



A Latent Class Analysis of the Social Determinants of Health Impacting Heavy Alcohol Consumption Among Women Living with HIV in Canada: The Canadian HIV Women's Sexual and Reproductive Health Cohort Study

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Abstract

We used longitudinal data from the 2013–2017 Canadian HIV Women's Sexual and Reproductive Health Cohort Study (N = 1422) to assess the clustered impact of social determinants of health (SDoH) on hazardous drinking. Two measures of alcohol use were defined: (i) weekly alcohol use, with > 7 drinks/week as heavy drinking, and (ii) monthly binge drinking (≥ 6 drinks at one sitting), with ≥ 1/month as frequent bingeing. Twelve SDoH indicators were classified using latent class analysis: no/least adversities, discrimination/stigma, economic hardship, and most SDoH adversities. Inverse-probability weighted multinomial logistic regression was used to report relative-risk ratio (RRR). Women living with HIV (WLWH) in no/least adversity class had a substantially lower likelihood of both heavy weekly alcohol use and frequent bingeing than those in discrimination/stigma, economic hardship, and most SDoH adversities classes, with RRR estimates ranging from 0.02 to 0.18. Findings indicate the need to address SDoH to reduce hazardous drinking among WLWH.

Keywords Women · HIV · Alcohol drinking · Social determinants · CHIWOS

Resumen

Utilizamos información del Estudio de Salud Sexual y Reproductiva de Mujeres viviendo con VIH en Canadá 2013-2017 (N = 1422) para evaluar el impacto agrupado de los determinantes sociales de la salud (DSS) sobre consumo riesgoso de alcohol. Se definieron dos medidas de consumo de alcohol: i) consumo abusivo de alcohol: uso de alcohol por semana, > de 7 bebidas/por semana y ii) consumo excesivo mensual (≥ 6 bebidas en una ocasión), con ≥ 1/mes como consumo excesivo frecuente. Utilizando el análisis de clases latentes se clasificaron doce indicadores de los DSS: no/menos adversidades, discriminación/estigma, dificultad económica, y la mayoría de las adversidades de los DSS. Para reportar el riesgo relativo (RR) se utilizó regresión logística multinomial ponderada de probabilidad-inversa. Mujeres viviendo con el VIH (MVCV) en la clase no/menos adversidad tuvieron menos probabilidad de ambos, consumo semanal abusivo de alcohol y de consumo excesivo frecuente, comparadas con aquellas en clases de discriminación/estigma, dificultad económica, y la mayoría de adversidades de los DSS, con estimaciones RR entre 0.02 a 0.18. Los hallazgos indican la necesidad de abordar los DSS para reducir el consumo riesgoso entre MVCV.

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Introduction

Heavy alcohol consumption is prevalent among individuals living with HIV, including women [1–3]. For example, a study conducted in the United States (US) over an 11-year follow-up period found that almost half of women living with HIV (WLWH) reported any past-year alcohol consumption, with 14 to 24% reporting hazardous drinking [1],

defined as ≥ 4 drinks per occasion or > 7 drinks/week [4]. Research in Canada has documented that 20% (i.e., 15.4% less than once a week and 4.6% weekly) of WLWH reported any past-month binge drinking, defined as ≥ 4 drinks per occasion [5], compared to 34.5% (i.e., 30.6% less once a week and 3.9% weekly) from general population women of similar ages/ethnoracial backgrounds [3].

While less frequent in WLWH than the general population [3], heavy alcohol use has been shown to be negatively associated with outcomes along the HIV treatment cascade. For example, Monroe et al. in a US longitudinal study found that heavy drinkers and frequent binge drinkers were respectively associated with inferior retention in HIV care and lower visit adherence [6]. Research on WLWH has also documented the impact of heavy drinking and poor HIV outcomes; for example, Barai et al. in a secondary analysis of data collected in a US randomized control trial found heavy drinking as a barrier to achieving viral suppression [7], appearing through alteration of virus infectivity, immune response, tissue injury and inflammatory markers [8–10]. In addition, heavy drinking accounts for considerable mortality among WLWH; e.g., Neblett et al. in a US longitudinal cohort of WLWH found that heavy drinking independently increased the risk of earlier death by 40% [11]. Indeed, a better recognition of heavy drinking has implications for HIV care and treatment. Further, the identification of such prevalent but modifiable risk-taking practices is essential to improve the health and wellbeing of WLWH, who now represent almost one-quarter of all new HIV diagnoses in Canada [12].

