% CI 9.5–10.8) had moderate use, and 14.5% (95% CI 13.8–15.2) had unhealthy use. Table 2 displays the results of the multinomial logit regression model exploring correlates of unhealthy alcohol use among adolescents and adults in Zambia. Those with HIV were about 50 percent more likely to have moderate (RRR=1.48, 95% CI 1.27–1.72) or unhealthy alcohol use (RRR=1.51; 95% CI 1.29–1.77) than abstain compared to those with negative HIV status.

Male sex, older age, living in an urban area, and being employed were all also associated with greater relative risk of moderate use vs. abstaining and with risk of unhealthy use vs. abstaining.

Association of alcohol use with 90-90-90 indicators among PLWH:

Among PLWH (N=18,796), 81.8% were diagnosed, including 66.3% who self-reported prior awareness of their status and 15.6% who reported being undiagnosed but had ART detected in their blood. Among those with prior diagnosis, 92.1% were on ART, including 85.0% who self-reported taking ART and 7.1% who did not report being on ART but had ART detected in their blood. Of note, ART was not detected in the blood samples from 4.8% of PLWH who self-reported its use. Finally, among those categorized as being on ART, 89.2% (95% CI 87.1–90.9) had HIV RNA <1,000 copies/ml. Overall viral suppression among PLWH in the survey was 60.8% (95% CI 58.8–62.8).

Table 3 and Figure 1 show the association of unhealthy and moderate alcohol use with HIV care cascade indicators. Among all with a confirmed HIV positive status, unhealthy alcohol use was significantly associated with lower odds of HIV diagnosis (AOR: 0.66, 95% CI 0.49–0.87). Among the subset of 81.8% with prior diagnosis, unhealthy use (compared to abstention) was associated with a non-significant trend towards lower odds of being on ART (AOR: 0.73, 95% CI 0.48–1.10). Among those on ART, there was a similar non-significant trend towards lower VS (AOR: 0.91, 95% CI 0.57–1.44) with unhealthy alcohol use versus abstinence. Overall, unhealthy alcohol use in a person with HIV at the population-level was associated with approximately 25% lower odds of viral suppression (AOR: 0.75, 95% CI 0.58–0.96) compared to no alcohol use. Compared to abstinence, moderate use was not associated with any of the care cascade indicators and effect modification analyses provided no evidence that the association between alcohol use and the care cascade varied by either age or sex.

Discussion

In a nationwide survey in Zambia, we documented a large burden of unhealthy alcohol use among adolescents and adults, and significant intersection of alcohol use and HIV infection. The study had three key findings. First, although a large majority (74%) of Zambians reported abstaining from alcohol use, over half of people who reported drinking had unhealthy alcohol use. Second, PLWH were 50% more likely to consume alcohol at both moderate and at unhealthy levels than those without HIV. Male sex, urban settings, and employment were also correlated with unhealthy use. Third, people with HIV and unhealthy alcohol use had lower odds of completed the HIV continuum of care leading to VS.

The first key finding, that prevalence of unhealthy alcohol use was high in the overall population in Zambia, adds to recent literature showing that the alcohol-attributable burden of disease throughout SSA, and particularly in the southern region of Africa (of which Zambia is included), is substantial (Ferreira-Borges et al., 2017; Ferreira-Borges et al., 2016). Unhealthy alcohol use is not only strongly linked to the HIV epidemic, but is also a leading risk factor for non-communicable diseases, injuries, and accidents, which are emerging threats. According to an analysis by Ferreira-Borges and colleagues (2016), the crude alcohol-attributable death rate per 100,000 among men in southern Africa was 106.3 and among women was 19.9 (Ferreira-Borges et al., 2016). Our findings may also be reflective of an ‘all or nothing’ alcohol consumption pattern, in which the majority of a population reports no drinking, but among those who do consume alcohol, the prevalence of heavy chronic or episodic use is high (Kane et al., 2018; World Health Organization, 2014).

Male sex, increasing age, urban residence, having employment, and having HIV infection were all associated with unhealthy alcohol use. Unhealthy drinking among men is well-documented globally and is more normative in Zambia. However, in Zambia, alcohol use by young women is becoming more widely accepted (Helova et al., 2019). Alcohol use was less common (~8%) among the 4,281 older adolescents (15–19 years old) who participated in the survey, compared to adults. Increased alcohol use in urban areas, as noted in our data, was similarly reported in other studies and is likely to due to better access to alcohol. Finally, employment – an economic factor – was linked to unhealthy alcohol use, which may be due to increased alcohol access made possible by higher income. This is also concordant with some data suggesting that improved economies in SSA are linked with increased alcohol use (World Health Organization, 2018).

