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## **Substance use patterns and awareness of biomedical HIV prevention strategies among sexual and gender minority men in Canada**

### **ABSTRACT**

Sexual and gender minority men (SGMM) who use drugs are frequently cited as at-risk for HIV. Fortunately, biomedical prevention can greatly reduce transmission, provided individuals are aware of and interested in the uptake of these strategies. We examined associations between substance use patterns and biomedical prevention among SGMM in Canada. Latent class analysis identified patterns of substance use. Demographic-adjusted logistic regression models assessed the associations between latent classes and key biomedical prevention indicators. Among 669 participants living with HIV (PLWH) and 7,184 HIV-negative participants, six substance use classes characterized “limited” (46.0%; infrequent/low use of drugs), “common” (31.9%; alcohol, cannabis, and tobacco), “club” (5.2%; alcohol, cocaine, and psychedelics), “sex” (4.8%; alcohol, crystal methamphetamine, GHB, poppers, and erectile drugs), “prescription” (11.0%; alcohol and prescription drugs), and “polydrug” (1.1%; most drugs) use. HIV-negative men in the “prescription” and “sex” substance use classes were more likely to know about the preventive benefits of HIV treatment. All non-“limited use” HIV-negative men were more likely to report interest in taking pre-exposure prophylaxis (PrEP). For PLWH, substance use patterns were not associated with detectable viral loads or treatment awareness. While PLWH exhibited high levels of undetectability and treatment awareness regardless of substance use class, a variety of substance use patterns were associated with increased awareness, interest, and uptake of risk management strategies among HIV-negative participants.

### **Introduction**

Sexual and gender minority men (SGMM) are 71 times more likely to acquire HIV compared with other men (Public Health Agency of Canada, [2015](#)). Among the most successful HIV prevention strategies is “Treatment as Prevention” (TasP), which involves using antiretroviral therapies (ART) to reduce the viral loads of persons living with HIV to undetectable levels (Hull, Lange, & Montaner, [2014](#)). There is now scientific consensus that a person with an undetectable viral load cannot pass on the virus (Rodger et al., [2019](#)). However, HIV can still be acquired from people living with HIV who do not have undetectable viral loads (Hull et al., [2014](#)). Qualitative work among men living with HIV suggests that viral load undetectability has become an important feature of the identities of people living with HIV (Grace et al., [2015](#)). In addition to some provinces making ART freely available to all people living with HIV (Yoong, Bayoumi, Robinson, Rachlis, & Antoniou, [2018](#)), an increasing number of jurisdictions across Canada are making pre-exposure prophylaxis (PrEP) available to clinically eligible HIV-negative men. Like TasP, PrEP is highly effective, reducing the risk for HIV acquisition by more than 90% when used as prescribed (Golub, Gamarel, Rendina, Surace, & Lelutiu-Weinberger, [2013](#)).

However, poor awareness of these biomedical prevention strategies among marginalized SGMM, particularly those who use drugs, has the potential to undercut their effectiveness (Card, Armstrong, Lachowsky, et al., [2017](#); Lachowsky et al., [2016](#)). This might explain why HIV

incidence has been stable among SGMM, despite a declining incidence in the broader population. There is an urgent need to address the barriers that limit ART and PrEP awareness, access, uptake, and adherence among at-risk SGMM (Card, Armstrong, Lachowsky, et al., [2017](#); Golub et al., [2013](#); Grace et al., [2015](#)). In particular, SGMM who use drugs, and who constitute a large though heterogeneous group in gay communities, show patterns of low uptake of and adherence to ART and PrEP (Card, Armstrong, Lachowsky, et al., [2017](#)).

Although not all patterns of substance use are a significant public health concern, problematic substance use often presents concurrently with a range of other negative health outcomes (for example mood, anxiety, and psychotic disorders; Card, Lachowsky, et al., [2018](#); Lachowsky et al., [2017](#)) and is associated with increased costs to healthcare systems (Stockwell et al., [2019](#)). Indeed, analyses among SGMM living in Vancouver, British Columbia, have identified distinct patterns of substance use and explored their etiology. Results of these analyses show that while most SGMM engage in limited (36.7%) or common (25.9%) patterns of substance use, key subgroups of polydrug use (4.5%), street drug use (12.1%), sex drug use (11.4%), and club drug used (12.1%) are also prevalent in gay communities. Of concern, sex, street, and polydrug use are associated with higher odds for key indicators for HIV risk (Card, Armstrong, Cui, et al., [2017](#)). If used effectively, biomedical prevention strategies such as PrEP may therefore prove an acceptable intervention for reducing the risk of HIV among these individuals (Hoenigl et al., [2018](#)).