While extant research has shown the association of increased heavy drinking with sociodemographic factors (e.g., age and race/ethnicity) as well as psychological, and treatment or clinical factors (e.g., viral load and CD4 indicators) [1, 11, 13–16], less has been explored through a social determinants of health (SDoH) framework. SDoH are living conditions in which people are born, live, work, and age [17], and represent structural causes of health problems [17, 18]. SDoH are particularly important among WLWH as an array of socio-structural adversities such as low income, food insecurity, low social support, stigma and discrimination have been reported [19, 20]. Approaches informed by an SDoH framework may examine such daily living stressors that contribute to WLWH's likelihood of initiating or continuing hazardous drinking as a coping behavior. This framework underscores the complex dynamic of social, economic and structural factors that have the potential to cluster together; a key feature of these determinants that has been methodologically less taken into account.

In the present study, we aimed to explore the association between SDoH and hazardous alcohol use among WLWH in Canada. As SDoH may tend to co-occur in particular combinations [20], we examined the concomitant patterns

of these determinants using latent class analysis (LCA). We then explored the association of the clustered SDoH with heavy drinking. This research is informed by an SDoH framework contending that upstream socio-structural determinants share or influence individuals' health [17], as well as a syndemics framework referring to disease-social condition interactions that synergistically influence the health of a population within the context of persistent social inequalities [21]. Understanding the social determinants with their unique clusters through which heavy drinking may be impacted and/or intervened on can help address alcohol use among WLWH.

Methods

Study Sample

We used data from the community-based Canadian HIV Women's Sexual and Reproductive Health Cohort Study (CHIWOS). As previously described [22, 23], CHIWOS enrolled WLWH aged ≥ 16 years, including transgender women, residing in the provinces of British Columbia (BC), Ontario, or Quebec. A total sample of 1422 were interviewed during 2013–2015 (time-point 1), and 1252 after ~ 18 -months (2016–2017, time-point 2). Participants who had died or did not participate in time-point 2 were considered as *censored* ($N=170$; 11.9%). Participants were recruited from HIV clinics, community-based organizations, peers, and online networks. The survey was administered via trained peer research associates (PRAs) through face-to-face interviews at clinics, community sites, participants' homes, or via phone/Skype [23]. CHIWOS was approved by the Research Ethics Boards of Simon Fraser University, University of British Columbia/Providence Health, Women's College Hospital and McGill University Health Centre.

Alcohol Use Measures

Alcohol use measures at time-point 2 were considered as the study outcomes when investigating its association with SDoH measured at time-point 1. A standard drink was defined as having a 341 ml (12 oz.) bottle of 5% alcohol beer, cider or cooler, or a 142 ml (5 oz.) glass of 12% alcohol wine, or a 43 ml (1.5 oz.) (single shot) serving of liquor or spirits. Two measures of alcohol consumption were defined according to the definitions from the available recommendations [4, 5]:

Weekly Alcohol Use

The average quantity of drinks per week was computed by multiplying last-year frequency of alcohol use (with

five response options: never, monthly or less, 2–4 times a month, 2–3 times a week, 4 or more times a week) by quantity of alcohol consumed on a typical drinking day (with five response categories: 1–2, 3–4, 5–6, 7–9, 10 or more). We used the midpoint for response options. We then created a three-category measure: nondrinking or low drinking (< 1 drink/week), moderate drinking (1–7 drinks/week), and heavy drinking (> 7 drinks/week).

Binge Drinking

Past-month *heavy* binge drinking (i.e., ≥ 6 drinks on one single occasion) at least once/month was measured and categorized into three categories: non-drinking or non-binge drinking, infrequent binge drinking (< 1/month), or frequent binge drinking (≥ 1 /month). The typical threshold for binge drinking among women is 4 or more drinks [5]; however, having a more conservative measure of two more drinks over the typical binge drinking threshold has been found to be of value in capturing adequately the nature of problem drinking practice in other studies [24].

SDoH Indicators

The following 12 potentially modifiable current or recent SDoH indicators measured at time-point 1 were examined: race discrimination, gender discrimination, enacted HIV stigma, social support, barriers to access to care, food security, housing status, employment status, education, income level, recent sex work involvement, and recent incarceration. In this study, we only included the current/recent SDoH indicators to avoid the potential for spurious correlation and biased estimation known as collider stratification bias [25]. Such bias can be introduced in studies of selected populations (here, WLWH) if they investigate earlier exposures (here earlier social determinants such as childhood events) that may have affected study inclusion/exclusion criteria (here HIV status).

