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THE POPULATION IMPACT OF ELIMINATING HOMELESSNESS ON HIV VIRAL SUPPRESSION AMONG PEOPLE WHO USE DRUGS

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Abstract

Objective—We sought to estimate the change in viral suppression prevalence if homelessness were eliminated from a population of HIV-infected people who use drugs (PWUD).

Design—Community-recruited prospective cohort of HIV-infected PWUD in Vancouver, Canada. Behavioral information was collected at baseline and linked to a province-wide HIV/AIDS treatment database. The primary outcome was viral suppression (<50 copies/mL) measured during subsequent routine clinical care.

Methods—We employed an imputation-based marginal modelling approach. First, we used modified Poisson regression to obtain effect estimates (adjusting for sociodemographics, substance use, addiction treatment, and other confounders). Then, we imputed an outcome probability for each individual while manipulating the exposure (homelessness). Population viral suppression prevalence under realized and “housed” scenarios were obtained by averaging these probabilities across the population. Bootstrapping was conducted to calculate 95% confidence limits.

Results—Of 706 individuals interviewed between January 2005 and December 2015, the majority was male (66.0%), of Caucasian race/ethnicity (55.1%), and had a history of injection (93.6%). At first study visit, 223 (31.6%) reported recent homelessness, and 37.8% were

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subsequently identified as virally suppressed. Adjusted marginal models estimated a 15.1% relative increase (95%CI: 9.0%, 21.7%) in viral suppression in the entire population—to 43.5% (95%CI: 39.4%, 48.2%)—if all homeless individuals were housed. Among those homeless, eliminating this exposure would increase viral suppression from 22.0% to 40.1% (95%CI: 35.1%, 46.1%), an 82.3% relative increase.

Conclusions—Interventions to house homeless, HIV-positive individuals who use drugs could significantly increase population viral suppression. Such interventions should be implemented as a part of renewed HIV/AIDS prevention and treatment efforts.

Keywords

homelessness; HIV; viral suppression; population health; structural intervention; causality; intervention studies

INTRODUCTION

HIV infection remains a major cause of morbidity and mortality among homeless persons [1, 2]. The prevalence of HIV infection among the global homeless population (estimated at 100 million worldwide) ranges from 0.3% to over 20.0% [3]. Studies investigating the relationship between housing and the health of persons infected with HIV have found homelessness to be a critical barrier to effective antiretroviral therapy (ART) utilization, and an independent risk factor for sub-optimal HIV treatment outcomes [4, 5]. For example, homelessness has been associated with a reduced likelihood of ART initiation [6], poorer adherence to therapy [7], and lower rates of HIV viral suppression [8, 9]. Among homeless individuals living with HIV, substance use, mental health problems, a lack of social support, food insecurity, and other unmet subsistence needs have been found to be key drivers of poor health and HIV treatment outcomes [9–11].

Despite the established deleterious relationship between homelessness and effective ART [12], few studies have examined the efficacy of housing interventions for HIV-infected persons [13]. Of published studies, results are equivocal. For example, the Chicago Housing for Health Partnership (CHHP) study was a randomized controlled trial of supportive housing placement and intensive case management for chronically ill homeless persons with HIV [14]. Persons who received the intervention were approximately twice as likely to have an undetectable viral load at 12 months, compared to control patients who received discharge planning and referral services (relative risk = 1.93, $p = 0.051$). A second randomized controlled trial, the Housing and Health Study, enrolled homeless and unstably housed people with HIV infection in Los Angeles, Chicago, and Baltimore to examine the efficacy of case management and housing provision through a rental assistance program [15]. In contrast to the CHHP study, this intervention did not demonstrate a significant effect on viral suppression: at 18 months the proportion with an undetectable viral load was 43.0% and 36.6% in the treatment and control conditions, respectively ($p = 0.956$). However, this study was limited by the fact that many persons in the control condition obtained stable housing during the follow-up period. In the as-treated analysis, homelessness was associated with having a detectable viral load (i.e., 61.4% among continuously housed participants and 79.1% among persons who experienced homelessness for at least one night) [16].