According to Diffusion of Innovation Theory, early adopters play an important role in promoting these strategies, but it is unclear how early support of PrEP relates to the diverse patterns of substance use associated with SGMM. This study, therefore, aims to retrospectively (before widespread awareness and acceptability of PrEP) examine the associations between patterns of substance use among SGMM and their awareness of the preventive benefits of ART, PrEP, and post-exposure prophylaxis (PEP). We also assess interest in PrEP among HIV-negative men and examine clinical indicators of TasP engagement (currently on ART and viral load detectability) among men living with HIV.

## **Methods**

### *Data collection*

Data were collected through the *Sex Now Study*, Canada's largest and longest-running periodic survey of gay, bisexual, and other men who have sex with men, aged 16 years or older. Participants for the 2014/15 (October 2014 to April 2015) cross-section were recruited from sex-seeking and dating apps and websites, community-based organizations, social media advertisements, word of mouth, and through an existing database of previous survey participants. All participants provided informed consent and completed an online questionnaire in either French or English. Questions included those related to sociodemographics, physical health, sexual health, mental health, social health, health care access, and substance use. Research ethics

approval for the study was granted by the Research Ethics Board of the Community Based Research Centre in Vancouver, British Columbia, Canada. Ethics for secondary data analysis was approved by the University of Victoria Human Research Ethics Board.

### *Measures*

*Outcome measures.* To assess awareness and knowledge of PrEP, PEP, and the preventive benefits of HIV treatments, all participants were given the following prompt: “The following statements are TRUE. Were you previously aware of them before taking this survey?” and asked to indicate “Yes” or “No” to each statement (1) “PrEP – Pre Exposure Prophylaxis is a daily antiretroviral medication now available for HIV negative men that can prevent sexual transmission of HIV (not yet approved in Canada)”, (2) “PEP – Post Exposure Prophylaxis: Within three days after a sexual risk event (such as fucking without a condom) there are medications you can take for a month that can prevent an HIV infection from establishing”, (3) “Antiretroviral medications, taken daily, significantly reduce the chance that HIV positive persons can transmit HIV to their sexual partners by suppressing their viral load”. HIV-negative men were then told that “PrEP is a new drug-based approach to HIV prevention that uses an antiretroviral medication to help prevent new HIV infections from establishing” and asked “How interested would you be in taking a daily medication for HIV prevention?”

Participants living with HIV were also asked whether they were taking antiretroviral medications and whether they had an “undetectable” or “detectable” viral load. Owing to the skip logic employed in the survey, these measures were collapsed into a single variable which, because of the small sample size of participants living with HIV not taking medications or who were detectable, was categorized as either “currently taking antiretroviral medications and has an undetectable viral load” or “either not currently taking ART and/or has a detectable viral load”.

*Explanatory measures.* The primary explanatory measure in this analysis was a latent variable capturing patterns of substance use using latent class analysis (LCA) (Lanza, Collins, Lemmon, & Schafer, 2007). Latent class analysis has been widely used to study patterns of substance use among women (Lanza & Bray, 2010) and SGMM (Card, Armstrong, et al., 2018a; Lim et al., 2015; McCarty-Caplan, Jantz, & Swartz, 2014; Newcomb, Ryan, Greene, Garofalo, & Mustanski, 2014; Tobin, Yang, King, Latkin, & Curriero, 2015; Yu, Wall, Chiasson, & Hirshfield, 2015). Owing to the power of our large sample size, we examined frequency of use (once a month or less, once a week or less, a few times a week, daily) by asking “How often have you used the following recreational substances in the last 12 months?”. Participants were then provided the following list of drugs: alcohol, tobacco, cannabis, cocaine, crack, crystal methamphetamine, poppers, erectile drugs (ED) (with or without a prescription), ecstasy, gamma-hydroxybutyrate (GHB), ketamine, steroids, pain medications (e.g., Vicodin, OxyContin, Tylenol 3; without a prescription), stimulant medication (e.g., Ritalin, Dexedrine, Concerta; without a prescription), sleeping medications (e.g., Ambien, Halcion, temazepam; without a

prescription), anxiety medications (e.g., Ativan, Xanax, Valium; without a prescription). Lay names for each drug were also provided to participants as shown above.