We separately measured *racial discrimination* and *gender discrimination*, defined as any discriminatory mistreatments due to race and gender, using the 8-item Everyday Discrimination Scale [26]. Consistent with its operationalized definition [27], WLWH who reported (sometimes, frequently, or almost everyday) having discriminatory experiences due to their race and gender were considered as having experienced race discrimination and gender discrimination, respectively. Three items of Wright's shortened version of Berger's HIV Stigma Scale were used to measure *enacted HIV stigma* (i.e., been hurt by people's reaction, stopped socializing, or lost friends), indicating the extent to which participants faced mistreatment due to their HIV status [28]. Participants who reported any HIV-related discriminatory events with strongly agree/agree response options were considered as

having experienced HIV-related stigma. A 4-item Medical Outcome Study: Social Support Survey [29] was used to gauge *perceived social support*, measuring emotional-informational, tangible, affectionate, and positive social interaction supports. The overall possible mean score ranged from 1 to 5, with scores > 2 indicating poor social support availability [30]. *Barriers to Access to Care* was measured using a 12-item scale [31]. Overall possible mean severity scores ranged from 1 to 4, with scores ≥ 2 indicating severe/significant barriers [32]. *Food insecurity* over the past 12 months was assessed using three items: fears of running out of food; experiences of running out of food; and unaffordability of balanced meals. The sum of these items yielded an overall score ranged 1–6, with scores > 1 indicating food insecure [33]. Other SDoH indicators included *yearly household income level* (less than \$20,000 vs. \$20,000 or more), current *employment status* (unemployed [e.g., no income or income from non-employment sources such as employment insurance/compensation/welfare, dividends and interest, or pension plan] versus employed [i.e., having any paid jobs]), current *education level* (below high school vs. completed high school), current *housing status* (unstable [e.g., residing in a self-contained room, transition house, halfway house, safe house, or outdoors] vs. stable housing), any *sex work involvement* in the last 6 months (Yes, No), and any history of *incarceration* in the last year (Yes, No).

Covariates

Covariates with potential association with either both SDoH classes and alcohol consumption measures or only alcohol consumption measures were considered, including: age (continuous; with its linear and quadratic forms in the model); ethnoracial groups (white, African/Caribbean/Black, Indigenous, other); city size (large, others); study province (Ontario, BC, Quebec); sexual orientation (heterosexual, LGBQ); relationship status (single (non-married), married/common-law, others); years living with HIV (< 6 years, 6–14 years, > 14 years); antiretroviral therapy status (optimal [$\geq 95\%$ treatment adherence], suboptimal [$< 95\%$ treatment adherence], not engaged in treatment); ever being diagnosed with a mental health condition by a care provider (Yes, No); resilience measured using the 10-item version of the Resilience Scale [34], ranging 10–70, with higher scores implying increased resilience, dichotomized at its median; any history of childhood sexual/physical violence (Yes, No); any experience of adulthood sexual/physical/verbal/action-limited violence (Yes, No); having been under the care of Child Protection Services or in foster care (Yes, No); last-year cigarette smoking history (never/former, occasional/regular); last-month non-prescribed cannabis use (never/former, occasional/regular), last 3 months

any non-prescribed/illicit opioid and/or stimulant use (Yes, No), ever used alcohol counseling services (Yes, No).

Latent Class Analysis (LCA)

We conducted LCA to identify the clusters of SDoH assessed at time-point 1. LCA as a data reduction strategy is a probabilistic model-based clustering technique to detect homogeneous clusters of individuals with unique patterns within an unobserved categorical measure under the assumption that the identified latent classes are independent given the observed categorical measures [35]. The expectation–maximization (EM) algorithm with 5000 iterations was used to find the best model fit [36]. We started LCA with a 2-class model and progressively increased (Supplementary Table 1), for each the log-likelihood was replicated with 1000 random starting values in order to increase the confidence that the best identified model solution is the true maximum likelihood solution. Therefore, we reported the percentage of seeds associated with best fitting model, with higher values indicating being unlikely to hit the local maxima. While we predominantly relied on the interpretability of class memberships, the following fit statistics were also reported to help obtain the best model: log-likelihood, Akaike’s information criteria (AIC), Bayesian information criteria (BIC), and sample-size-adjusted BIC (aBIC), and consistent AIC (CAIC) [37–39], with their lower values implying better goodness-of-fit and parsimony. Entropy as a measure of classification accuracy was also reported (varied from 0 to 1), with higher values suggesting clearer separation/distinction among the latent classes [35].