Given the inconsistency of findings to date, additional studies are needed to determine the extent to which eliminating homelessness could improve HIV treatment outcomes and prevent onward viral transmission to uninfected populations. However, substantial logistical and methodological challenges impede the conduct of additional randomized controlled trials of housing interventions for homeless people living with HIV. Although non-randomized studies provide important insights, traditional analyses of observational data produce *exposure effects* (the impact of a particular exposure at the individual level, averaged over the population), rather than *population intervention effects* (the causal effect of an intervention on an entire population) [17]. Although causal inference methods to identify population intervention effects from observational data have been developed [18], such methods have not been widely adopted. This is despite the fact that population intervention effects are often of greater policy relevance, since results represent the effect of intervening on an exposure (e.g., homelessness) in the entire population [19]. Moreover, we are unaware of any studies that have sought to identify the intervention effect of eliminating homelessness among people who use drugs (PWUD), a population at particularly high risk for both HIV infection and homelessness [20].

Here, we employ an imputation-based marginal modelling approach to estimate the change in viral suppression prevalence among HIV-infected PWUD, if homelessness were eliminated from the population. We use data from an ongoing cohort study of PWUD in Vancouver, Canada, where HIV/AIDS treatment and care is free of charge and universal, and thus the relationship between homelessness and viral suppression is free of the confounding effects of financial barriers to HIV treatment.

METHODS

Study design, eligibility criteria, and data sources

We examined data collected as part of the AIDS Care Cohort to Evaluate Exposure to Survival Services (ACCESS) study, which enrolled HIV seropositive PWUD in Vancouver, Canada. The sampling and recruitment procedures have been described in detail previously [21–23]. In brief, word-of-mouth, snowball sampling, and street-based outreach were used to advertise the study and recruit participants. Outreach was focused in Vancouver's Downtown Eastside, an inner city neighborhood with an established open drug market and high levels of poverty, injection drug use, poor housing, and HIV infection [24]. Outreach activities were conducted in harm reduction services, health care settings, and open drug-using areas (e.g., parks, street corners) in the neighborhood.

Individuals were eligible to participate in ACCESS if at the time of enrolment they were aged 18 years or older, HIV seropositive, and reported use of illicit drugs other than, or in addition to, cannabis in the past month. HIV status was confirmed at enrolment using enzyme-linked immunosorbent assay and Western blot. All eligible subjects provided written informed consent prior to enrolment. At baseline and semi-annually, participants completed an interviewer-administered questionnaire and underwent examination by a study nurse. Sociodemographic information, as well as data on drug use patterns, housing status, trauma, mental health problems, and health care utilization was collected. Participants were

compensated \$30 CAD for each visit. The University of British Columbia/Providence Healthcare Research Ethics Board approved the ACCESS study.

The data collected during the interview process were augmented with comprehensive clinical information on HIV care and treatment outcomes managed by the British Columbia Centre for Excellence in HIV/AIDS (BCCfE). Specifically, the BCCfE maintains a population-based, centralized ART dispensary and HIV/AIDS clinical monitoring program for all individuals who have ever had a viral load test or accessed antiretroviral therapy in the province [25]. Thus, this registry provides a complete profile of all CD4 T-cell count and HIV RNA plasma viral load measurements for all HIV seropositive patients in the province of British Columbia. The registry also contains confidential HIV treatment pharmacy dispensation data. As in previous studies [7, 26], ART adherence was defined as the number of days in which ART was dispensed, divided by the number of days an individual was eligible for ART in the past six months. This proportion was dichotomized to represent 95% versus <95% adherence. Information from this database was extracted and linked to each ACCESS participant using a unique, government-issued personal health identifier collected during the first study visit.

Study sample

Between January 1, 2005 and December 31, 2013, 770 persons completed at least one baseline or follow-up assessment. Of these participants, four (0.5%) did not have a viral load value recorded within 365 days following the date of the behavioral interview, six (0.8%) did not provide information pertaining to recent homelessness, and 54 (7.0%) were missing other covariates of interest. Thus, the final analytic sample was 706. Participants who were excluded did not differ with respect to gender ($p=0.069$), racial/ethnic origin ($p=0.167$), or viral suppression status ($p=0.289$), but were more likely to be 18–34 years of age (35.9% vs. 18.4%, $p=0.003$).

