HHS Public Access

Author manuscript

AIDS Care. Author manuscript; available in PMC 2025 October 01.

Published in final edited form as:

AIDS Care. 2024 October ; 36(10): 1508–1517. doi:10.1080/09540121.2024.2343587.

Heavy alcohol use and the HIV care continuum in Kenya: a population-based study

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Abstract

Heavy alcohol use (HAU) can destabilize engagement along the HIV care continuum, but population-based studies measuring the potential effects of HAU on HIV treatment outcomes are lacking, especially in sub-Saharan Africa. We leveraged data from the 2018-19 Kenya Population-based HIV Impact Assessment, a nationally representative household survey, to identify associations of self-reported HAU, assessed using two items measuring the frequency and quantity of past-year alcohol consumption, with serum biomarkers for HIV serostatus unawareness, antiretroviral therapy (ART) non-use, and HIV viremia (≥1,000 RNA copies/mL). Overall and sex-stratified survey-weighted logistic regression with jackknife variance estimation modeled adjusted odds ratios (adjOR) of HIV treatment indicators by HAU. Overall, 1,491 persons living with HIV aged 15-64 years (68.4% female) were included in the present analysis. The prevalence of HAU was 8.9% (95% confidence interval [95%CI]: 6.8-11.0%) and was significantly more pronounced in males than females (19.6% vs. 4.0%, $p<0.001$). In multivariable analysis, HAU was significantly ($p<0.001$) associated with HIV serostatus unawareness (adjOR=3.65, 95%CI: 2.14-6.23), ART non-use (adjOR=3.81, 95%CI: 2.25-6.43), and HIV viremia (adjOR=3.13, 95%CI: 1.85-5.32). Incorporating sex-specific alcohol use screening into HIV testing and treatment services in populations where HAU is prevalent could optimize clinical outcomes along the HIV care continuum.

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Author Contributions

JGR conceptualized the analysis. EW managed and analyzed data, with oversight and supervision from JGR. EW prepared the first draft of the manuscript, with input from JGR. All authors contributed to and approved the final version of the manuscript submitted for publication.

Disclaimer

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Declaration of Interests

The authors report there are no competing interests to declare.

Keywords

HIV treatment; binge drinking; antiretroviral therapy; people living with HIV; Population-based HIV Impact Assessment; sub-Saharan Africa

Introduction

Despite substantial progress towards HIV epidemic control over the last decade, challenges along the HIV care continuum persist. Approximately 14% of the 39 million persons living with HIV worldwide are unaware of their status, 24% are not accessing life-saving antiretroviral therapy (ART), and 29% are not virally suppressed and, thus, experience heightened risk of clinical complications and onward HIV transmission (Joint United Nations Programme on HIV/AIDS, 2023). Even for individuals who achieve and sustain viral load suppression (VLS), people living with HIV experience excess morbidity and mortality from non-communicable diseases (e.g., hypertension, liver disease, neurocognitive dysfunctions) and mental health challenges (e.g., depression, suicidality)—all of which affect quality of life (Croxford et al., 2017; Fontela et al., 2020; Davis et al., 2021). Identifying and addressing socio-structural drivers of disengagement at various stages of the HIV clinical cascade, as well as antecedents of suboptimal quality of life among people living with HIV, remain areas of critical public health importance.

Heavy alcohol use (HAU), or excessive alcohol consumption potentially indicative of an alcohol use disorder, is an increasingly recognized driver of suboptimal HIV treatment outcomes and excess morbidity/mortality among people living with HIV globally. A recently published meta-analysis of 21 studies, representing 3,450 adults on ART, reported that alcohol/substance misuse was endorsed as a barrier to treatment adherence by 13% of participants (Shubber et al., 2016). Studies have linked ART non-adherence to HAU, as persons living with HIV may be unable to appropriately time medication dosing or refills while heavily intoxicated or may skip ART doses due to intolerable alcohol-treatment interactions, both perceived and actual (Nkosi et al., 2016; Fatch et al., 2017; Bukenya et al., 2019; Lesko et al., 2023). In addition to ART adherence challenges among persons linked to HIV care, HAU is also associated deferred HIV testing and delayed linkage to HIV treatment services among persons newly diagnosed with HIV (Fatch et al., 2013; Kiene et al., 2019). Thus, HAU has potential to destabilize engagement across the HIV care continuum, from timely HIV diagnosis to achieving and maintaining VLS.