As shown in Supplementary Table 1, we proposed the 4-class model as the best fitting model of the SDoH classes among WLWH. The observed prevalence of each item as well as item-response probabilities (Yes category only) condition on class membership of the 4-class model are illustrated in Supplementary Fig. 1. These four classes included: WLWH who experienced none or only one SDoH adversity (class 1, labeled as none/least SDoH adversities; 6.6%); WLWH who predominantly reported experiencing racial discrimination, gender discrimination and HIV-related stigma, accompanied by experiencing barriers in access to care without economic hardship experiences (class 2, labeled as discrimination/stigma group; 17.9%); WLWH who mainly reported food insecurity, low household income, and unemployment without stigma/discrimination (class 3, labeled as economic hardship group; 31.6%); and WLWH who experienced gender and racial discrimination, HIV-related stigma, low social support, greater difficulties access to care, food insecurity, low income, and unemployment (class 4, labeled as most SDoH adversities; 43.9%). After identification of the fitting model, each participant was assigned to the SDoH latent classes in which they had

the greater posterior probability. LCA accounted for missing values using the full information maximum likelihood estimation under the assumption of missing at random. We conducted LCA using SAS PROC LCA procedure [35].

Models and Estimations

Inverse probability weights (IPW) was used to account for confounding bias due to the potentially imbalanced covariates across the SDoH classes. We also used inverse probability censoring weights (IPCW) to account for prospective selection bias due to potentially non-random loss to follow-up (Supplementary Table 2).

Covariate Selection

Consistent with recommendations [40], measured covariates that were potentially associated with the study outcomes were considered. To account for confounding by outcome history, we also included alcohol use measures at time-point 1 [41]. Missing values of covariates considered for generating the weights were singly imputed under the assumption of missing at random to reduce the loss of statistical power [42].

Control of Confounding Using IPW

We generated stabilized weights using multinomial logistic regression models: the numerator was computed as the marginal probability of the SDoH classes (accounting for imbalanced proportions of the SDoH classes) divided by the denominator which was computed as the probability that a participant assigned to a SDoH class conditioning on the measured covariates. These models were performed among WLWH without censored information in time-point 2.

Control of Selection Bias Using IPCW

We first created a binary measure indicating censored individuals at time-point 2. Then, IPCW using binary logistic regression model was obtained: the numerator was defined as the probability of not being censored given SDoH classes, and the denominator was calculated as the probability of not being censored given SDoH and the study covariates [43].

Final Stabilized Weight

We created the final stabilized weight using the product of IPW and IPCW. The distribution of the weights across the SDoH classes is presented in Supplementary Table 3. Under the following assumptions: correct specification of IPW models, conditional exchangeability, consistency, and positivity [44], the final weight removes the association between

SDoH classes, as the main independent variable, and the study covariates [43] (Supplementary Table 4).

Association of SDoH Classes with Alcohol Use Measures

The association between SDoH classes and alcohol use measures was examined using multinomial logistic regression models as the alcohol use outcomes had more than two categories. We then estimated crude and weighted relative-risk ratios (RRR) and 95% confidence intervals (CI). Further adjustment was made for history of the study outcomes. Additionally, a sensitivity analysis was conducted to evaluate the extent to which unmeasured confounding would explain away the observed associations. To do this, we computed the E-values as: $E = RRR + \sqrt{RRR \times RRR - 1}$, where RRR referred to the significant observed estimates. We replaced RRR with $RRR^* = 1/RRR$ for the estimate less than the null ($RRR = 1$) [45]. E-value for RRR provides values below, equal to or above the null, representing the minimum strength of the association between unmeasured confounders with SDoH clusters and/or alcohol use to nullify the observed associations. These analyses were done using Stata 15.

Results

Participants' Characteristics

Characteristics of study participants enrolled in time-point 1 can be seen in Table 1. The mean age was 42.8 [SD 10.6] years old. The largest category identified as white (41.1%), while 29.4% identified as African/Caribbean/Black, 22.3% as Indigenous, and 7.2% as other. The majority reported their sexual orientation as heterosexual (87.3%). About one-third (32%) reported being in a relationship, married, or common-law; 40.2% reported living with HIV for 6–14 years; and 70.0% reported optimal HIV treatment adherence. Childhood and adulthood violence were reported by 62.7% and 80.4%, respectively. Ever having a mental health diagnosis was reported by 40.7%. The distribution of these covariates across the SDoH classes is also presented in Table 1.