Measures

For this analysis, we examined behavioural data collected from each participant's first visit during the study period. The primary independent variable was reporting homelessness any time in the past 6 months. To be consistent with prior work [9], homelessness was defined as living on the street with no fixed address. The primary outcome of interest was HIV RNA plasma viral load. Specifically, we analyzed the result obtained during the first viral load test in the BCCfE registry within 365 days following the date of the first behavioural interview during the study period. We defined a viral load as undetectable an observation that was less than 50 copies/mL.

Other covariates of interest were selected based on a review of previous literature examining the relationship between homelessness and effective antiretroviral therapy utilization among PWUD. We also considered variables theorized to potentially confound the relationship between housing status and viral suppression among PWUD. Sociodemographic characteristics included were age (18–34 vs. 35–51 vs. >51); sex at birth (male vs. female); self-reported racial/ethnic origin (Caucasian vs. non-Caucasian); and educational attainment (<high school vs. high school completion). We also included the following lifetime

experiences or activities: ever been hospitalized for a mental illness (yes *vs.* no), history of injection drug use (yes *vs.* no), history of incarceration (overnight stay or longer, yes *vs.* no), sexual abuse (defined as any coerced or forced sexual activity before the age of 19, yes *vs.* no), physical abuse (defined as experiencing physical violence committed by parents, a relative, or others in a position of authority before the age of 19, yes *vs.* no), and sex work involvement (receipt of money, gifts, food, shelter, clothes or drugs in exchange for sex, yes *vs.* no). We used the Center for Epidemiologic Studies Depression (CES-D) scale as a measure of depressive symptomatology, with scores greater than 22 indicating depression [27]. Finally, we included the following, all defined as occurring within 6 months of the baseline interview: participation in a methadone program (yes *vs.* no); enrolment in any other kind of non-methadone based addiction treatment (including detox, residential treatment, behavioural therapy, or support groups, yes *vs.* no); and any formal employment (having a regular job, temporary work, or self employment, yes *vs.* no). We included year of the interview as a categorical variable in all models. Since we were interested in estimating the total causal population-level effect of homelessness on viral suppression, we did not adjust for factors that could lie on the causal pathway between homelessness and viral suppression: for example, adherence to ART, and current patterns of drug use (including recent binge drug use, defined as any use significantly more than usual). The relationship between these variables and viral suppression is shown in Table 1.

Statistical analyses

Several descriptive analyses were conducted initially, including summaries of the prevalence and distribution of the covariates. Next, homelessness and all covariates were examined in association with having an undetectable viral load using modified Poisson regression [28]. Crude prevalence ratios describing each relationship are reported. Then, we constructed a multivariable modified Poisson regression model to estimate the independent relationship between homelessness and viral suppression. We included all measured covariates in the model to fully control for potential confounding.

On the basis of the model described above, we employed an imputation-based marginal modelling approach to estimate the population effect of eliminating homelessness on viral suppression. The principles and mechanics of the approach are detailed in the Supplemental Material. In brief, this method, described previously [18], estimates the overall effect of a hypothetical public health intervention on an outcome of interest in the entire study population. First, the effect estimates from the multivariable model described above are used to predict the outcome (i.e., viral suppression) for each individual, *had* she or he been housed. Second, the imputed individual outcome probabilities are averaged to estimate the population viral suppression prevalence, had all individuals been housed. Third, confidence intervals for these prevalences were bootstrapped using the percentile method [29]. Finally, we compared the viral suppression prevalence observed empirically to that estimated if all individuals had been housed. Specifically, we calculated the relative increase in the proportion virally suppressed among the entire study population and also only among those homeless at baseline.

Finally, recognizing that completely eliminating homelessness might not be a realistic goal in some settings, we conducted several secondary analyses. Specifically, we modelled scenarios representing interventions in which: (1) 50% of homeless population (chosen at random) are housed, and (2) all persons not enrolled in an addiction treatment program are provided housing. The latter represents a “Housing First” model, in which housing is provided without the requirement that persons are abstinent from alcohol and drug use, or are actively engaged in substance abuse treatment [30]. All statistical analyses were conducted in SAS version 9.3 (SAS Institute Inc., Cary, NC), and all p-values are two-sided.