Moreover, the relative absence of screening for alcohol use disorders in African HIV testing and treatment programs further complicates efforts to identify and appropriately triage persons at elevated risk of HIV service disengagement and other clinical complications attributed to excess alcohol consumption. Limited HAU screening in sub-Saharan Africa is attributed, at least in part, to a dearth of evidenced-based, accessible alcohol use disorder counseling and treatment services in outpatient settings (Parcesepe et al., 2018, 2020). While emerging evidence affirms the effectiveness of psychosocial, non-pharmacological interventions on reducing alcohol consumption among people living with HIV in sub-Saharan Africa (Sileo et al., 2020, 2021), the resources required (i.e., personnel, time)

to implement these interventions with fidelity in outpatient HIV clinics may overwhelm health systems. Alcohol use disorder screening and referral have, thus, been historically absent from national HIV care and treatment guidelines throughout sub-Saharan Africa (Ferreira-Borges et al., 2017).

Despite a burgeoning evidence base documenting HAU's deleterious impacts on HIV self-management and clinical service engagement, evidence of HAU's effects on population-level HIV treatment outcomes, especially in generalized HIV epidemic settings, remains scarce. In response, we leveraged data from a large, population-based study in Kenya to quantify burdens of HAU and associations with HIV treatment outcomes among people living with HIV. A recently published multi-country, population-based study in six East and Southern African countries found that HAU was significantly associated with unawareness of HIV status and ART non-use, but not HIV viremia, among men and women living with HIV (Chang et al., 2022). Similar relationships were observed in a population-based study in Kenya and Uganda, where alcohol use was associated with elevated risks of HIV status unawareness and ART non-use, but no significant differences in VLS were observed when analyses were restricted to persons on ART (Puryear et al., 2020; Miller, Pitpitan, et al., 2021). Because alcohol use patterns are shaped by social norms and contextually specific policies and practices related to alcohol production and consumption (Ferreira-Borges et al., 2017), country-level analyses of HAU and its effect on HIV clinical outcomes are warranted.

Materials and Methods

Study Context and Procedures

Data are derived from the Kenya Population-based HIV Impact Assessment (KENPHIA), a nationally representative, population-based HIV sero-epidemiologic study implemented from June 2018 to February 2019 (National AIDS and STI Control Programme, 2022). Briefly, KENPHIA employed a two-stage, stratified cluster sampling design, whereby 800 enumeration areas across 47 counties were selected using probability-proportional-to-population-size. Within each enumeration area, 25 households were identified via systematic random sampling. Adults aged 18-64 years and minors aged 15-17 years who slept in occupied households the prior evening and provided written informed consent or assent with parental permission (for unemancipated minors) were enrolled. The study protocol was reviewed and approved by institutional review boards of the Kenya Medical Research Institute, Columbia University, and the U.S. Centers for Disease Control and Prevention.

Interviewer-administered questionnaires in English and/or combination of local languages assessed household characteristics, demographic factors, sexual behaviors, healthcare-seeking experiences, and uptake HIV prevention and care services. Home-based HIV testing and counseling were offered to all participants, with venous blood samples and dried blood spots (DBS) collected from persons living with HIV, ascertained via rapid HIV testing algorithm involving two distinct testing platforms. Individuals with reactive results to the Alere Determine™ HIV-1/2 RT and then the First Response® HIV 1-2.0 Card Test (PMC Medical, Gujarat, India) were deemed to be living with HIV. Qualitative screening for detectable concentrations of select antiretroviral drugs was conducted on DBS specimens using high-resolution liquid chromatography with tandem mass spectrometry

(Koal et al., 2005). Plasma viral loads were quantified using the COBAS AmpliPrep/ Taqman 96 assay on the COBAS AmpliPrep/COBAS TaqMan (CAP/CTM) HIV-1, v2.0 Test (Roche Molecular Diagnostics, Branchburg, NJ, USA) or, when plasma was unavailable, the COBAS AmpliPrep/COBAS TaqMan (CAP/CTM) Free Virus Elution (FVE) Protocol (Roche Molecular Diagnostics, Branchburg, NJ, USA) on DBS.

Measures

The primary independent variable of interest was HAU, assessed using the first two items ("How often do you have a drink containing alcohol?", "How many drinks containing alcohol do you have on a typical day?") of the Alcohol Use Disorder Identification Test-Concise (AUDIT-C), a widely implemented, validated measure of alcohol consumption patterns for identifying heavy or binge drinking behaviors consistent with alcohol use disorder symptomology (Bush et al., 1998). HAU was ascertained from tabulated item scores using cutpoints of ≥4 for males and ≥3 for females (Bradley et al., 2007). Because only the first two items from the AUDIT-C were captured in KENPHIA, the sex-specific cutpoints used to measure HAU represent heavier alcohol use patterns among persons who may screen positively for hazardous alcohol use from the three-item AUDIT-C (Rosen et al., 2023). Participants reporting less-heavy alcohol use (item scores <4 for males and <3 for females) and no alcohol consumption, respectively, in the past year served as reference groups in analysis.