Among PLWH, unhealthy drinking was associated with lower overall odds of HIV VS, the ultimate goal of HIV programs. When analyzing individual steps in the cascade, we found a larger negative impact of alcohol on HIV diagnosis and smaller impacts for use of ART once diagnosed and VS once on ART. This builds on other prior reports demonstrating the deleterious association between alcohol and HIV through both biological and behavioral mechanisms (Vagenas et al., 2015; Williams et al., 2016). Among diagnosed people and those on ART, we did not find statistically significant associations between unhealthy alcohol use and ART use and VS respectively. We believe these data should be interpreted cautiously, as the later steps in the care continuum (adherence, retention, and viral suppression) are more accurately assessed using longitudinal data (Sikazwe et al., 2019). Our results are supported by a qualitative study where people with diagnosed HIV in Zambia reported that alcohol use both impaired their medication adherence and contributed to them having unsafe sex (Rogers et al., 2019). Similar to our survey, a cross-sectional analysis of >100,000 individuals in Kenya and Uganda found strong negative impacts of unhealthy alcohol use on HIV diagnosis, use of ART, and viral suppression (Puryear et al., 2019). Collectively, these data suggest that lack of viral suppression in PLWH who drink alcohol may be primarily driven by low uptake of HIV testing; however, unhealthy alcohol use in some people likely undermines downstream ART outcomes. Our data and others also suggest the need to focus on men.

These data highlight the burden of alcohol use in Zambia and its negative impact on control of the HIV epidemic. Zambia has made significant progress towards its goals at the time - 90% diagnosis, 90% use of ART, and 90% VS; however, certain subpopulations have fallen behind in achieving these targets (Zambian Ministry of Health et al., 2016). Among these groups are young, urban males, a group that has among the highest rates of unhealthy alcohol use according to our findings. Therefore, HIV program activities should integrate evidence-based strategies to screen for and treat alcohol problems. For example, Common Elements Treatment Approach, an evidence-based and transdiagnostic cognitive behavioral therapy (Murray et al., 2020), was recently discussed for possible use within Zambian HIV programs funded by the Presidents Emergency Plan for AIDS Relief. National treatment guidelines should include both stronger emphasis on alcohol and provide tools for front-line health workers to care for the patients. These data also provide a baseline snapshot for the Ministry's first Alcohol Control Policy, launched in 2018 (Zambian Ministry of Health, 2018). We also found that moderate alcohol use did not significantly reduce HIV care cascade indicators compared to abstinence. This supports the notion that reduction from unhealthy to moderate use, rather to abstinence, may also have benefits to the individual and program at large.

Strengths of the analysis included nationally representative data with information on all three levels of the care cascade and the use of a widely accepted and used alcohol screening tool (AUDIT-C), which allows the results to be comparable across studies. We innovatively incorporated the detection of ARVs in participant blood samples to more accurately estimate HIV diagnosis and current ART use, which can be subjective. There were important limitations to consider as well. Our main limitations were due to the cross-sectional nature of the study, which precludes the ability to evaluate directionality or a causal relationship between alcohol, HIV, and HIV care outcomes. As mentioned, use of ART and VS depend on longitudinal behaviors that are better characterized with longitudinal data. There is also growing recognition that patterns of alcohol use, rather than single assessments of use (i.e., a single AUDIT-C measure) is a better way to understand effects on HIV treatment outcomes. Another limitation that we acknowledge was that alcohol data were collected via participant self-report during face-to-face interviews, leaving them prone to reporting biases, which in the context of HIV infection, may be common (Bajunirwe et al., 2014; Eyawo et al., 2018; Hahn et al., 2012; Vinikoor et al., 2018). Is likely that the true prevalence of alcohol use was underestimated in this study. This bias may have been differential—that is, PLWH may have been more likely to underreport alcohol use than those without HIV due to stronger social desirability bias. In future investigations, alcohol biomarkers could be used to augment self-report (Williams et al., 2016).