RESULTS

Of 706 eligible participants, 466 (66.0%) were male, 389 (55.1%) were of Caucasian racial/ethnic origin, and the majority ($n = 485$, 68.7%) was between 35 and 51 years of age. At first study visit, 223 (31.6%) participants reported recent homelessness. The mean time between study visit and viral load ascertainment was 22.4 days ($SD=52.0$). The proportion with viral suppression was 37.8% ($n=267$). As shown in table 1, participants reporting recent homelessness were significantly less likely to have an undetectable viral load: 22.0% among those homeless versus 45.1% among those not homeless (prevalence ratio [PR] = 0.49; 95%CI: 0.37, 0.64; $p<0.001$). Other factors that were associated with a decreased likelihood of having an undetectable viral load included younger age, reporting a history of injection drug use, reporting a history of incarceration, recent daily injection heroin use, recent daily crack use, and $<95\%$ adherence (all $p<0.05$, see Table 1). Factors associated with an increased likelihood of having an undetectable viral load included older age, being male, recent participation in a methadone program, and reporting any recent addiction treatment (all $p<0.05$, see Table 1).

The results of the final modified Poisson regression model are shown in table 2. After adjusting for potential confounders, persons reporting recent homelessness were approximately half as likely to have an undetectable viral load (adjusted prevalence ratio [APR] = 0.55; 95%CI: 0.42, 0.71; $p<0.001$). Age was also independently associated with viral suppression: compared to persons 35–51, older individuals were more likely to have an undetectable viral load ($APR=1.33$; 95%CI: 1.08, 1.65; $p=0.008$), while younger individuals were less likely to be virally suppressed ($APR=0.54$; 95%CI: 0.38, 0.78; $p=0.001$). Participation in a methadone program ($APR=1.35$; 95%CI: 0.99, 1.83; $p=0.056$) and higher educational attainment ($APR=1.19$; 95%CI: 0.99, 1.43; $p=0.058$) approached statistical significance.

Using the estimates from the multivariable model shown in table 2, we generated marginal estimates for the population effect of eliminating homelessness on viral suppression. These results are shown in figure 1. If the whole study population had been housed, the estimated prevalence of HIV viral suppression would have been 43.5% (95%CI: 39.4%, 48.2%), representing a 15.1% relative increase (see panel A). Among those homeless at first study visit, the HIV viral suppression prevalence observed empirically was 22.0%. If these individuals had been housed, the estimated proportion with an undetectable viral load would have been 40.1% (95%CI: 35.1%, 46.1%), representing an 82.3% increase (see panel B). In both the full sample and among those homeless, the results were similar with and without

covariate adjustment, suggesting that the population effect of homelessness on viral suppression was not confounded by measured factors (see “Crude Model,” panels A and B, figure 1).

The results of the secondary analyses are shown in the Appendix. If 50% of the homeless population were housed, viral suppression in the entire population would increase to 40.8% (95%CI: 37.0%, 44.8%), representing a 7.9% relative increase (see Figure S1). Among those homeless at baseline, viral suppression would increase from 22.0% to 31.4% (a 42.7% relative increase). Similar results were observed if all homeless persons not currently engaged in addiction treatment were housed (see Figure S2).

DISCUSSION

In this cohort study of HIV-infected people who use drugs, we found that, independent of any other intervention, eliminating homelessness could increase viral suppression in the entire population by 15.1%. Among those homeless, we estimated that viral suppression prevalence could increase by 82.3% if these persons were housed. These results provide strong evidence that interventions to provide housing to homeless, HIV-positive individuals would significantly improve community viral suppression rates among HIV-infected PWUD (assuming correct model specification and no unmeasured confounding, selection biases, or measurement error). Given evidence that community viral load is a predictor of HIV incidence independent of proximate risk behaviours among PWUD [31], as well as new efforts to curb the HIV/AIDS pandemic (such as the United Nations’ recently-announced 90-90-90 campaign) [32], housing should be considered a critical intervention within comprehensive HIV prevention and treatment programs for people who use drugs.