Table 1 defines the primary outcomes of indicators, specifically indicators of disengagement along the HIV care continuum among persons with serologically confirmed HIV infection. Unawareness of HIV status was ascertained through self-report of HIV-negative or unknown serostatus without detected ART in DBS. ART non-use was determined through the absence of select antiretroviral drugs in DBS, irrespective of self-reported ART use—overall and restricted to persons aware of their HIV serostatus. ART non-adherence was defined as missing ≥2 doses of antiretroviral medication in the past 30 days—equivalent to <95% ART adherence—among persons with detectable ART in DBS. Lastly, HIV viremia was assessed from plasma or DBS viral loads using a cutpoint of ≥1,000 RNA copies/mL, per World Health Organization guidelines (World Health Organization, 2021).

Other measures included socio-demographics like age (in discrete years and 10-year groups), sex, marital status, education, religion, and residence type. Household wealth was ascertained from a composite measure of enumerated household possessions, subsequently collapsed into quintiles using principal components analysis (Filmer & Scott, 2011).

Statistical Analysis

Data were managed and analyzed in Stata/IC 17.0 (StataCorp LLC, College Station, TX). Descriptive statistics of sample socio-demographics and HIV care continuum indicators were calculated and compared by HAU symptomology using design-adjusted F-statistics. Survey-weighted binomial logistic regression with jackknife variance estimation—overall and stratified by sex—modeled associations of HAU with HIV treatment outcomes, specifically HIV status unawareness, ART non-use, ART non-adherence, and HIV viremia. Statistical models were fit for all persons living with HIV (unconditional) and separately

restricted to persons aware of their HIV status, on ART, and reporting high (≥95%) ART adherence, respectively (conditional). Multivariable models controlled for theorized confounders (e.g., age, education, religion, residence) of the relationship between alcohol use and HIV treatment outcomes, with logistic estimates reported as adjusted odds ratios (adjOR) with 95% confidence intervals (95%CI). Given the paucity of missing records, data missingness was addressed using complete case analysis.

Results

A total of 33,267 individuals aged 15-64 years from 16,918 households participated in KENPHIA. HIV prevalence was 4.9% (95%CI: 4.5-5.3%) overall but was substantially outsized in females (6.6%, 95%CI: 6.0-7.1%) relative to males (3.1%, 95%CI: 2.8-3.5%). Table 2 presents descriptive survey-weighted characteristics among the 1,523 persons living with HIV included in the final analytic sample. The mean age was 38.4 years (95%CI: 37.6-39.1 years). Most participants were female (68.5%), were married or in a cohabiting partnership (55.8%), reported incomplete primary education (59.4%), identified as Christian or Catholic (93.3%), and resided in rural areas (63.9%).

The distribution of past-year alcohol use in the population was as follows: HAU, 8.9% (95%CI: 6.8-11.0%); less heavy alcohol use, 12.6% (95%CI: 10.2-15.0%); no alcohol use, 78.5% (95%CI: 75.6-81.4%). Figure 1 illustrates sex-stratified prevalence estimates for past-year alcohol consumption, with HAU (19.6% vs. 4.0%, $p<0.001$) and less-heavy alcohol use (23.6% vs. 7.6%, $p<0.001$) observed with significantly greater frequency among males relative to females. Table 2 presents the fraction of participants HAU by other socio-demographic factors. HAU was significantly more pronounced among persons reporting incomplete primary than no formal education (11.4% vs. 2.7%, $p=0.001$) and participants identifying with another or no religion than as Catholic/Christian or Muslim (22.8% vs. 8.4% vs. 3.0%, $p=0.005$). HAU prevalence was comparable by age group, marital status, household wealth, and residence.

Table 3 reports overall and sex-stratified multivariable logistic estimates of HIV care continuum indicators by HAU. Relative to persons reporting less-heavy or no alcohol use in the past year, persons reporting HAU exhibited significantly greater adjusted odds of HIV status unawareness (adjOR=3.65, 95%CI: 2.14-6.23, $p<0.001$), ART non-use (adjOR=3.81, 95%CI: 2.25-6.43, $p<0.001$), and HIV viremia (adjOR=3.13, 95%CI: 1.85-5.32, $p<0.001$) in multivariable analysis. When restricted to persons aware of their HIV status, the adjusted odds of ART non-use were significantly elevated among persons reporting HAU relative to persons with less-heavy or no past-year alcohol use (adjOR=3.23, 95%CI: 1.30-8.09, $p=0.014$). The adjusted odds of ART non-adherence and HIV viremia, by comparison, did not differ significantly by HAU among persons with detectable ART in DBS. Sex-stratified logistic estimates for unconditional and conditional HIV care continuum indicators by HAU were largely consistent with estimates obtained from the overall multivariable models but were notably more pronounced among males than females.

