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Patterns of social determinants of health associated with drug use among women living with HIV in Canada: a latent class analysis

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ABSTRACT

Background and Aims Identifying typologies of social determinants of health (SDoH) vulnerability influencing drug use practices among women living with HIV (WLWH) can help address associated harms. This research aimed to explore the association of SDoH clusters with drug use among WLWH. **Design** Latent class analysis (LCA) was used to identify the distinct clusters of SDoH. Inverse probability weighting (IPW) was employed to account for confounding and potential selection bias. Associations were analyzed using generalized linear model with log link and Poisson distribution, and then weighted risk ratio (RR) and 95% confidence intervals (CI) were reported. **Setting, Participants** Data from 1,422 WLWH recruited at time-point 1 of the Canadian HIV Women's Sexual and Reproductive Health Cohort Study (CHIWOS, 2013-2015), with 1,252 participants at 18 months follow-up (time-point 2). **Measurements** Drug use was defined as use of illicit/non-prescribed opioids/stimulants in the past six months. SDoH indicators included: race discrimination, gender discrimination, HIV stigma, social support, access to care, food security, income level, employment status, education,

housing status, and histories of recent sex work and incarceration. **Findings** LCA identified four SDoH classes: no/least SDoH adversities (6.6%), discrimination/stigma (17.7%), economic hardship (30.8%), and most SDoH adversities (45.0%). Drug use was reported by 17.5% and 17.2% at time-point 1 and 2, respectively. WLWH with no/least SDoH adversities were less likely to report drug use than those in economic hardship class (weighted RR = 0.13; 95% CIs= 0.03, 0.63), discrimination/stigma class (weighted RR = 0.15; 95% CIs = 0.03, 0.78), and most SDoH adversities class (weighted RR = 0.13; 95% CIs = 0.03, 0.58). **Conclusions** Social determinants of health vulnerabilities are associated with greater likelihood of drug use, underscoring the significance of addressing interlinked social determinants and drug use through the course of HIV care and treatment.

Keywords Drug use; social determinants; HIV; women; CHIWOS; Canada.

INTRODUCTION

Illicit drug use, particularly opioids and stimulants, is common among people living with HIV (PLWH). For example, 10%, 24%, and 39% of PLWH in a US study reported heroin, amphetamines, and cocaine use, respectively, by any administration route [1]. Although data on the prevalence of drug use among women living with HIV (WLWH) is limited, 28.6% of WLWH reported recent crack cocaine use, with 3.2% as persistent users [2]. In Canada, available evidence showed that 25.0% and 11.3% of WLWH reported recent crack cocaine and heroin use (by any route), respectively [3].

Illicit drug use remains one of the most important factors influencing engagement in the HIV care cascade among individuals with HIV [1, 4-6]. Much evidence has documented poorer HIV treatment outcomes among people who use drugs, particularly among WLWH [5-11]. For example, greater suboptimal combination antiretroviral therapy (cART) adherence was documented among WLWH who reported a history of drug use than among women who did not, or among men regardless of drug use [7]. Drug use also predicts increased risk of disease progression, HIV transmission, and mortality [1, 2, 10], and continues to complicate HIV care and treatment efforts among PLWH [12, 13]. Although active drug use has been shown to complicate the clinical management of individuals with HIV and common comorbidities such as hepatitis C, increasing evidence documents how marginalization and criminalization of people who use/inject drugs interferes with access and adherence to HIV medications [14]. Particular

attention, therefore, needs to be given to such drug use practice throughout the course of HIV care and treatment among WLWH.

Although some determinants of illicit drug use are well documented (e.g., demographics, cognitive, behavioral) [15], few studies have explored the role of the social determinants of health (SDoH). The SDoH are the conditions (e.g., economic and social marginalization, and various forms of discrimination) in which people are born, work, live, and age, and the wider set of forces shaping the conditions of daily life that greatly contribute to health inequalities [16]. Greater adversities regarding these living conditions can lead to high levels of physiological and psychological stresses arising from coping with stressors [16]. For PLWH, HIV-related stigma in intersection with other social determinants (e.g., race and gender discrimination)[17] can result in coping behaviors such as illicit drug use [18] to help contend with worries and stresses [19], which can in turn increase vulnerabilities to HIV-related health outcomes [18, 20-22].

Notably, multiple dimensions of SDoH tend to co-occur, and may cluster together into common combinations. Such concomitant determinants have been consistently treated as independent when studied in association with drug use. For example, previous studies have assessed the separate association of HIV stigma [23], food insecurity [24], unemployment [25], and low social support [26] with drug use. However, there are limited data examining how clustering of these determinants is related to drug use. Such evidence is essential for developing HIV care and treatment programs to address potentially modifiable adversities and reduce their impacts on the lives of WLWH. Drawing on the Canadian HIV Women's Sexual and

Reproductive Health Cohort Study (CHIWOS) [27], we conducted a latent class analysis (LCA) to uncover underlying clusters of SDoH. LCA as a data reduction strategy classifies individuals into mutually exclusive and exhaustive latent classes using multiple categorical observed variables [28]. LCA has been a useful technique for identifying population subgroups in different disciplines (e.g., substance using women at risk for HIV [29]. We then applied inverse probability weighting to address confounding and selection bias in examining the association of the clusters of SDoH with drug use.