Based on these indicators, we explored several models, ranging from 2 to 7 classes, and selected the model that optimized the sample size-adjusted Bayesian Information Criterion (aBIC). The AIC, BIC, and aBIC are all commonly used to determine the number of classes, with the last of these three being favoured for optimal selection (Nylund, Asparouhov, & Muthen, [2007](#)). Several factors influence the performance of these measures (Dziak & Donna, [2012](#); Nylund et al., [2007](#)). For instance, BIC is less sensitive to complex models with unequal class sizes, thus underestimating the number of classes; AIC regularly overestimates the number of classes, as it is not sample size-adjusted (Lin & Dayton, [1997](#); Nylund et al., [2007](#); Yang, [2006](#)). Given our sample size and the distributions of class memberships represented by each model, we relied on the aBIC, with considerations also given to model parsimony (preferring simpler solutions for nested categories), interpretability (clear and theoretically consistent distinction between classes), and consistency with previous analyses (Card et al., [2018b](#), [2018a](#)).

Given that patterns of substance use and awareness of biomedical HIV prevention strategies are intertwined with the lives, experiences, and social status of SGMM (Card, Armstrong, et al., [2018a](#); Card, Armstrong, Lachowsky, et al., [2017](#)), we sought to control for several potential confounders, including age, birthplace (Canada, outside Canada), ethnicity (White, Indigenous, other), Province/Region (Northern Canada, the Atlantic, and the Prairies; British Columbia; Ontario; Quebec), self-assessed residential area classification (urban; suburban, small city, rural, or remote), sexual orientation (gay, bisexual other), educational attainment (high school or less, some college/bachelor's degree, graduate degree or higher), annual income in Canadian dollars (\$0 to \$39,999, \$40,000 to \$69,999, \$70,000 or More), relationship status (single, in a relationship), and self-reported HIV status (negative/unknown, positive). We also controlled for the number of years someone had lived with HIV.

### *Data analysis*

All statistical analyses were conducted in SAS v. 9.4 (SAS, [n.d.](#)). LCA was conducted using the PROC LCA procedure (Lanza et al., [2007](#)). We performed a complete case analysis of all participants, with listwise deletion of records missing values for any variables included in this analysis, or for participants who reported not living in Canada. Participants were removed if they had missing values for the included variables to ensure consistency between the reported descriptive statistics and the observations included in each model. Multivariable binary logistic regression models were created for each outcome (PrEP, PEP, and treatment benefits awareness, interest in PrEP [for HIV-negative men], and viral load undetectability/treatment status [for men living with HIV]). Modelling was stratified by HIV status, given previous findings that awareness of biomedical prevention strategies among men living with and without HIV

significantly differ (Card, Armstrong, Lachowsky, et al., 2017). As our latent variable was used as an explanatory variable for a distal outcome, latent class assignments were made based on the pseudoclass draws method, which assigns individuals 20 times based on their class-specific membership probabilities (Bandeem-roche, Miglioretti, Zeger, & Rathouz, 1997). Multiple imputation procedures for regression were then used to construct final effect and error estimates. We report odds ratios with 95% confidence intervals, with significance at  $p < 0.05$ , for each multivariable binary logistic regression model.