Table 4 displays overall and sex-stratified logistic estimates for unconditional logistic estimates of HIV care continuum by HAU and less-heavy alcohol use, relative to no

past-year alcohol consumption. In the overall multivariable models, effect sizes for HAU outsized effect sizes for less-heavy alcohol use across unconditional HIV care continuum indicators, although both HAU and less-heavy alcohol use were significantly associated with HIV serostatus unawareness, ART non-use, and HIV viremia. In sex-stratified models, however, the observed significant associations of less-heavy alcohol use with unconditional HIV care continuum indicators were attenuated for males but not females, suggesting any alcohol use, irrespective of quantity or frequency, was associated with adverse outcomes along the HIV clinical cascade for females.

Discussion

Findings highlight ongoing challenges to meeting ambitious HIV treatment targets in the context of HAU in Kenya. Nearly one in 10 adults living with HIV in Kenya reported HAU, which exceeds estimates of HAU prevalence reported from other sub-Saharan African countries with generalized HIV epidemics (Farley et al., 2010; Necho et al., 2020). HAU was also associated with suboptimal outcomes along the HIV care continuum, with persons reporting HAU exhibiting significantly elevated odds of HIV serostatus unawareness, ART non-use, and HIV viremia relative to persons reporting less-hazardous or no alcohol use. Furthermore, less-heavy alcohol use was also significantly associated with suboptimal outcomes along the HIV care continuum for females only, indicative of a differential effect of the quantity and frequency of alcohol use by sex. Taken together, these findings reaffirm that HAU may not only interfere with HIV self-management practices like ART use, but also prompt disengagement with HIV services at various stages of the care cascade.

Suboptimal outcomes along the HIV care continuum appeared to be driven most prominently by the effect of HAU on HIV serostatus awareness. Among participants reporting HAU, nearly half (~47%) were unaware of their HIV status, compared to fewer than one-fifth (~18%) of persons reporting less-heavy or no alcohol use in the past year. When looking exclusively at persons enrolled in HIV care and on ART, however, rates of VLS were comparable between persons reporting and not reporting HAU, consistent with evidence from other population-based studies in sub-Saharan Africa (Chang et al., 2022; Miller, Pitpitan, et al., 2021; Puryear et al., 2020). Findings suggest that HIV testing uptake is insufficient among persons exhibiting HAU or, alternatively, that some individuals may use alcohol to cope with the traumas surrounding an HIV diagnosis (e.g., disclosure concerns, anticipated stigma/discrimination), which can reinforce HIV serostatus-denial (Hershow et al., 2018; Lyimo et al., 2014). Continued expansion and scale-up of venue-based HIV testing initiatives in Kenya (e.g., provider-initiated testing or distribution of HIV self-testing kits at bars or nightclubs) (Virkud et al., 2020; Wilson et al., 2022), complemented by enhanced linkage-to-care efforts, with the aid of adequate psychosocial and mental health services, could address gaps in the HIV care continuum attributed to HAU.

A disproportionately larger fraction of Kenyan adults living with HIV reporting HAU were males (~20%), demonstrating how HAU may contribute, at least in part, to sex-based disparities in HIV clinical outcomes (Beckham et al., 2016; Bor et al., 2015). Moreover, any alcohol use, irrespective of quantity and frequency, significantly elevated the odds of

suboptimal clinical outcomes along the HIV clinical cascade for Kenyan females. In the context of HIV diagnosis and self-management, the literature has attributed excess alcohol consumption in males to perceived isolation and limited social support from male-dominated social networks (Austin-Keiller et al., 2023; Miller, Ddaaki, et al., 2021). Compared to females, males living with HIV may also belong to social and occupational networks where alcohol consumption, particularly heavy alcohol use, is tolerated and normalized (Breuer et al., 2019; Nkosi et al., 2016; Sileo et al., 2016). Study findings suggest that in order to optimize HIV treatment outcomes, interventions seeking to mitigate the adverse consequences of alcohol use among people living with HIV should be sex-specific. Specifically, beyond incorporating sex-specific cutpoints for HAU, alcohol use screening tools integrated into Kenyan clinic-based and out-of-facility HIV testing and treatment programs may benefit from differentiating instruments to males and females; for instance, simplified instruments capturing any past-year alcohol use may be appropriate, feasible substitutes for more extensive alcohol use disorder screening instruments (i.e., AUDIT-C) for females reached by Kenyan HIV testing and treatment services.