Our results are remarkably consistent with those of the CHHP trial, which found that supportive housing (defined as housing without time limits combined with other supportive services) and intensive case management increased the likelihood of viral suppression by 93.0% [14]. In this study, patients who were actively using alcohol or drugs were referred to a shelter where they could stay as long as they were not disruptive to other clients. The “population intervention” modelled in our study is broader in scope, in that the referent group (i.e., not homeless) consisted of all housing statuses other than living on the street with no fixed address. Nonetheless, these results suggest that the provision of low-threshold shelters and other supportive housing services for drug-using individuals living with HIV should be implemented and brought to scale. Specifically, “Housing First” strategies (in which housing is provided without any prerequisites of sobriety or engagement in addiction treatment) have been found to improve health and housing outcomes among individuals with dual diagnoses of psychiatric illness and substance abuse [30]. In our secondary analyses, we demonstrated that housing interventions targeted specifically to persons not engaged in addiction treatment (representing a Housing First model) did increase viral suppression prevalence, although not to the same extent as the primary scenario in which all homeless persons were housed. In the first, and to our knowledge only, study that used viral loads to assess the “Housing First” model for HIV-infected homeless individuals, the proportion with viral suppression increased from 27% to 69% following enrolment in the program [33]. However, the results were limited by a small sample size ($n = 26$) and a lack of a

comparison group. Further research is urgently needed to identify specific housing models that most effectively improve the health and HIV treatment outcomes of HIV-infected persons who are homeless and use drugs.

This study has a number of important strengths and limitations. Notably, four assumptions need to be met to permit causal interpretation of the effect estimates [18]. First, one must assume that the confounders came before the exposure, and that the exposure came before the outcome (i.e., the temporal ordering assumption). By limiting covariate control to variables representing predominately lifetime or past experiences, and by using prospective measurements of viral load after the assessment of housing status, we believe this assumption has been met. Second, there should be no unmeasured confounding of the exposure-outcome relationship being studied. Although we adjusted for a wide variety of socioeconomic and behavioural factors known to be associated with viral suppression among PWUD, unmeasured confounding remains a possibility. However, we note that the study setting, in which all HIV treatment and care (including medications) is free of charge and universally provided, helps eliminate the potentially confounding effects of financial barriers to HIV treatment access on the relationship between homelessness and viral suppression (i.e., homeless persons, as a function of being poor rather than homeless, are less likely to achieve viral suppression). Furthermore, in order to control as much as possible for measured confounding, we included all covariates in the final models, regardless of their significance in bivariable analyses. Third, the outcome of any individual should be independent of the exposure or outcome of other individuals (the stability assumption). Unfortunately, we were unable to assess whether any participants cohabitate, or would otherwise be non-independent with respect to exposure-outcome assessments. If some observations are non-independent, the standard errors and 95% confidence limits would be under-estimated. If present, we expect the magnitude of this bias to be small. Fourth, one must assume that the exposure is possible for all members of the study population. Given the high prevalence of homelessness and unstable housing conditions among study participants, we expect this assumption to be met. Finally, the primary exposure of interest (homelessness) was self-reported. Although we defined homelessness clearly and consistently in all interviewer-administered surveys, misclassification error is possible. With regards to the outcome, an important strength of our study was the utilization of a province-wide registry to obtain viral load values as collected during routine clinical care. In this manner, the study design more accurately reflects the *effectiveness* of a population health intervention rather than intervention *efficacy*, since patients followed their natural course of observation. However, as the study sample was non-random, the results are not necessarily generalizable to the entire population of HIV-infected PWUD in Vancouver or those in other settings.

In summary, we employed an imputation-based marginal modelling approach to estimate the population effect of eliminating homelessness on viral suppression prevalence among people living with HIV who also use drugs. First, we recommend additional refinement and further application of these methods to improve the policy relevance of epidemiological studies examining HIV-related outcomes. Second, our results demonstrate that interventions to address and eliminate homelessness likely represent effective strategies to improve the HIV

care continuum for people who use drugs. As such, the development, implementation and evaluation of evidence-based housing strategies for HIV-infected people who use drugs should be prioritized as part of local, national, and international comprehensive HIV prevention and treatment programs.

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B.D.L.M. designed the study and wrote the analytic protocol. T.K., E.W., and M.J.M. were responsible for designing the involved cohort study and acquiring the data. B.E. conducted the analysis with input from B.D.L.M. and M.J.M. All authors contributed to the interpretation of data. B.D.L.M. conducted the literature review and wrote the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content, and approved the final version for submission.

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Panel A: Full Sample (N = 706)

Panel B: Homeless At Baseline (N = 223)

Figure 1.