## Results

### *Descriptive results*

7,991 participants were recruited into 2015 *Sex Now Study*, from which we included records of 7,184 HIV-negative (91.2%) and 669 men living with HIV (8.8%). [Table 1](#) provides demographic characteristics of the sample. The median age was 43 years (Q1, Q3 = 30, 53) and most participants self-identified as White (81.0%), born in Canada (84.7%), gay (64.3%), living in an urban area (56.6%), and single (50.9%). [Table 2](#) shows frequency of use for each drug over the past year. Alcohol (88.9%), cannabis (39.4%), tobacco (30.3%), poppers (23.4%), erectile drugs (21.9%), and pain medications (e.g., Vicodin, OxyContin, Tylenol 3; without a prescription; 21.2%) were the most frequently reported drugs, and frequency of use for other drugs was low. **Table 1.** Demographic characteristics of 2014/15 [Study Name Redacted] respondents ( $N = 7,853$ ). ([Table view](#))

	n	%
Age ( <i>Median, Q1, Q3</i> )	43	(30, 53)
<i>Born in Canada</i>		
No	1198	15.26
Yes	6655	84.74
<i>Ethnicity</i>		
White	6362	81.01
Indigenous	358	4.56
Mixed Race and Other	1133	14.43
<i>Geographic region</i>		
Northern Canada, the Atlantic, and The Prairies	2063	26.27

	n	%
British Columbia	1847	23.52
Ontario	2815	35.85
Quebec	1128	14.36
<i>Residential Classification</i>		
Urban	4443	56.58
Suburban, Small City, Rural, or Remote	3410	43.42
<i>Orientation</i>		
Gay	5052	64.33
Bisexual/Other	2801	35.67
<i>Education Level</i>		
High School or Less	1109	14.12
Some College/Bachelors Degree	5459	69.51
Graduate Degree or Greater	1285	16.36
<i>Annual Income (CAD)</i>		
\$0 to \$39,999	3087	39.31
\$40,000 to \$69,999	2284	29.08
\$70,000 or More	2482	31.61
<i>Relationship Status</i>		
Single	3995	50.87
In a relationship	3858	49.13
<i>HIV Status (self-reported)</i>		
Negative/Unknown	7164	91.22
Positive	689	8.77

**Table 2.** Self-reported prevalence and frequency of substance use among 2014/15 sex now survey respondents ( $N = 7853$ ), by substance. ([Table view](#))

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	Never	Once a month or less	Once a week or less	A few times a week	Daily
	n (%)	n (%)	n (%)	n (%)	n (%)
Alcohol	873 (11.1)	2094 (26.7)	2071 (26.4)	2184 (27.8)	631 (8.0)
Tobacco	5471 (69.7)	638 (8.1)	185 (2.4)	244 (3.1)	1315 (16.8)
Cannabis	4757 (60.6)	1615 (20.6)	379 (4.8)	492 (6.3)	610 (7.8)
Cocaine	7097 (90.4)	651 (8.3)	79 (1.0)	17 (0.2)	9 (0.1)
Crack	7767 (98.9)	68 (0.9)	9 (0.1)	0 (0.0)	9 (0.1)
Crystal Methamphetamine	7533 (95.9)	211 (2.7)	45 (0.6)	33 (0.4)	31 (0.4)
Poppers	5611 (71.5)	1363 (17.4)	476 (6.1)	359 (4.6)	44 (0.6)
Erectile Dysfunction Drugs	5932 (75.5)	1241 (15.8)	475 (6.1)	160 (2.0)	45 (0.6)
Ecstasy	7111 (90.6)	680 (8.7)	49 (0.6)	4 (0.1)	9 (0.1)
Gamma-hydroxybutyrate	7485 (95.3)	302 (3.9)	42 (0.5)	14 (0.2)	10 (0.1)
Ketamine	7606 (96.9)	213 (2.7)	22 (0.3)	3 (0.0)	9 (0.1)
Steroids	7745 (98.6)	44 (0.6)	27 (0.3)	18 (0.2)	19 (0.2)
Pain Medications (e.g., Vicodin, OxyContin, Tylenol 3)	5955 (75.8)	1366 (17.4)	295 (3.8)	152 (1.9)	85 (1.1)
Stimulant Medication (e.g., Ritalin, Dexedrine, Concerta)	7660 (97.5)	132 (1.7)	18 (0.2)	11 (0.1)	32 (0.4)

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	Never	Once a month or less	Once a week or less	A few times a week	Daily
	n (%)	n (%)	n (%)	n (%)	n (%)
Sleeping Medications (e.g., Ambien, Halcion, temazepam)	7004 (89.2)	506 (6.4)	121 (1.5)	96 (1.2)	126 (1.6)
Anxiety Medications (e.g., Ativan, Xanax, Valium)	7218 (91.9)	357 (4.6)	62 (0.8)	57 (0.7)	159 (2.0)