This study joins a limited, albeit burgeoning, body of literature characterizing the relationship between HAU and HIV clinical outcomes at population level. Nevertheless, findings are subject to several limitations. First, HAU was measured using only the first two items of the AUDIT-C. The resultant measure, thus, likely only captured individuals with the heaviest or most hazardous alcohol consumption patterns, likely yielding an underestimate of excess alcohol consumption prevalence in the population. This underestimate is further exacerbated by the limited rapport established between survey enumerators and participants, likely inducing response biases. Second, although widely deployed in the substance use literature, the past-year alcohol consumption measures used in KENPHIA rely on individual self-report and are, thus, subject to acquiescence and recall biases. Third, multivariable models adjusted for socio-demographic factors with potential to confound the observed association of HAU with HIV treatment outcomes, but findings may still be susceptible to residual confounding, specifically from unmeasured covariates (e.g., prior HIV testing history, duration of HIV infection or ART use). Fourth, analyses were conducted cross-sectionally, limiting capacity to establish temporality in the observed exposure-outcome relationships or assess the relationship between sustained HAU and HIV treatment outcomes over time. Lastly, findings are derived from a nationally representative survey in Kenya and may, therefore, not be transferrable to other generalized HIV epidemic contexts in sub-Saharan Africa.

In conclusion, we found that burden of past-year HAU was pronounced among adults, particularly males, living with HIV in Kenya and was associated with suboptimal outcomes along the HIV care continuum, including HIV status unawareness, ART non-use, and HIV viremia. Less-heavy past-year alcohol use was also significantly associated with HIV serostatus unawareness, ART non-use, and HIV viremia among females but not males. Integration of evidenced-based alcohol use screening, treatment, and referral services—like Screening, Brief Intervention, and Referral to Treatment (Babor et al., 2007)—into HIV testing and treatment programs in Kenya can better meet the health-related and social needs of people living with HIV reporting excess alcohol consumption. Additionally, psychosocial interventions delivered by lay providers can also be effective in addressing syndemic drivers

of disengagement from HIV services, including HAU (Murray et al., 2014; Nadkarni et al., 2017).

The advent of long-acting injectable ART formulations, specifically cabotegravir-rilpiverine, holds great promise in optimizing HIV treatment outcomes for people reporting HAU, for whom daily adherence to oral antiretroviral drugs and/or sustained engagement with HIV services (i.e., frequent clinical visits or refill appointments) remains infeasible. Expanding access to long-acting injectable antiretrovirals for persons without sustained VLS, which is restricted under current treatment guidelines (Kilcrease et al., 2022; Christopoulos et al., 2023), may circumvent suboptimal outcomes along the HIV care continuum attributed to HAU.

Acknowledgements

We thank all KENPHIA participants for sharing their time and their bodies in advancement of HIV science. We extend our gratitude to the survey enumerators and study managers, without whom this study would not be possible. Finally, we acknowledge all the organizations who supported the implementation of KENPHIA, specifically the Kenya Council of Governors, the Association of People Living with HIV/AIDS in Kenya, Westat, the U.S. Centers for Disease Control and Prevention, ICAP at Columbia University, and the Kenya Ministries of Health, Devolution and Planning, and Interior and Coordination of National Government.

Funding

This work was supported by U.S. Centers for Disease Control and Prevention (CDC), via the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), under cooperative agreements U2GGH001271 and U2GGH001226. JGR was supported by the National Institute of Mental Health (F31MH126796).

Data Availability

The data are available for public use and can be requested from: https://phia-data.icap.columbia.edu/datasets

List of abbreviations

ART	Antiretroviral therapy
AUDIT-C	Alcohol Use Disorder Identification Test-Concise
DBS	Dried blood spots
HAU	Heavy alcohol use
KENPHIA	Kenya Population-based HIV Impact Assessment
VLS	Viral load suppression