In summary, alcohol use is common in Zambia and most drinking is of an unhealthy nature. Among adults, men, urban residents, employed individuals, and those living with HIV are most likely to have unhealthy alcohol use. Among PLWH, unhealthy alcohol use was associated with lower rates of HIV VS. To achieve the 'last mile' in HIV epidemic control in Zambia, and settings with similar overlap between HIV and alcohol, standardized approaches to measure and intervene on unhealthy and harmful alcohol use are needed.

Data availability statement:

The data used for this manuscript are publically-available and can be requested via the following link: https://phia.icap.columbia.edu/countries/zambia/

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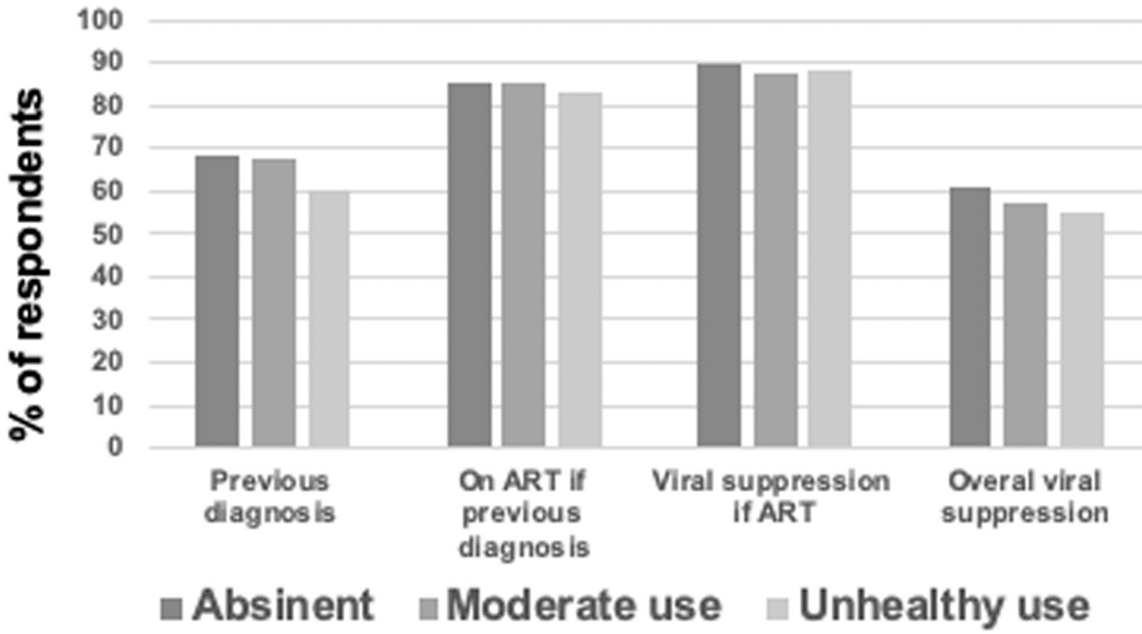

Figure 1.
HIV care cascade outcomes, by level of alcohol use

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Table 1.

Characteristics of 20,923 respondents in a population-based survey in Zambia, by level of alcohol use