Weekly Alcohol Use

Overall, moderate (1–7 drinks/week) and heavy (>7 drinks/week) alcohol use at time-point 2 were reported by 20.1% and 10.5%, respectively. Heavy alcohol use at time-point 2 was reported by 6.8% among WLWH in no/least SDoH adversities, 10.2% among WLWH in discrimination/stigma class, 8.8% among economic hardship class, and 12.6% among WLWH in the most SDoH adversities class (Table 2). Our results showed no crude associations between SDoH classes and heavy

weekly alcohol consumption. However, the weighted regression analysis demonstrated that WLWH in no/least SDoH adversities had lower likelihood of weekly heavy alcohol use than WLWH in discrimination/stigma class (RRR 0.10; 95% CI 0.02, 0.68), economic hardship class (RRR 0.18; 95% CI 0.03, 1.04; not significant), and most SDoH adversities class (RRR 0.11; 0.02, 0.62). While crude associations showed an increased likelihood of moderate weekly alcohol consumption among WLWH in the no/least SDoH adversity in comparison with other three classes, no significant association was observed in the weighted analyses (Table 3).

Binge Drinking

Overall, infrequent (<1/month) and frequent (\geq 1/month) binge drinking at time-point 2 were reported by 12.6% and 9.9%, respectively. Frequent binge drinking was reported by 3.4% among WLWH in no/least SDoH adversities, 7.2% among WLWH in discrimination/stigma class, 9.6% among economic hardship class, and 12.3% among WLWH in the most SDoH adversities class (Table 2). WLWH in no/least SDoH adversities class were shown to have a lower likelihood of frequent binge drinking than WLWH in discrimination/stigma class (RRR 0.02; 95% CI 0.002, 0.21), economic hardship class (RRR 0.03; 95% CI 0.01, 0.24), and most SDoH adversities class (RRR 0.02; 95% CI 0.002, 0.13). Furthermore, the likelihood of infrequent binge drinking was lower among WLWH in no/least SDoH adversities class than those in discrimination/stigma and the most SDoH adversities classes (Table 4).

Sensitivity Analysis

The sensitivity analysis reflected that our observed associations were relatively robust to potential unmeasured confounding. For example, for the observed RRR: 0.11 for heavy weekly alcohol consumption among WLWH in the no/least SDoH adversities class versus the most SDoH adversities class, an unmeasured confounder correlated with both exposure and outcome by RRRs of ~17.6-fold each, above and beyond the measured confounders, would explain away the observed association, but weaker confounding would not. Such an E-value for the upper 95% limit of the same comparison (Upper CI 0.62) was 2.6-fold. The E-values for the significant observed associations were reported in Supplementary Table 5.

Discussion

We explored the pattern of alcohol consumption measures and their association with four SDoH classes in a diverse cohort of WLWH in Canada. We found that

Table 1 Characteristics of women living with HIV overall and stratified by social determinants of health (SDoH) classes, CHIWOS survey—time-point 1