METHODS

Study sample

We used data from CHIWOS (www.chiwos.ca), a community-based cohort study. As previously described [27], CHIWOS is a large cohort of WLWH (≥16 years; trans inclusive) residing in the Canadian provinces of British Columbia (BC), Ontario, and Quebec. WLWH (n=1,422) were interviewed during 2013-2015 (time-point 1) and after ~18-months (time-point 2; n=1,252). We considered 170 participants (11.9%) lacking time-point 2 data as *censored*. Participants were recruited through peers, HIV clinics, AIDS service or community-based organizations, word of mouth, and other methods [30]. Trained Peer Research Associates (PRAs) administered the survey through in-person interviews at clinics, community sites, or participants' homes, or via phone/Skype. Informed consent was obtained from all participants prior to the interview,

consistent with the ethics protocol approved by Simon Fraser University, University of British Columbia/Providence Health, Women's College Hospital, and McGill University Health Centre.

Drug use

Recent drug use was defined as last three months at the first time-point and last six months at the second time-point, and included use of opioids (heroin, speedballs, Dilaudid, non-prescribed methadone, OxyContin/Oxycodone, morphine, Talwin & Ritalin) or stimulants (cocaine, crack, crystal methamphetamine, amphetamine, MDA). The regular (daily or at least once/week) or episodic (less than once/week) use of these drugs was ascertained among those who reported any use. Due to small proportions in the episodic use category (i.e., ~1%), a binary outcome at time-point 2 was created: use of any vs. no drugs.

SDoH indicators

A set of potentially modifiable SDoH that have the potential to co-occur among WLWH were examined at time-point 1, including: racial discrimination, gender discrimination, enacted HIV stigma, perceived social support, barriers to access to care, food security, housing status, income level, employment status, education, recent sex work involvement, and recent incarceration. Included SDoH indicators: a) were measured at the first survey time-point, b) are potentially modifiable, c) were currently or recently experienced, and; d) align with the Canadian list of SDoH [19] (HIV-related stigma being an exception specific to PLWH). Selection of SDoH was limited to current or recent conditions to avoid the potential for collider stratification bias [31]

that could be introduced in a selected (HIV-positive) sample by studying earlier social determinants that may have affected HIV status.

Racial discrimination was measured with the 8-item Everyday Discrimination Scale (current study α=0.96) [32]. In line with operationalization used in the prior research [33], WLWH who reported discriminatory experiences due to their race (e.g., treated with less courtesy, respect) sometimes, frequently, or almost every day were considered as having experienced racial discrimination. The same scale (with the same definition) focusing on discriminatory mistreatments due to gender was used to measure *gender discrimination* (α=0.94). *Enacted HIV stigma* was measured using three items of Wright's abridged 10-item version of Berger's HIV Stigma Scale (α=0.85), measuring the extent to which WLWH experienced enacted/personalized stigma toward PLWH [34]. Experience of HIV-related stigma was defined if WLWH reported any HIV-related discriminatory events with strongly agree/agree response options (i.e., been hurt by people's reaction, stopped socializing, or lost friends). *Social support* was examined by the 4-item Medical Outcome Study: Social Support Survey [35], measuring emotional-informational, tangible, affectionate, and positive social interaction supports (α=0.85). The overall mean score ranged 1-5, with > 2 indicating poor social support availability [36]. *Difficulties in access to care* was assessed using the 12-item Barriers to Access to Care Scale [37], measuring barriers experienced due to geography/distance, medical and psychological service, community stigma, and personal resource (α=0.93). The overall mean severity scores ranged 1-4, with ≥ 2 signifying severe/significant barriers [21]. Past-year experiences of *food*

security were examined by three items: fears of running out of food; experiences of running out of food; and unaffordability of balanced meals, yielding an overall score ranging 1-6, with > 1 indicating food insecurity [38]. *Income level* was defined as low if participants reported having a yearly household income level < $20,000. Current *employment status* was categorized as unemployed (no income or income only from non-employment sources such as unemployment/welfare, dividends and interest, or pension) vs. employed (any paid job). Current *education level* was dichotomized as below high school vs. completed high school or more. Current housing status was also measured. Participants who reported residing in places such as a self-contained room, transition house, halfway house, safe house, or outdoors were considered as *unstable housing*. Past six months *sex work involvement* was also included, and defined as having been provided with money, drug, shelter, food, etc. in exchange for sex. Finally, any past year experience of *incarceration* was included as a structural-level determinant indicating social exclusion.

Covariates

The following covariates were hypothesized to be associated with either both SDoH clusters and drug use or only drug use: age (continuous); ethnoracial groups (white/Caucasian, African/Caribbean/Black, Indigenous, others); province (BC, Ontario, Quebec); city size (large, others); sexual orientation (heterosexual, LGBQ); relationship status (married/common-law/relationship, others); years living with HIV (<6 years, 6-14 years, > 14 years); cART status (optimal [≥ 95% adherence], suboptimal [< 95% adherence], not engaged in HIV treatment);

ever diagnosed with a mental health condition; resilience (10-item Resilience Scale) [39]; any history of childhood sexual/physical violence; any experience of adulthood sexual/physical/verbal/action-limited violence; having been under the care of Child Protection Services or in foster care; and alcohol use (abstainers/low, moderate [1-7 drinks/week], heavy [> 7 drinks/week]). Drug use history before or at time-point 1 was also included to account for confounding by outcome history [40]. Missing values of covariates under the assumption of missing at random were singly imputed to reduce the loss of statistical power when computing inverse probability weights (IPW) [41].