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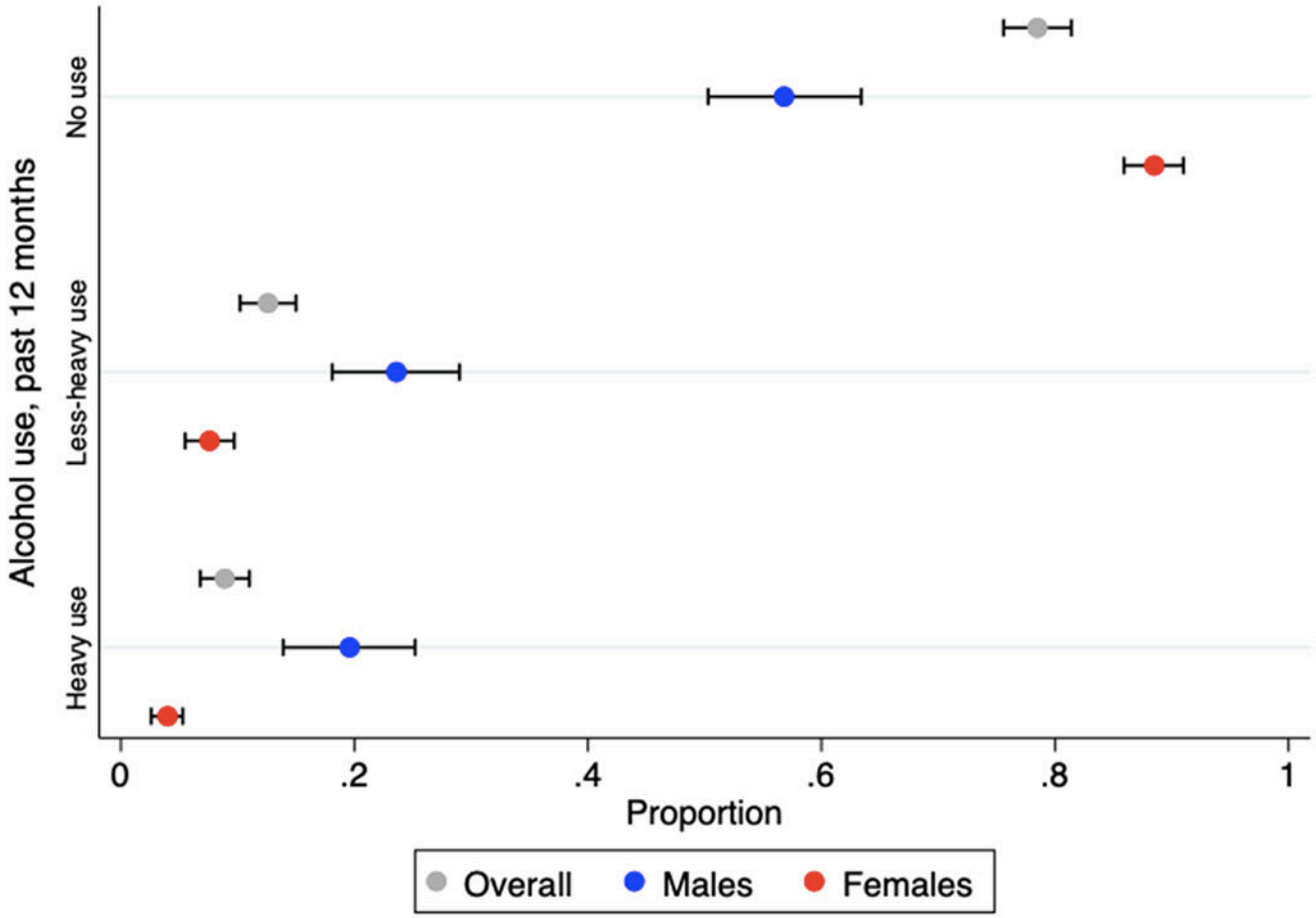

Figure 1.
Prevalence estimates for past-year alcohol use among people living with HIV, by sex.

Table 1.

Definitions for unconditional and conditional HIV care continuum indicators among persons living with HIV (serologically confirmed).

Indicator	Definition
Unconditional	
HIV status unawareness	Proportion of persons self-reporting HIV-negative or unknown status with no detectable ART in DBS.
ART non-use	Proportion of persons without detectable ART in DBS.
HIV viremia	Proportion of persons who have unsuppressed viral loads (≥1,000 RNA copies/mL) in plasma or DBS.
Conditional	
ART non-use	Proportion of persons aware of their HIV status with no detectable antiretroviral drugs in DBS.
ART non-adherence	Proportion of persons with detectable ART in DBS self-reporting ≥2 missed medication doses in the past 30 days (i.e., <95% adherence).
HIV viremia	Proportion of persons self-reporting high (≥95%) ART adherence with unsuppressed viral loads in plasma or DBS.

Notes:

ART = antiretroviral therapy, DBS = dried blood spots.