Variables at time-point 1	Overall	SDoH classes at time-point 1				P value ^b
		None/least adversities	Discrimination/stigma	Economic hardship	Most adversities	
N	1422 (100)	94 (6.6)	256 (18.0)	430 (30.2)	642 (45.2)	–
Age, year (mean [SD])	42.8 [10.6]	39.2 [10.3]	43.5 [10.6]	42.9 [11.5]	43.1 [10.0]	0.007
Ethno-racial identity						<0.001
White	584 (41.1) ^a	58 (61.7)	97 (37.9)	219 (50.9)	210 (32.7)	
African/Caribbean/Black	418 (29.4)	23 (24.5)	109 (42.6)	123 (28.6)	163 (25.4)	
Indigenous	318 (22.3)	7 (7.4)	29 (11.3)	60 (14.0)	222 (34.6)	
Other	102 (7.2)	6 (6.4)	21 (8.2)	28 (6.5)	47 (7.3)	
Province						<0.001
Ontario	717 (50.4)	50 (53.2)	131 (51.2)	235 (54.6)	301 (46.9)	
British Columbia	356 (25.0)	13 (13.8)	49 (19.1)	65 (15.1)	229 (35.7)	
Quebec	349 (24.6)	31 (33.0)	76 (29.7)	130 (30.2)	112 (17.5)	
Living in large cities	1169 (82.2)	83 (88.3)	203 (79.3)	345 (80.2)	538 (83.8)	0.106
Being heterosexual	1237 (87.3)	85 (90.4)	237 (93.3)	395 (91.9)	520 (81.4)	<0.001
Relationship status						<0.001
Single (non-married)	689 (48.5)	40 (42.6)	100 (39.1)	201 (46.7)	348 (54.4)	
Married/common-law	454 (32.0)	44 (46.8)	103 (40.2)	134 (31.1)	173 (27.0)	
Others	277 (19.5)	10 (10.6)	53 (20.7)	95 (22.1)	119 (18.6)	
Years living with HIV						0.001
< 6 years	345 (25.1)	23 (25.0)	40 (15.7)	128 (31.4)	154 (24.8)	
6–14 years	552 (40.2)	35 (38.0)	118 (46.7)	140 (34.3)	259 (41.8)	
> 14 years	477 (34.7)	34 (37.0)	96 (37.8)	140 (34.3)	207 (33.4)	
Taking treatment						0.001
Yes, optimal adherence (≥95%)	863 (70.0)	65 (69.9)	163 (64.7)	279 (65.0)	356 (55.5)	
Yes, suboptimal adherence (<95%)	312 (22.0)	12 (12.9)	52 (21.4)	74 (17.2)	172 (26.8)	
Not engaged in treatment	240 (17.0)	16 (17.2)	35 (13.9)	76 (17.7)	113 (17.6)	
Mental health diagnosis	573 (40.7)	26 (28.0)	93 (36.6)	134 (31.6)	320 (50.3)	<0.001
Low resiliency (below median) ^c	662 (47.1)	22 (23.66)	104 (40.9)	172 (40.6)	364 (57.4)	<0.001
Childhood violence	819 (62.7)	34 (38.6)	138 (56.8)	211 (53.8)	436 (74.7)	<0.001
Adulthood violence	1057 (80.4)	52 (59.1)	189 (77.5)	284 (71.9)	532 (90.5)	<0.001
Child development events	326 (23.0)	10 (10.6)	33 (13.0)	74 (17.3)	209 (32.7)	<0.001
Cigarette smoking (regular/occasional)	616 (43.7)	15 (16.1)	65 (25.5)	176 (41.1)	360 (56.7)	<0.001
Non-prescribed cannabis use (regular/occasional)	264 (18.9)	7 (7.7)	34 (13.4)	75 (17.7)	148 (23.6)	<0.001
Drug use ^d	244 (17.5)	2 (2.2)	11 (4.3)	50 (11.9)	181 (28.8)	<0.001
Received alcohol counseling	3 (3.2)	24 (9.4)	60 (14)	201 (31.3)	3 (3.2)	<0.001
Weekly alcohol use						0.132
Abstainers to low (< 1 drink)	956 (69.1)	64 (68.8)	174 (68.5)	302 (71.1)	419 (68.1)	
Moderate (1/7 drinks)	288 (20.8)	22 (23.7)	60 (23.6)	88 (20.7)	118 (19.2)	
Heavy (> 7 drinks)	140 (10.1)	7 (7.5)	20 (7.9)	35 (8.2)	78 (12.7)	
Binge drinking						0.037
Non-drinkers/no binge drinking	1107 (81.9)	73 (79.4)	214 (85.3)	348 (85.5)	472 (78.5)	
Infrequent (< 1 per month)	14 (1.0)	1 (1.1)	4 (1.6)	1 (0.3)	8 (1.3)	
Frequent (≥ 1 per month)	230 (17.0)	18 (19.6)	33 (13.2)	58 (14.3)	121 (20.1)	

^aData are presented as N (%) unless specified

^bP values are for the Chi square test for categorical covariates and one-way ANOVA for continuous covariates

^cScores ranged 10–70, with higher scores indicating increased resilience (median = 64)

^dLast 3 months any non-prescribed/illicit opioid and/or stimulant use measured

Table 2 Alcohol consumption measures (study outcomes) overall and across the social determinants of health (SDoH) classes among women living with HIV, CHIWOS survey

Alcohol use measures at time-point 2	Overall	SDoH classes at time point 1				P value
		None/least adversities	Discrimination/stigma	Economic hardship	Most adversities	
N	1237	88	231	378	540	–
Weekly alcohol use*						0.006
Abstainers to low (< 1 drink)	858 (69.4)	55 (62.5)	156 (67.5)	282 (74.6)	365 (67.6)	
Moderate (1/7 drinks)	249 (20.1)	27 (30.7)	54 (23.4)	65 (17.2)	103 (19.1)	
Heavy (> 7 drinks)	130 (10.5)	6 (6.8)	21 (9.1)	31 (8.2)	72 (13.3)	
Binge drinking ^{b,*}						0.001
Non-drinkers/no binge drinking	952 (77.5)	70 (79.6)	183 (79.2)	309 (82.4)	390 (72.9)	
Infrequent (< 1 per month)	155 (12.6)	15 (17.1)	33 (14.3)	32 (8.5)	75 (14)	
Frequent (≥ 1 per month)	122 (9.9)	3 (3.4)	15 (6.5)	34 (9.1)	70 (13.1)	

^aData are presented as N (%)

^bHeavy binge drinking at time-point 2 was defined as having 6 or more drinks in one single occasion

*P value < 0.05, indicating that the distribution of both alcohol consumption measures is significantly different across the SDoH classes