Latent class analysis (LCA)

We used LCA to identify clusters of SDoH indicators. Under the assumption that latent classes are independent given the observed indicators, LCA aims to identify distinct groups of individuals with similar patterns within an unobserved categorical variable [28]. LCA was started with a two-class model and systematically increased to more classes (**Table S1**). LCA provides both class membership probabilities and item-response probabilities condition on class membership to help interpret the final identified class (**Table 1**). The expectation–maximization (EM) algorithm with 5,000 iterations was employed to identify the best model fit [42]. The selection of the best LCA model was informed by using goodness-of-fit indices, supporting statistics, and interpretability of class memberships. The following fit statistics were reported: log-likelihood, Akaike's information criterion (AIC), Bayesian information criterion (BIC), and sample-size-adjusted BIC (aBIC), and consistent AIC (CAIC) [43-45]. Lower values of these

criteria indicate better fit and parsimony. Two supporting statistics were also reported: Entropy as a measure of classification accuracy, with values approaching to 1 indicating better class separation [46], and the percentage of seeds associated with the fitting models, with values close to 100% indicating they were unlikely to have hit the local maxima. For each model, the log-likelihood was replicated with 1,000 random starting values to avoid local maxima. Under the assumption of missing at random, LCA accounted for missing values of the SDoH indicators using the full information maximum likelihood estimation. LCA was conducted using SAS PROC LCA procedure [47].

Models and estimations

We used inverse probability weights (IPW) [48, 49] to account for confounding due to the presence of potentially imbalanced covariates across the SDoH clusters, and inverse probability censoring weights (IPCW) to account for prospective selection bias due to potentially non-random loss to follow-up/censoring (**Table S2**). The product of these two weights yielded the final stabilized weights (**Table S3**), producing a pseudo-population in which the independent variable and covariates are unassociated (**Table S4**) [48]. In fitting models through IPW, we assumed correct specification of IPW models, conditional exchangeability, consistency, and positivity [50].

Control of confounding using IPW

SDoH clusters were modeled using a multinomial logistic regression to estimate stabilized weights: the numerator was computed as the marginal probability of the SDoH clusters divided

by the denominator, which was computed as the probability that a participant was assigned to an SDoH cluster given the covariates and opioid/stimulant use history. These models were all performed among participants without censored information in time-point 2.

Control of selection bias using IPCW

Additionally, to account for any potential selection bias due to differential loss-to-follow-up at time-point 2, we estimated IPCW using logistic regression models: *numerator* was defined as the probability of not being censored given SDoH, and *denominator* was computed as the probability of not being censored given SDoH, covariates and opioid/stimulant use history [48].

Association of SDoH clusters with drug use

The association between SDoH clusters and any opioid/stimulant use was examined using generalized linear models with log link and Poisson distribution; crude and weighted risk ratios (RRs) and 95% confidence intervals (CIs) were reported. Further adjustment was made for imbalanced covariates after applying the IPW. These analyses were conducted using Stata 15.

Sensitivity analysis

We reported E-value to evaluate the extent to which residual (unmeasured) confounding might explain away the observed associations, and computed as: $E = RR^{*} + \text{sqrt}\{RR^{*} \times RR^{*} - 1\}$, where $RR^{*} = 1/RR$ for $RR < 1$ [51]. E-value is a representation of the minimum strength of association that an unmeasured confounder would need to have with SDoH clusters and drug use to nullify the observed associations.

RESULTS

SDoH classes

Prevalences for individual social determinants ranged from 6.3% (N = 82/1307) and 6.5% (N = 92/1419) for recent sex work involvement and incarceration to 71.8% (N = 1004/1398) and 77.8% (N = 1098/1412) for enacted HIV stigma and unemployment, respectively (**Table 1**). After considering LCA fit statistics and model interpretability, the four-class model was determined as the optimal number of classes (**Table S1**). These four classes included WLWH with either none/least SDoH adversities (class 1 labeled as no/least SDoH adversities: N = 94 [6.6%]); WLWH who predominantly reported experiencing race and gender discrimination along with HIV-related stigma and barriers in access to care, but without economic hardship indicators (class 2 labelled as discrimination/stigma: N = 256 [18.0%]); WLWH who mainly reported food insecurity, low household income, and unemployment, accompanied with HIV-related stigma (class 3 labeled as economic hardship: N = 430 [30.2%]); and WLWH who experienced gender and race discrimination, HIV-related stigma, low social support, access to care difficulties, food insecurity, low income, and unemployment (class 4 labeled as most SDoH adversities: N = 642 [45.2%]).

Participants' characteristics

WLWH were an average of 42.8 [SD 10.6] years of age, with 584 (41.1%) members of the white ethnoracial group, 1237 (87.3%) heterosexual, 689 (48.5%) single, 552 (40.2%) living with HIV

for 6-14 years, 863 (70.0%) self-reporting optimal cART adherence; 819 (62.7%) and 1057 (80.4%) reported exposure to violence as children and adults, respectively, 573 (40.7%) reported a mental health diagnosis, and 140 (10.1%) were heavy alcohol users. The distributions of these covariates across the SDoH clusters are presented in **Table 2**.