HIV serostatus was assessed using the Alere Determine™ HIV-1/2 RT and, if reactive, the First Response® HIV 1-2.0 Card Test (PMC Medical, Gujarat, India). Qualitative screening for detectable concentrations of select antiretroviral drugs was conducted on DBS specimens using high-resolution liquid chromatography with tandem mass spectrometry. Plasma viral load was measured using the COBAS AmpliPrep/Taqman 96 assay on the COBAS AmpliPrep/COBAS TaqMan (CAP/CTM) HIV-1, v2.0 Test (Roche Molecular Diagnostics, Branchburg, NJ, USA), and DBS viral load was measured using the COBAS AmpliPrep/COBAS TaqMan (CAP/CTM) Free Virus Elution (FVE) Protocol (Roche Molecular Diagnostics, Branchburg, NJ, USA).

Table 2.

Survey-weighted descriptive sample characteristics and prevalence of heavy alcohol use among adults (aged 15-64 years) living with HIV in Kenya.

	Overall	Heavy Alcohol Use	
Socio-demographics	***N* = 1,523**	**8.9% (95%CI: 6.8%, 11.0%)**	***p*-value**
Age group			0.791
15-24 years	139 (10.1%)	6.7% (2.9%, 10.5%)	
25-34 years	450 (30.1%)	7.8% (4.6%, 11.0%)	
35-44 years	431 (29.2%)	9.9% (6.2%, 13.6%)	
45-54 years	332 (21.5%)	9.6% (4.6%, 14.6%)	
55-64 years	171 (9.1%)	9.9% (2.4%, 17.3%)	
Sex			**<0.001**
Male	423 (31.5%)	19.6% (13.9%, 25.2%)	
Female	1,100 (68.5%)	4.0% (2.6%, 5.3%)	
Marital status			0.912
Never married (single)	199 (12.9%)	9.5% (4.0%, 14.9%)	
Married or cohabiting	842 (55.8%)	9.0% (6.1%, 12.0%)	
Separated, widowed, or divorced	481 (31.3%)	8.4% (5.4%, 11.3%)	
Education			**0.001**
No formal education	192 (13.4%)	2.7% (0.2%, 5.2%)	
Incomplete primary	951 (59.4%)	11.4% (8.5%, 14.2%)	
Complete primary	314 (23.1%)	6.2% (2.0%, 10.5%)	
Complete secondary	66 (4.1%)	7.3% (0.4%, 14.3%)	
Religion			**0.005**
Christian or Catholic	1,416 (93.3%)	8.4% (6.4%, 10.6%)	
Muslim	53 (2.9%)	3.0% (0.1%, 7.0%)	
Other or none	54 (3.8%)	22.8% (8.4%, 37.3%)	
Household wealth			0.410
Lowest	359 (20.6%)	6.7% (3.4%, 10.0%)	
Second	377 (23.6%)	7.8% (4.3%, 11.3%)	
Third	371 (24.8%)	8.7% (4.6%, 12.8%)	
Fourth	280 (18.0%)	9.9% (5.0%, 14.7%)	
Highest	135 (13.0%)	13.2% (4.6%, 21.9%)	
Residence			0.271
Rural	918 (63.9%)	8.0% (5.7%, 10.3%)	
Urban	605 (36.1%)	10.4% (6.3%, 14.5%)	

Notes: *p*-values generated from design-adjusted F-statistics comparing the survey-weighted prevalence of heavy alcohol use by socio-demographic characteristics. **Bolding** indicates statistically significant values at the $p<0.05$ level.

Table 3.

Logistic estimates for unconditional and conditional HIV care continuum indicators and heavy alcohol use (measured dichotomously), overall and by sex.