Table 3 The association of social determinants of health (SDoH) classes on *Weekly Alcohol Use* using inverse-probability weighting analysis among women living with HIV in Canada, CHIWOS

SDoH classes at time-point 1	Moderate use (1–7 drinks per week) ^a		Heavy use (> 7 drinks per week) ^a	
	Crude estimates RRR (95% CI) ^b	IPW estimates RRR (95% CI)	Crude estimates RRR (95% CI)	IPW estimates RRR (95% CI)
Economic hardship versus most adversities	0.82 (0.58, 1.16)	<i>0.66 (0.43, 1.01)</i>	0.56 (0.36, 0.87)	0.61 (0.32, 1.13)
P value	0.253	<i>0.060</i>	0.011	0.120
Discrimination/stigma versus most adversities	1.23 (0.84, 1.79)	1.04 (0.59, 1.84)	0.68 (0.41, 1.15)	1.09 (0.39, 3.03)
P value	0.291	0.866	0.151	0.863
No/least adversities versus most adversities	1.74 (1.04, 2.9)	0.39 (0.09, 1.62)	0.55 (0.23, 1.33)	0.11 (0.02, 0.62)
P value	0.033	0.200	0.187	0.013
Discrimination/stigma versus economic hardship	1.50 (1.00, 2.26)	1.56 (0.87, 2.83)	1.22 (0.68, 2.20)	1.79 (0.64, 4.95)
P value	0.052	0.135	0.499	0.262
No/least adversities versus economic hardship	2.13 (1.25, 3.63)	0.59 (0.14, 2.45)	0.99 (0.40, 2.49)	<i>0.18 (0.03, 1.04)</i>
P value	0.005	0.473	0.987	<i>0.056</i>
No/least adversities versus discrimination/stigma	1.42 (0.81, 2.47)	0.38 (0.08, 1.64)	0.81 (0.31, 2.11)	0.10 (0.02, 0.68)
P value	0.217	0.196	0.667	0.019

^aBase group in multinomial logistic regression: abstainers to low [< 1 drink/week]

^bRRR: relative-risk ratio (95% confidence intervals: CI)

^cItalicized estimates indicate having a p value less than 0.10

^dBold estimates indicate having a p value less than 0.05

10.5% of WLWH reported heavy weekly alcohol use at enrollment and 9.9% reported frequent binge drinking at ~ 18 months follow up, with greater proportion among WLWH who experienced multiple forms of SDoH adversities than those with no/least SDoH adversity. We also documented that WLWH with no/least SDoH adversity were less likely to report heavy alcohol consumption relative to WLWH experiencing either discrimination/stigma or economic hardship or suffering from the most SDoH

adversities. These findings can inform intervention strategies to advance health among WLWH.

Our research contributes to the literature in several ways. Firstly, we found that a large proportion of WLWH reported experiencing specific forms of socio-structural adversities including economic hardship and stigma/discrimination, or multiple types of disadvantages. Secondly, this study adds to the current understanding of how social determinants clustered together and such clustering increased the likelihood

Table 4 The association of the classes of social determinants of health (SDoH) on *Binge Drinking* using inverse-probability weighting analysis among women living with HIV in Canada, CHIWOS

SDoH classes at time-point 1	Binge drinking < 1 per month ^a		Binge drinking ≥ 1 per month ^a	
	Crude estimates RRR (95% CI) ^b	IPW estimates RRR (95% CI)	Crude estimates RRR (95% CI)	IPW estimates RRR (95% CI)
Economic hardship versus most adversities	0.53 (0.34, 0.83)	0.75 (0.35, 1.59)	0.61 (0.39, 0.94)	0.56 (0.29, 1.10)
P value	0.006	0.456	0.028	0.097
Discrimination/stigma versus most adversities	0.93 (0.60, 1.46)	1.57 (0.76, 3.22)	0.45 (0.25, 0.82)	0.70 (0.28, 1.70)
P value	0.777	0.217	0.009	0.432
No/least adversities versus most adversities	1.11 (0.60, 2.05)	0.20 (0.04, 0.99)	0.23 (0.07, 0.77)	0.02 (0.002, 0.13)
P value	0.728	0.050	0.018	< 0.001
Discrimination/stigma versus economic hardship	1.74 (1.03, 2.92)	2.09 (0.81, 5.39)	0.74 (0.39, 1.40)	1.23 (0.46, 3.26)
P value	0.036	0.126	0.363	0.671
No/least adversities versus economic hardship	2.06 (1.06, 4.02)	0.26 (0.04, 1.44)	0.38 (0.11, 1.30)	0.03 (0.01, 0.24)
P value	0.032	0.127	0.126	0.001
No/least adversities versus discrimination/stigma	1.18 (0.60, 2.32)	0.12 (0.02, 0.69)	0.52 (0.14, 1.86)	0.02 (0.002, 0.21)
P value	0.614	0.017	0.317	0.001