SDoH clusters and drug use

Overall, opioid/ stimulant use at time-points 1 and 2 were respectively reported by 244 (17.5%) and 212 (17.2%.). Drug use at time-point 2 was reported by 143 (26.4%) among WLWH with most SDoH adversities, with 53 (14.1%), 13 (5.6%) and 3 (3.5%) for economic hardship, discrimination/stigma, and no/least SDoH classes, respectively (**Figure 1**). The crude regression analysis demonstrated that WLWH in the no/least SDoH adversities, discrimination/stigma, and economic hardship classes had significantly lower likelihood of opioid/stimulant use than WLWH in the most SDoH adversities class. Compared with the most SDoH adversities class, weighted analysis showed that WLWH in no/least SDoH class were at 87% decreased risk of drug use (RR 0.13, 95% CI: 0.03, 0.58), while an association was not observed for other classes. Additionally, WLWH in the no/least SDoH class were at decreased risk of drug use compared to WLWH in the economic hardship class (RR 0.13, 95% CI: 0.03, 0.63) and discrimination/stigma class (RR 0.15; 95% CI: 0.03, 0.78) (**Table 3**).

The sensitivity analysis suggested that these associations were relatively robust to potential unmeasured confounding. For instance, for the observed RR: 0.13 for drug use among those with no/least SDoH adversities versus those with most adversities, an unmeasured

confounder correlated with both exposure and outcome by RRs of ~14.86-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 association was 2.84-fold (**Table 3**).

DISCUSSION

In our study of data from a large prospective cohort of WLWH in Canada, we observed that most WLWH reported experiencing multiple forms of a set of mutually reinforcing SDoH. We identified two partially overlapped SDoH clusters of discrimination/stigma and economic hardship as well as one cluster containing most of the SDoH adversities. Most notably, we found that the prevalence of self-reported opioid/stimulant use was approximately seven times higher in WLWH who experienced the most SDoH adversities than those experiencing no/least adversity (26.4% vs. 3.5%). WLWH with no/least adversity were substantially less likely to report drug use at ~18 months follow up compared with WLWH experiencing an accumulation of social disadvantages.

Overall, the high prevalence of socio-structural adversities among WLWH is consistent with existing knowledge that women experience substantial SDoH vulnerabilities and multiple forms of these adversities [52, 53]. The majority of the SDoH indicators were well-distinguished across the SDoH classes using LCA analysis, except for low education, unstable housing, sex

work involvement, and incarceration. That these four determinants were less distinctive may be due to their relatively low proportions, likely resulted in a low overall impact on drug use in the current sample of WLWH.

We documented that the clustered classes of multiple SDoH adversities were associated with drug use. Notably, no difference was observed in the risk of drug use for the two classes of discriminations/stigma and economic hardship compared with the class with most SDoH adversities and also the same risk of drug use was estimated when WLWH in the no/least class were compared with WLWH in these two classes. Such findings may help shed light on the processes that generate and reinforce well-documented syndemics of HIV and substance use, by showing the role that each specific cluster of SDoH may play in initiation/continuation of drug use. Our results suggest that improving modifiable social determinants may be crucial to addressing this syndemic [54]. Harm reduction and treatment interventions need to seriously consider the important role of multiple SDoH – regardless of their types. Drug treatment programs that mainly focus on behavior change interventions may result in limited impact if no additional efforts are made to change the social environments of drug users [55].

Our findings may also have implication for HIV care and treatment programs by illuminating the association of current social determinants with illicit drug use, which has been shown to create challenges within the HIV care cascade. Prior evidence has demonstrated how income level [56], HIV stigma [22], and food insecurity [57] increase vulnerabilities to suboptimal cART adherence by limiting access to HIV care and treatment services, and affecting

individuals' health seeking behaviors. Illicit drug use, e.g., crack cocaine, also impacts HIV clinical care through the same mechanism of HIV treatment interruptions [2, 10, 11, 58]. Individually or combined, these factors can threaten the benefits accompanied with early HIV treatment initiation and the commitments toward eliminating the HIV pandemic. Paying particular attention to these interlinked social and drug use determinants should be a key priority in efforts to improve HIV medical care for WLWH, and merits continued and thorough investigation. Given the impacts of these SDoH adversities and risk practices on HIV care and treatment outcomes, these findings indicate a need for regular assessment of these factors and targeted support for women with greater needs within routine HIV care [59], which if addressed holistically, may reduce the likelihood of suboptimal HIV clinical outcomes.

While this study took advantage of CHIWOS as the largest community-based research cohort of WLWH in Canada, it had some limitations. First, non-random sampling of the participants may limit the generalizability and interpretation of our findings. Second, we relied on self-reported drug use, which may be subject to social desirability bias; however, participants were interviewed by PRAs who also experienced living with HIV (and in some cases, using drugs), and this may have limited such bias. Third, although unmeasured confounding is a source of bias in observational research, our sensitivity analysis showed that relatively strong unmeasured confounding would be required to nullify the observed associations.

The current research has several strengths despite these limitations: First, we used data from a nationwide large sample of WLWH. Second, our research extends the relatively limited

extant knowledge on drug use among women with HIV. Third, our research contributes to theoretical development through examining the inclusion of detailed individual-level data of current and modifiable social determinants as leading stressors in the target population's daily life. Fourth, we demonstrated how these determinants cluster together using LCA, a probability-based technique that provides a better insight into the underlying clusters of the individual SDoH indicators given the concurrent occurrence of these determinants. Fifth, IPW was used to account for both confounding and selection bias. Finally, the survey had a high retention rate (88%) after 18 months of follow-up.