	Heavy Alcohol Use		Overall (*N* = 1,523)		Males (*n* = 423)		Females (*n* = 1,100)	
HIV Care Continuum	***No* (%, 95%CI)**	***Yes* (%, 95%CI)**	**adjOR (95%CI)**	***p*-value**	**adjOR (95%CI)**	***p*-value**	**adjOR (95%CI)**	***p*-value**
Unconditional								
Knowledge of HIV serostatus								
Aware	82.1 (79.6, 84.6)	53.0 (41.3, 64.7)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Unaware	17.9 (15.4, 20.4)	47.0 (35.3, 58.7)	**3.65 (2.14, 6.23)**	**<0.001**	**4.11 (1.94, 8.72)**	**0.001**	**3.09 (1.59, 6.02)**	**0.002**
Antiretroviral therapy (ART) use								
On ART	79.1 (76.4, 81.8)	47.1 (35.4, 58.9)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Not on ART	20.8 (18.2, 23.6)	52.9 (41.1, 64.6)	**3.81 (2.25, 6.43)**	**<0.001**	**4.46 (2.16, 9.23)**	**<0.001**	**2.90 (1.48, 5.68)**	**0.003**
Viral load suppression								
Suppressed (<1,000 copies/mL)	74.0 (71.3, 76.7)	46.4 (34.5, 58.2)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Unsuppressed (≥1,000 copies/mL)	26.0 (23.3, 28.7)	53.6 (41.8, 65.5)	**3.13 (1.85, 5.32)**	**<0.001**	**3.26 (1.57, 6.77)**	**0.003**	**2.99 (1.48, 6.01)**	**0.004**
Conditional								
Antiretroviral therapy (ART) use [a]								
On ART	96.4 (95.1, 97.7)	88.9 (80.7, 97.1)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Not on ART	3.6 (2.3, 4.8)	11.1 (2.9, 19.3)	**3.23 (1.30, 8.09)**	**0.014**	**3.77 (1.08, 13.17)**	**0.038**	1.54 (0.37, 6.44)	0.539
ART adherence, past 30 days [b]								
Missed 1 ART dose or none	89.3 (86.7, 92.0)	79.1 (63.6, 94.7)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Missed ≥2 ART doses	10.7 (8.0, 13.3)	20.9 (5.3, 36.4)	1.95 (0.81, 4.67)	0.128	1.55 (0.49, 4.92)	0.440	2.83 (0.88, 9.08)	0.078
Viral load suppression [c]								
Suppressed (<1,000 copies/mL)	92.9 (90.9, 94.9)	93.5 (86.3, 99.0)	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Unsuppressed (≥1,000 copies/mL)	7.1 (5.1, 9.1)	6.5 (0.1, 13.6)	1.32 (0.45, 3.82)	0.597	1.03 (0.20, 5.43)	0.971	1.35 (0.38, 4.85)	0.629

Notes: Multivariable logistic regression models were adjusted for age, sex, education, religion, and residence. **Bolding** indicates statistically significant logistic estimates at the $p<0.05$ level.

[a] Restricted to persons aware of their HIV serostatus.

[b] Restricted to persons with detectable ART in dried blood spots.

[c] Restricted to persons with detectable ART in dried blood spots self-reporting high (≥95%) ART adherence in the past 30 days.

Table 4.

Logistic estimates for unconditional HIV care continuum indicators and alcohol use (measured categorically), overall and by sex.

Alcohol use, past 12 months	Unaware of HIV serostatus[a]		Not on ART[b]		Unsuppressed viral load[c]	
	adjOR (95%CI)	*p*-value	adjOR (95%CI)	*p*-value	adjOR (95%CI)	*p*-value
Overall (*N* = 1,523)						
No alcohol use	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Less-heavy alcohol use	**1.78 (1.06, 3.00)**	**0.031**	**1.87 (1.15, 3.02)**	**0.013**	**2.12 (1.37, 3.27)**	**0.002**
Heavy alcohol use	**4.21 (2.44, 7.28)**	**<0.001**	**4.44 (2.62, 7.53)**	**<0.001**	**3.76 (2.22, 6.37)**	**<0.001**
Males (*n* = 423)						
No alcohol use	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Less-heavy alcohol use	1.71 (0.78, 3.75)	0.170	1,54 (0.74, 3.21)	0.237	1.60 (0.82, 3.12)	0.162
Heavy alcohol use	**4.86 (2.17, 10.89)**	**<0.001**	**5.09 (2.39, 10.88)**	**<0.001**	**3.74 (1.78, 7.88)**	**0.001**
Females (*n* = 1,100)						
No alcohol use	1.00	*Ref.*	1.00	*Ref.*	1.00	*Ref.*
Less-heavy alcohol use	**2.22 (1.19, 4.13)**	**0.014**	**2.73 (1.48, 5.03)**	**0.002**	**3.04 (1.71, 5.40)**	**0.001**
Heavy alcohol use	**3.39 (1.74, 6.61)**	**0.001**	**3.25 (1.67, 6.34)**	**0.001**	**3.37 (1.68, 6.76)**	**0.001**

Notes: Multivariable logistic regression models were adjusted for age, sex, education, religion, and residence. **Bolding** indicates statistically significant logistic estimates at the $p<0.05$ level.

[a] HIV serostatus awareness served as the reference group in multivariable analysis.

[b] ART use served as the reference group in multivariable analysis.

[c] Viral load suppression (<1,000 RNA copies/mL) served as the reference group in multivariable analysis.