Estimated population effect of eliminating homelessness on viral suppression prevalence among HIV-infected people who use drugs in Vancouver, Canada.

Legend

Note: bootstrapping was used to calculate 95% confidence limits.

* Models adjusted for year of interview, age, gender, ethnicity, educational attainment, ever hospitalized for a mental illness, history of injection drug use, history of incarceration, history of sex trade involvement, methadone program participation (past 6 months), any addiction treatment (past 6 months), and recent employment.

Table 1

Factors associated with having an undetectable HIV viral load (<50 copies/mL) among people who use drugs in Vancouver, Canada (*N* = 706)

Characteristic	Undetectable Viral Load				Prevalence Ratio (95%CI)	p-value
	No (N = 441)		Yes (N = 267)			
	No.	%	No.	%		
Homeless[‡]						
No	267	60.4	218	81.6	1 (ref)	
Yes	174	39.6	49	18.4	0.49 (0.37, 0.64)	<0.001
Age						
18–34	106	24.1	24	9.0	0.47 (0.32, 0.68)	<0.001
35–51	294	67.0	191	71.5	1 (ref)	
52	39	8.9	52	19.5	1.45 (1.18, 1.79)	0.001
Sex at birth						
Female	163	37.1	77	28.8	1 (ref)	
Male	276	62.9	190	71.2	1.27 (1.03, 1.57)	0.028
Race/ethnicity						
Non-Caucasian	206	46.9	111	41.6	1 (ref)	
Caucasian	233	53.1	156	58.4	1.15 (0.94, 1.39)	0.168
Educational Attainment						
< High school	238	54.2	126	47.2	1 (ref)	
High school completion	201	45.8	141	52.8	1.19 (0.99, 1.44)	0.071
Hospitalized for a mental illness[‡]						
No	222	50.6	124	46.4	1 (ref)	
Yes	217	49.4	143	53.6	1.18 (0.96, 1.45)	0.112
Injection drug use[‡]						
No	21	4.8	24	9.0	1 (ref)	
Yes	418	95.2	243	91.0	0.69 (0.51, 0.92)	0.012
Incarceration[‡]						
No	358	81.5	240	89.9	1 (ref)	
Yes	81	18.5	27	10.1	0.62 (0.44, 0.88)	0.007

Characteristic	Undetectable Viral Load				Prevalence Ratio (95%CI)	p-value
	No (N = 441)		Yes (N = 267)			
	No.	%	No.	%		
Sexual abuse[‡]						
Refused/Don't Know	19	4.3	8	3.0	0.80 (0.44, 1.45)	0.463
No	226	51.5	133	49.8	1 (ref)	
Yes	194	44.2	126	47.2	1.06 (0.88, 1.29)	0.533
Physical abuse[‡]						
Refused/Don't Know	25	5.7	13	4.9	0.94 (0.58, 1.51)	0.794
No	122	27.8	70	26.2	1 (ref)	
Yes	292	66.5	184	68.9	1.06 (0.85, 1.32)	0.599
Sex work involvement[‡]						
No	230	52.4	154	57.7	1 (ref)	
Yes	209	47.6	113	42.3	0.88 (0.72, 1.06)	0.174
Depressive Symptomatology[*]						
Refused/Don't Know	75	17.1	41	15.4	0.85 (0.65, 1.13)	0.276
No	181	41.2	128	47.9	1 (ref)	
Yes	183	41.7	98	36.7	0.84 (0.68, 1.04)	0.104
Participation in methadone program[‡]						
No	289	65.8	139	52.1	1 (ref)	
Yes	150	34.2	128	47.9	1.42 (1.18, 1.71)	<0.001
Any addiction treatment[‡]						
No	250	56.9	115	43.1	1 (ref)	
Yes	189	43.1	152	56.9	1.41 (1.17, 1.71)	<0.001
Any formal employment[‡]						
No	362	82.5	216	80.9	1 (ref)	
Yes	77	17.5	51	19.1	1.07 (0.84, 1.35)	0.597
Year of interview						
2005-2007	258	58.8	120	44.9	0.75 (0.52, 1.07)	0.114
2008-2010	154	35.1	127	47.6	1.06 (0.74, 1.52)	0.740