Despite a growing body of evidence on the independent associations between social determinants and drug use, less focus has been put on ways these determinants overlap, or on their clustering impacts on drug use. The complex relationships between the SDoH indicators, the documented (individual) associations with barriers to care, and stigma that surrounds both drug use and many aspects of social adversity suggest that HIV care programs will need to make intentional efforts to ensure that patients have full access to optimal care across the HIV care cascade. Our findings support the targeted assessment of multiple social determinant and drug use vulnerabilities; HIV-specific and women-centered care models have good potential to create the kind of low-stigma environment that would allow for these issues to be both assessed and addressed [60]. Developing evidence-based treatment for drug dependence, including harm reduction strategies, requires a recognition of the role of social determinants of health. Individuals with these socio-structural adversities in intersection with drug use may continue to

experience greater challenges with regard to HIV treatment adherence and HIV outcomes; therefore, the continued support for individuals with greater vulnerabilities is required.

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Table 1 Class Membership Probabilities and Item-Response Probabilities of Social Determinants of Health (SDoH) from the Latent Class Analysis (LCA) among Women Living with HIV – CHIWOS (N=1,422).

SDoH measures		None/least SDoH (N = 94; 6.6%)[b]	Discrimination and Stigma (N = 256; 18.0%)	Economic hardship (N = 430; 30.2%)	Most SDoH adversities (N = 642; 45.2%)
Race discrimination	No	0.00	0.40[c]	0.91	0.18
(708/1408; 50.3%)[a]	Yes	0.00	**0.60**	0.09	**0.82**
	None[d]	1.00	0.00	0.00	0.00
Gender discrimination	No	0.00	0.33	0.91	0.04
(818/1415; 57.1%)	Yes	0.00	**0.67**	0.09	**0.96**
	None	1.00	0.00	0.00	0.00
Enacted HIV stigma	No	0.00	0.22	0.40	0.17
(1004/1398; 71.8%)	Yes	0.00	**0.78**	**0.60**	**0.83**
	None	1.00	0.00	0.00	0.00
Low social support	No	0.00	0.51	0.51	0.37
(722/1367; 52.8%)	Yes	0.00	0.49	0.49	**0.63**
	None	1.00	0.00	0.00	0.00
High barriers to access to	No	0.00	0.43	0.55	0.36
care	Yes	0.00	**0.57**	0.45	**0.64**

(725/1371; 52.8%)	None	1.00	0.00	0.00	0.00
Food insecurity	No	0.00	0.63	0.31	0.18
(907/1416; 64.1%)	Yes	0.00	0.37	**0.69**	**0.82**
	None	1.00	0.00	0.00	0.00
Low income	No	0.00	0.90	0.21	0.11
(901/1379; 65.3%)	Yes	0.00	0.10	**0.79**	**0.89**
	None	1.00	0.00	0.00	0.00
Unemployment	No	0.00	0.67	0.09	0.02
(1098/1412; 77.8%)	Yes	0.00	0.33	**0.91**	**0.98**
	None	1.00	0.00	0.00	0.00
Low education	No	0.00	1.00	0.83	0.75
(227/1415; 16.0%)	Yes	0.00	0.00	0.17	0.25
	None	1.00	0.00	0.00	0.00
Unstably housed	No	0.00	0.99	0.90	0.83
(152/1422; 10.7%)	Yes	0.00	0.01	0.10	0.17
	None	1.00	0.00	0.00	0.00
Recent sex work practice	No	0.00	0.99	0.95	0.90
(82/1307; 6.3%)	Yes	0.00	0.01	0.05	0.10
	None	1.00	0.00	0.00	0.00
Recent incarceration	No	0.00	1.00	0.96	0.88

(92/1419; 6.5%)	Yes	0.00	0.00	0.04	0.12
	None	<u>1.00</u>	0.00	0.00	0.00

[a] (n/N; %) indicating the prevalence of the SDoH indicators under the study; [b] Class membership probabilities; [c] Item-response probabilities, indicating the probability of experiencing a SDoH indicator for each identified latent class; [d] We categorized each SDoH measure into three categories: No: indicating either did not have/experience this determinant, Yes: indicating either living/experiencing this determinant, None: indicating either did not experience any of these 12 determinants or experienced only one (i.e., least). Item response probabilities of "Yes" category ≥ 0.50 are bolded, and item response probabilities of "None" category with 100% are underlined. The "None" category was added to produce a distinct class named "None/leased SDoH adversities" in order to ease interpretation of the latent classes and reduce LCA model complexity.

Table 2 Characteristics of Women Living with HIV (WLWH) across the Social Determinants of Health (SDoH) Classes– CHIWOS Time-point 1, 2013-2015 (N = 1,422).

Variables	Overall	SDoH classes				
		None/least adversities	Discrimination/ stigma	Economic hardship	Most adversities	P-value[b]
Age, yr[d] (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 group						<0.001
White/Caucasian	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
Bing 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 HIV treatment						0.001
Yes, optimal (≥ 95%)	863 (70.0)	65 (69.9)	163 (64.7)	279 (65.0)	356 (55.5)	
Yes, suboptimal (< 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
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
Heavy alcohol use						0.132
Abstainers/low (< 1 drink/week)	956 (69.1)	64 (68.8)	174 (68.5)	302 (71.1)	419 (68.1)	
Moderate (1-7 drinks/week)	288 (20.8)	22 (23.7)	60 (23.6)	88 (20.7)	118 (19.2)	
Heavy (> 7 drinks/week)	140 (10.1)	7 (7.5)	20 (7.9)	35 (8.2)	78 (12.7)	
Drug use history[d]						
Before study entry	234 (16.8)	3 (3.2)	10 (3.9)	48 (11.24)	173 (27.5)	<0.001
At entry (time-point 1)	244 (17.5)	2 (2.2)	11 (4.3)	50 (11.9)	181 (28.8)	<0.001

[a] Data are presented as N (%) unless specified; [b] P-values are for the chi-square test for categorical covariates and one-way ANOVA for continuous covariates; [c] Scores ranged 10-70, with higher scores indicating increased resilience (median = 64); [d] Opioid/stimulant

use histories before and at time-point 1.