^aBase group in multinomial logistic regression: non-drinkers/no binge drinking

^bRRR: relative-risk ratio (95% confidence intervals: CI)

^cItalicized estimates indicate having a p value less than 0.10

^dBold estimates indicate having a p value less than < 0.05

of heavy drinking among WLWH. Thirdly, we documented that the risk of alcohol use did not change much (vs. no/least SDoH class) whether a women reported experiencing primarily stigma/discrimination, primarily economic hardship, or the most SDoH adversities. These findings may indicate that in addressing hazardous drinking, it is important to consider the role that any form of SDoH inequities play in shaping such risk-taking practice. This is particularly important as hazardous drinking has been shown to be a significant predictive of mortality among WLWH of the same cohort in Canada [46]. Overall, our findings suggest that WLWH continue to experience a high level of stress as a result of social and structural inequalities, contributing to elevated risk of alcohol consumption [47, 48].

While it is difficult for us to compare our findings directly with prior research, these findings are in line with the extant literature, implying that a greater level of social adversity is associated with increased likelihood of heavy drinking among WLWH [1, 13, 14]. Previous studies have mostly reported the independent impact of individual social factors (either modifiable or non-modifiable ones) on alcohol use. For example, Cook et al. in a longitudinal study identified unemployment and low education as the independent predictors of hazardous alcohol consumption among WLWH [1]. They also found the independent effect of low education (but not employment or race/ethnicity) on higher odds of heavy drinking in a trajectory analysis [13]. In 2018, Kelso-Chichetto et al. found an association between alcohol consumption trajectories and race/ethnicity, but not with annual

income levels among WLWH [14]. Concentrating on modifiable social factors, we found a significant association of the clustered SDoH on hazardous drinking among WLWH. While our estimates relied on a set of SDoH indicators gathered on only one time-period, future research could conduct a trajectory analysis to assess the stability of these social determinants over time in association with behavioral and HIV treatment outcomes.

Our study had some limitations. First, CHIWOS used a purposive, nonrandom sampling approach that may have oversampled WLWH receiving care, who may have different characteristics such as sociodemographic or socio-structural vulnerabilities than other WLWH. In turn, CHIWOS also oversampled WLWH experiencing intersecting forms of marginalization such as sex work and substance use to mitigate sampling bias [22]. Second, data on both alcohol use and social determinants were gathered via self-report, and are subject to social desirability and recall biases (particularly the past-year frequency and quantity of alcohol use). However, the survey was administered by PRAs who are also WLWH [22], to build trust with participants in sharing their information [23].

Despite these limitations, this study has several notable strengths. We included a large sample of WLWH with diverse ethno-racial identities and social-economic experiences, which may provide a better picture of the target population beyond only those in clinical settings. Second, this research enhances understanding of the clustered SDoH and their association with hazardous alcohol use. Third, a large

proportion of the study sample remained in the follow-up survey, allowing for assessment of study outcomes which makes temporality between SDoH classes and alcohol use measures clear. Fourth, use of LCA including 12 SDoH indicators allowed for data reduction and a clearer presentation of the impact of the clustered SDoH on the study outcomes. This underscores the interdependent nature of the SDoH beyond their independent impacts.

Conclusion

Approximately one out of ten WLWH from the CHIWOS cohort met criteria for heavy drinking and frequent binge drinking, with higher likelihood among those experiencing overlapping forms of SDoH adversities. Our findings suggest that multiple forms of SDoH adversities—regardless of their types—can substantially impact the initiation/continuation of hazardous drinking. In the current era where viral suppression is achieved and an improved survival is expected among individuals who have access to HIV medications and are on treatment and in care [49, 50], adversities regarding socioeconomic and structural determinants as well as behavioral factors (heavy drinking) may undermine the efforts of the management of HIV. Effective interventions aiming to target WLWH who drink at hazardous levels should also consider the substantial contribution of socio-structural barriers that WLWH inequitably experience in their daily life. While integration of harm reduction approach into HIV care through the women-centered care model may be considered as an approach in addressing heavy drinking and social barriers [51], more evidence-based research is needed to determine the effectiveness of such interventions. Our findings highlight the urgency to address SDoH for interventions to be fully beneficial for WLWH who involve in heavy drinking.

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Compliance with Ethical Standards

Conflict of interest 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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