Characteristic	Undetectable Viral Load				Prevalence Ratio (95%CI)	p-value
	No (N = 441)		Yes (N = 267)			
	No.	%	No.	%		
2011–2013	27	6.2	20	7.5	1 (ref)	
ART Adherence						
95%	66	15.0	199	74.5	1 (ref)	
< 95%	320	72.9	62	23.2	0.22 (0.17, 0.27)	<0.001
Missing	53	12.1	6	2.2	0.14 (0.06, 0.29)	<0.001
Recent Daily Heroin Injection						
No	342	78.1	248	92.9	1 (ref)	
Yes	96	21.9	19	7.1	0.39 (0.26, 0.60)	<0.001
Recent Daily Crack Use						
No	261	59.5	196	73.4	1 (ref)	
Yes	178	40.5	71	26.6	0.66 (0.53, 0.83)	<0.001
Recent Binge Drug Use						
No	252	57.5	155	58.1	1 (ref)	
Yes	186	42.5	112	41.9	0.99 (0.81, 1.20)	0.893

[†] Refers to activities or experiences in the past 6 months.

[‡] Refers to lifetime activities or experiences.

* Depressive symptomatology is defined as scoring above a cut-off of 22 on the CES-D.

Table 2

Modified Poisson regression model of the relationship between homelessness and HIV viral suppression among people who use drugs, Vancouver, Canada ($N=706$).

Characteristic	β	SE	Adjusted Prevalence Ratio (95%CI)	<i>p</i> -value
Homeless[†]				
No	0.0		1 (ref)	
Yes	-0.60	0.13	0.55 (0.42, 0.71)	<0.001
Age				
18–34	-0.61	0.18	0.54 (0.38, 0.78)	0.001
35–51	0.0		1 (ref)	
52	0.29	0.11	1.33 (1.08, 1.65)	0.008
Sex at birth				
Female	0.0		1 (ref)	
Male	0.18	0.12	1.20 (0.96, 1.51)	0.116
Race/ethnicity				
Non-Caucasian	0.0		1 (ref)	
Caucasian	-0.06	0.10	0.95 (0.78, 1.15)	0.574
Educational attainment				
< High school	0.0		1 (ref)	
High school completion	0.17	0.09	1.19 (0.99, 1.42)	0.058
Hospitalized for a mental illness[‡]				
No	0.0		1 (ref)	
Yes	0.15	0.10	1.16 (0.95, 1.42)	0.110
Injection drug use[‡]				
No	0.0		1 (ref)	
Yes	-0.13	0.16	0.88 (0.65, 1.19)	0.404
Incarceration[‡]				
No	0.0		1 (ref)	
Yes	-0.27	0.17	0.76 (0.55, 1.05)	0.101
Sexual abuse[‡]				
Refused/Don't Know	-0.24	0.42	0.79 (0.35, 1.79)	0.572
No	0.0		1 (ref)	
Yes	0.13	0.10	1.14 (0.93, 1.39)	0.214
Physical abuse[‡]				
Refused/Don't Know	0.02	0.32	1.02 (0.55, 1.89)	0.951
No	0.0		1 (ref)	
Yes	0.09	0.12	1.09 (0.87, 1.37)	0.453
Sex trade involvement[‡]				
No	0.0		1 (ref)	
Yes	0.11	0.12	1.11 (0.87, 1.42)	0.382

Characteristic	β	SE	Adjusted Prevalence Ratio (95%CI)	<i>p</i> -value
Depressive symptomatology[*]				
Refused/Don't Know	-0.10	0.14	0.91 (0.68, 1.20)	0.493
No	0.0		1 (ref)	
Yes	-0.10	0.10	0.90 (0.73, 1.11)	0.322
Participation in methadone program[†]				
No	0.0		1 (ref)	
Yes	0.30	0.16	1.35 (0.99, 1.84)	0.056
Any addiction treatment[‡]				
No	0.0		1 (ref)	
Yes	0.19	0.15	1.20 (0.89, 1.62)	0.222
Any formal employment[‡]				
No	0.0		1 (ref)	
Yes	0.02	0.12	1.02 (0.81, 1.27)	0.896

Note: model also adjusted for year of interview.

[†] Refers to activities or experiences in the past 6 months.

[‡] Refers to lifetime activities or experiences.

^{*} Depressive symptomatology is defined as scoring above a cut-off of 22 on the CES-D.