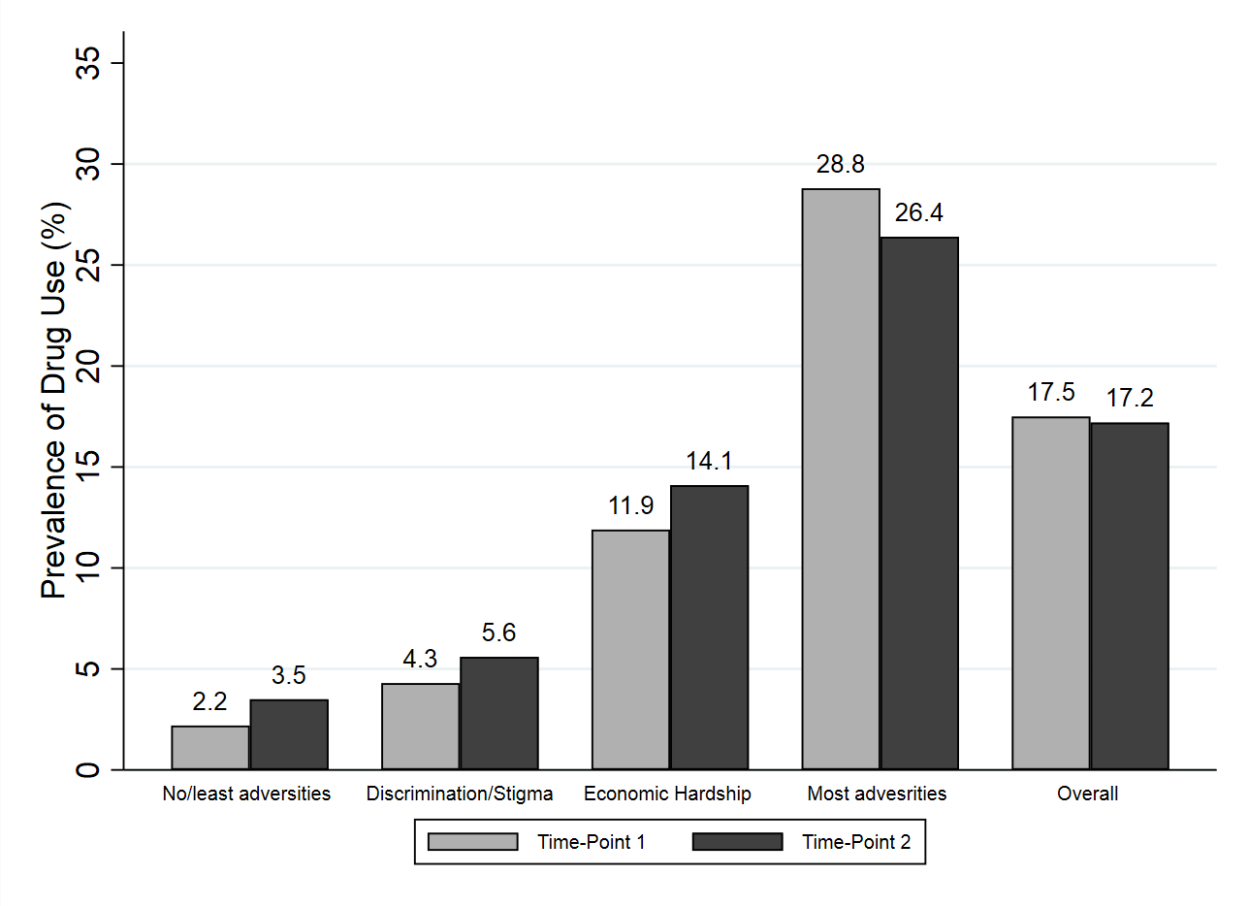
Table 3 Inverse Probability Weighted Estimates of the Association of the Social Determinants of Health (SDoH) Classes with Drug Use among Women Living with HIV (WLWH) – CHIWOS[a].

	Observed estimates				E-value for the observed estimates [c]	
SDoH classes[c]	Crude RR[b] (95% CI)	P-value	Weighted RR (95% CI)	P-value	Weighted RR	Upper CI
Economic hardship class vs. Most SDoH adversities	0.53 (0.40, 0.71)	<0.001	0.95 (0.67, 1.34)	0.760	---	---
Discrimination/stigma class vs. Most SDoH adversities	0.21 (0.12, 0.37)	<0.001	0.82 (0.44, 1.52)	0.539	---	---
None/least adversities class vs. Most SDoH adversities	0.13 (0.04, 0.40)	<0.001	**0.13 (0.03, 0.58)**	0.008	14.86	2.84
Discrimination/stigma class vs. Economic hardship	0.40 (0.22, 0.71)	0.002	0.87 (0.44, 1.68)	0.678	---	---
None/least adversities class vs.	0.24	0.015	**0.13**	0.011	14.86	2.55

Economic hardship	(0.07, 0.76)		**(0.03, 0.63)**				
None/least adversities class vs.	0.61	0.440	**0.15**	0.024			
					11.81	1.88	
Discrimination/stigma	(0.18, 2.1)		**(0.03, 0.78)**				

[a] N = 1,236 in crude analysis and N= 1,225 in weighted analysis; [b] RR: risk ratio (95% confidence intervals: CI); [c] This is a sensitivity analysis evaluating the extant to which an unmeasured confounder would explain away the exposure-outcome estimates observed for the association between the SDoH classes and drug use. E-value was check for the observed point estimate and the upper 95% CI that is close to the null RR = 1.