	Overall (20,923)	Abstinence (n=15,504)	Moderate use (n=2,218)	Unhealthy use (n=3,201)
Sex				
Female	11868 (56.7)	85.8 (84.8, 86.8)	7.6 (7.0, 8.2)	6.6 (6.0, 7.3)
Male	9055 (43.3)	61.9 (60.4, 63.4)	13.7 (12.7, 14.8)	24.3 (23.2, 25.5)
Age, years				
15–19	4281 (20.5)	92.3 (91.1, 93.3)	4.5 (3.8, 5.3)	3.2 (2.6, 4.0)
20–24	3671 (17.6)	75.7 (73.6, 77.6)	11.1 (9.8, 12.6)	13.2 (11.8, 14.8)
25–29	2961 (14.2)	69.1 (66.9, 71.1)	12.3 (11.0, 13.8)	18.6 (16.8, 20.6)
30–34	2733 (13.1)	68.7 (66.5, 70.8)	10.6 (9.2, 12.2)	20.7 (18.9, 22.6)
35–39	2214 (10.6)	65.1 (63.0, 67.2)	12.7 (11.2, 14.3)	22.2 (20.3, 24.2)
40–44	1887 (9.0)	64.7 (61.9, 67.5)	13.8 (11.7, 16.1)	21.5 (19.2, 24.0)
45–49	1287 (6.2)	64.9 (62.2, 67.7)	14.7 (12.7, 16.9)	20.4 (17.8, 23.3)
50–54	1106 (5.3)	63.8 (60.5, 67.1)	13.8 (11.6, 16.3)	22.4 (19.5, 25.6)
55–59	783 (3.7)	65.4 (61.4, 69.3)	15.2 (12.3, 18.6)	19.4 (16.6, 22.6)
Residence				
Urban	9104 (43.5)	70.1 (68.4, 71.7)	10.8 (9.9, 11.7)	19.1 (17.8, 20.4)
Rural	11819 (56.5)	77.4 (76.0, 78.7)	10.4 (9.5, 11.4)	12.2 (11.3, 13.1)
Province				
Central	1752 (8.4)	71.5 (68.4, 74.5)	10.5 (8.6, 12.7)	17.9 (15.9, 20.2)
Copperbelt	3579 (17.1)	68.2 (65.5, 70.7)	11.4 (10.0, 12.9)	20.5 (18.6, 22.5)
Eastern	1981 (9.5)	82.4 (5.4, 8.8)	6.9 (5.4, 8.8)	10.7 (9.2, 12.4)
Luapula	1108 (5.3)	78.5 (74.6, 82.0)	10.7 (8.7, 13.2)	10.8 (8.3, 13.9)
Lusaka	3567 (17.0)	69.0 (66.3, 71.7)	10.6 (9.2, 12.2)	20.3 (18.2, 22.6)
Muchinga	1883 (9.0)	68.9 (65.9, 71.7)	12.9 (11.4, 14.5)	18.2 (15.9, 20.8)
Northern	1704 (8.1)	71.4 (68.4, 74.2)	14.5 (11.9, 17.5)	14.1 (12.1, 16.4)
North-Western	1951 (9.3)	79.2 (76.6, 81.6)	9.2 (7.7, 11.1)	11.6 (9.6, 13.9)
Southern	2365 (11.3)	82.8 (80.2, 85.2)	7.6 (6.5, 9.0)	9.6, (7.9, 11.5)
Western	1033 (4.9)	77.6 (72.1, 82.3)	15.5 (11.6, 20.3)	6.9 (5.1, 9.3)
Employed				
Yes	6781 (32.4)	62.6 (60.9, 64.2)	9.2 (8.6, 9.9)	24.1 (22.6, 25.6)
No	14130 (67.6)	79.9 (78.9, 80.9)	10.9 (10.2, 11.6)	10.9 (10.2, 11.6)
Education				
No education	1109 (5.3)	75.9 (71.8, 79.5)	11.0 (8.6, 14.0)	13.2 (10.7, 16.1)
Primary	9069 (43.4)	76.0 (74.6, 77.3)	10.3 (9.5, 11.3)	13.7 (12.7, 14.7)
Secondary	9055 (43.3)	74.3 (73.1, 75.5)	10.3 (9.6, 11.1)	15.4 (14.5, 16.3)
Above secondary	1679 (8.0)	62.2 (58.8, 65.4)	13.3 (11.5, 15.2)	24.6 (21.9, 27.5)
HIV status				
Positive	2413 (12.8)	64.2 (61.9, 66.4)	14.2 (12.8, 15.8)	21.6 (19.5, 23.8)
Negative	16383 (87.2)	75.4 (74.3, 76.5)	10.1 (9.5, 10.8)	14.5 (13.8, 15.2)

All values are N, row % (95% CI)

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Table 2.

Correlates of moderate and unhealthy alcohol use in Zambia

	Moderate use vs. Abstinence		Unhealthy use vs. Abstinence	
	RRR (95% CI)	***p***	**RRR (95% CI)**	***p***
Sex				
Female	REF	REF	REF	REF
Male	2.54 (2.22, 2.90)	<.0001	5.09 (4.54, 5.71)	<.0001
Age *	1.17 (1.14, 1.20)	<.0001	1.23 (1.20, 1.26)	<.0001
Type of residence				
Rural	REF	REF	REF	REF
Urban	1.16 (1.0, 1.35)	.05	1.78 (1.54, 2.07)	<.0001
Employed				
No	REF	REF	REF	REF
Yes	1.35 (1.20, 1.52)	<.0001	1.65 (1.48, 1.85)	<.0001
Education *	1.01 (0.93, 1.11)	.75	0.99 (0.91, 1.08)	.88
HIV status				
Negative	REF	REF	REF	REF
Positive	1.48 (1.27, 1.72)	<.0001	1.51 (1.29, 1.77)	<.0001

Model included all participants with complete alcohol and HIV status data and who were not missing data on any of the included demographic characteristics

* Included as ordinal variables based on categories displayed in Table 1.