Figure 1 Prevalence of Drug Use[a] According to the Social Determinants of Health (SDoH) Classes Obtained from the Latent Class Analysis (LCA) – CHIWOS[b].



[a] Stimulants: cocaine, crack (crack cocaine), crystal, speed (amphetamine) and MDA; Opioids: heroin, speedballs (heroin+ cocaine), Dilaudid (hydromorphone), non-prescription use of methadone, OxyContin/Oxycodone, morphine, Talwins & Ritalin. These drugs were measured at baseline (time-point 1, 2013-15) and in ~18 month follow up (time-point 2; 2015-17); [b] Analytic sample size for these prevalences was 1,395 at time-point1 and 1,236 at time-point 2.

Supplementary tables

Table S1 Comparison of Goodness-of-fit Measures for Different Class Models (N=1,422)

Model	**LL**[a]	**AIC**[b]	**BIC**[c]	**CAIC**[d]	**Entropy**	**% seeds**[e]
1-class	-12363.0	10080.9	10207.2	10231.2	1.000	100%
2-class	-8582.2	2569.1	2826.9	2875.9	1.000	100%
3-class	-8271.3	1997.4	2386.7	2460.7	0.843	98.4%
4-class[f]	*-8030.0*	*1564.9*	*2085.6*	*2184.6*	*0.831*	*93.5%*
5-class	-7966.5	1487.8	2140.0	2264.0	0.819	35.0%
6-class	-7922.1	1449.0	2232.7	2381.7	0.814	15.0%
7-class	-7889.8	1434.5	2349.7	2523.7	0.745	32.4%

[a] Log-Likelihood (LL); [b] Akaike information criterion (AIC); [c] Bayesian information criterion (BIC); [d] Consistent AIC (CAIC), [e] Percentage of seeds associated with best fitted model (% seeds); [f] 4-class model had the lowest BIC and CAIC. Moving forward to model with more classes, entropy suggested lower classification accuracy (e.g., ~10% reduction from 4-class to 7-class). In addition, the 4-class model had a higher percentage of seeds associated with best fitted model (i.e., increased confidence that the best solution was achieved even though it is not a fit criterion). Fit indices/statistics align with model interpretability suggested the 4-class model provided a better fit with plausible distribution of the sample within each class.

Table S2 Characteristics of Women Living with HIV (WLWH) Who Were Lost to Follow-up (i.e., censored), CHIWOS, 2013-2017

Variables	Not Lost to follow up (N = 1252)	Lost to follow up (N = 170)	P-value
SDoH classes			0.057
Class 1: No/least SDoH adversities	88 (7.03)	6 (3.53)	
Class 2: Discrimination/Stigma	232 (18.53)	24 (14.12)	
Class 3: Economic adversities	381 (30.43)	49 (28.82)	
Class 4: Most SDoH adversities	551 (44.01)	91 (53.53)	
Age, yr[d] (mean [SD])	42.9 [10.61]	42.2 [10.34]	0.430
Ethno-racial group			0.062
White/Caucasian	515 (41.13)	69 (40.59)	
African/Caribbean/Black	380 (30.35)	38 (22.35)	
Indigenous	272 (21.73)	46 (27.06)	
Other	85 (6.79)	17 (10.00)	
Province			0.018
Ontario	637 (50.88)	80 (47.06)	
British Columbia	299 (23.88)	57 (33.53)	
Quebec	316 (25.24)	33 (19.41)	
Living in large cities	1029 (82.19)	140 (82.35)	0.958
heterosexual	1095 (87.81)	142 (83.53)	0.116
Relationship status			0.596
Single (non-married)	612 (48.92)	77 (45.56)	

Married/common-law	394 (31.49)	60 (35.50)	
Others	245 (19.58)	32 (18.93)	
Years living with HIV			0.648
< 6 years	310 (25.49)	35 (22.15)	
6-14 years	487 (40.05)	65 (41.14)	
> 14 years	419 (34.46)	58 (36.71)	
Taking HIV treatment			0.012
Yes, optimal (≥ 95%)	759 (60.91)	104 (61.54)	
Yes, suboptimal (< 95%)	264 (21.19)	48 (28.40)	
Not engaged in treatment	223 (17.90)	17 (10.06)	
Mental health diagnosis	499 (40.21)	74 (44.58)	0.282
Resiliency (below median)	568 (45.81)	94 (56.97)	0.007
Childhood violence	708 (61.51)	111 (71.15)	0.019
Adulthood violence	918 (79.07)	139 (90.26)	0.001
Child development events	269 (21.55)	57 (33.73)	<0.001
Heavy alcohol use			0.011
Abstainers/low (< 1 drink/week)	865 (70.44)	94 (59.12)	
Moderate (1-7 drinks/week)	242 (19.71)	46 (28.93)	
Heavy (> 7 drinks/week)	121 (9.85)	19 (11.95)	
Stimulant/opioid use			
Before study entry	187 (15.19)	47 (28.31)	<0.001
At entry (time-point 1)	193 (15.70)	51 (30.72)	<0.001

Table S3 Distributions of the Estimated Weights for the Classes of the Social Determinants of Health (SDoH), Censoring, and Both, CHIWOS, time-point 1, 2013-2015

	Mean (SD)	Percentiles				
		5th	25th	50th	75th	95th
Stabilized weights for SDoH weights						
Class 1	0.90 (1.30)	0.16	0.26	0.46	0.95	3.21
Class 2	0.96 (0.82)	0.39	0.54	0.74	1.04	2.20
Class 3	1.00 (0.67)	0.50	0.63	0.80	1.12	2.26
Class 4	0.99 (0.60)	0.48	0.60	0.81	1.18	2.01
Overall	0.98 (0.73)	0.43	0.58	0.78	1.13	2.18
Stabilized weights for censoring weights						
Overall	0.99 (0.08)	0.91	0.94	0.98	1.02	1.14
Stabilized weights for final weights						
Class 1	0.89 (1.38)	0.15	0.26	0.45	0.93	3.18
Class 2	0.97 (0.86)	0.39	0.53	0.73	1.02	2.30
Class 3	1.02 (0.75)	0.47	0.62	0.78	1.13	2.35
Class 4	0.97 (0.55)	0.50	0.62	0.81	1.15	1.89
Overall	0.98 (0.76)	0.43	0.58	0.77	1.12	2.12

Table S4 Inverse-Probability Weighted Estimates of the Parameters of a Marginal Structural Model for the Association of the Classes of the Social Determinants of Health (SDoH) on Drug Use among Women Living with HIV (WLWH), CHIWOS, Canada, 2013-2017

	SDoH classes[a]		
Variables	No/least SDoH adversities	Discrimination/ stigma	Economic adversities
Age, yr (mean)	0.99 (0.95, 1.02)	0.99 (0.97, 1.01)	1.00 (0.98, 1.01)
Ethno-racial groups			
White/Caucasian	1	1	1
Indigenous	1.01 (0.29, 3.46)	0.91 (0.5, 1.66)	0.88 (0.56, 1.38)
African/Caribbean/Black	0.75 (0.36, 1.56)	0.87 (0.57, 1.32)	0.96 (0.67, 1.38)
Other	0.58 (0.18, 1.85)	0.98 (0.48, 1.99)	0.99 (0.53, 1.86)
Study province			
Ontario	1	1	1
British Columbia	0.61 (0.21, 1.78)	0.63 (0.39, 1.02)	1.05 (0.69, 1.59)
Quebec	0.77 (0.35, 1.67)	0.90 (0.56, 1.45)	1.00 (0.69, 1.43)
Living large size cities	1.08 (0.42, 2.74)	1.11 (0.70, 1.76)	0.96 (0.63, 1.48)
Heterosexual	0.60 (0.14, 2.56)	1.65 (0.86, 3.14)	1.22 (0.76, 1.95)
Relationship status			
Single (non-married)	1	1	1
Married	0.84 (0.38, 1.85)	0.81 (0.53, 1.25)	1.07 (0.74, 1.56)
Others	0.89 (0.31, 2.55)	0.78 (0.49, 1.26)	1.02 (0.68, 1.53)
Years living with HIV			
< 6 years	1	1	1
6-14 years	1.22 (0.49, 3.05)	0.88 (0.52, 1.49)	0.91 (0.62, 1.34)
> 14 years	1.53 (0.68, 3.48)	0.89 (0.52, 1.52)	0.95 (0.63, 1.41)
Taking HIV treatment			

Yes, optimal	1	1	1
Yes, suboptimal	0.57 (0.23, 1.42)	1.11 (0.66, 1.87)	1.02 (0.67, 1.55)
Not in treatment	0.75 (0.32, 1.78)	0.97 (0.55, 1.70)	0.89 (0.59, 1.36)
Mental health diagnosis	1.44 (0.66, 3.18)	0.82 (0.55, 1.23)	0.94 (0.68, 1.31)
Resiliency (below median)	0.48 (0.22, 1.03)	0.90 (0.6, 1.34)	0.97 (0.71, 1.34)
Childhood violence	1.02 (0.51, 2.03)	0.89 (0.59, 1.34)	0.95 (0.69, 1.32)
Adulthood violence	0.71 (0.33, 1.53)	0.90 (0.55, 1.45)	0.92 (0.62, 1.37)
Childhood development events	0.67 (0.22, 2.02)	0.98 (0.56, 1.70)	0.96 (0.63, 1.45)
Heavy alcohol use			
Abstainers/low (< 1 drink/week)	1	1	1
Moderate (1-7 drinks/week)	1.55 (0.55, 4.34)	0.98 (0.62, 1.57)	0.87 (0.58, 1.30)
Heavy (> 7 drinks/week)	0.30 (0.12, 0.79)[b]	1.68 (0.79, 3.55)	0.97 (0.57, 1.67)
Stimulant/opioid use			
Before study entry	0.95 (0.17, 5.38)	0.84 (0.37, 1.90)	0.88 (0.55, 1.41)
At entry (time-point 1)	0.89 (0.16, 5.06)	0.72 (0.32, 1.58)	0.95 (0.61, 1.50)

[a] Base class in multinomial logistic regression was most SDoH adversities; [b] Further adjustment for this imbalanced covariate resulted in no changes in the regression estimates presented in Table 3.