Employment was over the past 12 months.

Abbreviations: RRR, Relative risk ratio, which is the exponentiated coefficient from the multinomial logit model; CI, confidence interval; REF, reference category

Table 3.

Association of moderate and unhealthy alcohol use with the HIV care continuum in Zambia

	Previously diagnosed with HIV infection		On ART if previously diagnosed		Viral suppression if on ART		Overall viral suppression	
	AOR (95% CI)	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**
Step 1: Main effects								
Alcohol use								
Abstain	REF	REF	REF	REF	REF	REF	REF	REF
Moderate	0.85 (0.64, 1.14)	0.27	0.92 (0.56, 1.49)	0.71	0.77 (0.47, 1.28)	0.31	0.81 (0.61, 1.08)	0.15
Unhealthy	0.66 (0.49, 0.87)	<.01	0.73 (0.48, 1.10)	0.13	0.91 (0.57, 1.44)	0.67	0.75 (0.58, 0.96)	0.03
Sex								
Female	REF	REF	REF	REF	REF	REF	REF	REF
Male	0.75 (0.59, 0.95)	0.02	1.03 (0.71, 1.52)	0.86	0.65 (0.44, 0.96)	0.03	0.75 (0.60, 0.96)	0.02
Age *	1.36 (1.28, 1.44)	<.0001	1.26 (1.16, 1.37)	<.0001	1.30 (1.17, 1.43)	<.0001	1.35 (1.28, 1.42)	<0.001
Type of residence								
Rural	REF01394)875al reliability (α=.89and “ll 20, or do we need to further explore dropping items?elations were weak. 2 were moderatel	REF	REF	REF	REF	REF	REF	REF
Urban	1.66 (1.30, 2.11)	<.0001	1.27 (0.88, 1.83)	0.19	0.97 (0.66, 1.42)	0.87	1.36 (1.08, 1.71)	0.01
Employed								
No	REF	REF	REF	REF	REF	REF	REF	REF
Yes	0.90 (0.73, 1.11)	0.32	0.76 (0.54, 1.07)	0.11	0.79 (0.53, 1.17)	0.23	0.82 (0.66, 1.01)	0.06
Education *	1.14 (0.99, 1.32)	0.08	1.24 (0.99, 1.56)	0.06	1.18 (0.88, 1.56)	0.26	1.22 (1.07, 1.40)	<0.01
Step 2: Main effects (not shown) plus interaction terms								
Alcohol use X Sex								
Abstain/Female	REF	REF	REF	REF	REF	REF	REF	REF
Moderate/Male	0.61 (0.33, 1.13)	0.11	1.24 (0.44, 3.54)	0.67	0.76 (0.26, 2.25)	0.61	0.68 (0.39, 1.20)	0.18
Unhealthy/Male	0.61 (0.34, 1.09)	0.09	1.61 (0.62, 4.18)	0.31	0.89 (0.70, 1.14)	0.55	0.78 (0.44, 1.38)	0.38
Alcohol use X Age *								
Abstain	REF	REF	REF	REF	REF	REF	REF	REF

	Previously diagnosed with HIV infection		On ART if previously diagnosed		Viral suppression if on ART		Overall viral suppression	
	AOR (95% CI)	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**
Moderate	0.98 (0.81, 1.19)	0.85	1.11 (0.86, 1.42)	0.40	1.18 (0.94, 1.48)	0.34	1.00 (0.85, 1.18)	0.98
Unhealthy	0.99 (0.86, 1.14)	0.88	1.18 (0.94, 1.48)	0.15	1.19 (0.84, 1.67)	0.32	1.07 (0.93, 1.23)	0.33

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; ART, antiretroviral therapy; REF, reference group

Prior diagnosis was yes if self-reported or ART medicines detected in blood.

On ART was yes if ART medicines detected in blood.

Viral suppression was defined as HIV RNA <1,000 copies/ml.

Overall viral suppression included all patients with HIV RNA results.

*Included as ordinal variables based on categories displayed in Table 1.

Employment was over the past 12 months.