### *Latent class analysis results*

Supplemental Figure 1 shows the fit statistics for our latent class analysis. Based on the adjusted BIC, a six-class solution was selected, balancing the BIC and AIC, which respectively tend to underestimate and overestimate the number of classes. The selection of a six-class solution was also interpretable, and except for one class, was highly congruent to our previous findings about latent-identified pattern of substance use among SGMM in Metro Vancouver (Card, Armstrong, et al., [2018b](#), [2018a](#)). The entropy was 0.73, suggesting moderate separability of classes.

Supplemental Figure 2 shows conditional item-response probabilities for each drug, by class. Classes were qualitatively described as representing “limited drugs”, “common drugs”, “club drugs”, “sex drugs”, “prescription drugs”, and “polydrugs”. We summarize these results below.

*Limited Drug Use.* The first latent class, representing 46.0% of participants, was distinguished by infrequent (once a month or less, not at all) use of most drugs, including otherwise common substances such as alcohol, tobacco, and cannabis. Half of individuals in this class (50.5%) drank alcohol once a month or less, 85.3% reported not smoking tobacco, 93.6% reported not using cannabis, and 87.2% reported not using poppers. Except for these drugs and the use of pain medication (e.g., Vicodin, OxyContin, Tylenol 3) without a prescription, no other drug was used by more than 2% of participants in this class.

*Common Drugs.* The second latent class represents 31.9% of participants, who reported elevated use of common drugs. 95.6% reported drinking alcohol in the past year (compared with 82.5% of the limited drugs class), 43.3% reported smoking (compared with 14.7% of the limited drugs class), 73.9% reported using cannabis (compared with 6.4% in the limited drugs class), and 37.8% reported using poppers (compared with 12.8% in the limited drugs class). However, like the limited use class, use of almost all the other drugs (except for EDs; 25.7% reported any use) was minimal.

*Club Drugs.* The third latent class, representing 5.2% of participants, was distinguished by frequent alcohol consumption, with 9.8% reporting daily alcohol consumption, and an additional 56.4% reporting alcohol consumption at least a few times a week. Most men in this class also

reported using cannabis (90.1% reported any use), cocaine (76.3% reported any use), ecstasy (63.0% reported any use) and some stimulant medication use without a prescription (e.g., Ritalin, Dexedrine, Concerta; 16.6% reported any use).

*Sex Drugs.* The fourth latent class, representing 4.8% of participants, was distinguished by frequent use of poppers (83.5% reported any use), EDs (70.9% reported any use), ecstasy (67.1% reported any use), GHB (65.8% reported any use), crystal methamphetamine (50.3% reported any use), and ketamine (37.0% reported any use). In several respects, participants in this class were similar to those in the club drugs class discussed above. However, their reported frequencies of crystal methamphetamine, GHB, ketamine, EDs, and popper use were higher than those in the club drugs class, and their reported use of cocaine was lower. The sex drugs class is also similar in some respects to the polydrugs class (discussed below). However, they were less likely to report use of cocaine, crack, off-prescription anxiety medications (e.g., Ativan, Xanax, Valium), and off-prescription sleeping medications (e.g., Ambien, Halcion, temazepam).

*Prescription Drugs.* The fifth latent class, representing 11.0% of participants, was distinguished by moderate use of the more commonly reported drugs (alcohol, tobacco, cannabis, poppers), abstention from the more infrequently reported drugs (crystal methamphetamine, crack cocaine, ecstasy, GHB, ketamine), and high levels of nonmedical use of prescription drugs, including pain medications (67.4% reported any use), sleeping medications (e.g., Ambien, Halcion, temazepam; 50.9% reported any use), anxiety medications (e.g., Ativan, Xanax, Valium; 39.7% reported any use), EDs (19.4% reported any use), and stimulant medications (e.g., Ritalin, Dexedrine, Concerta; 5.3% reported any use).

*Polydrugs.* The sixth latent class, representing 1.1% of participants, was distinguished by frequent use of most drugs. Except for the more commonly reported drugs (off-prescription pain medications [e.g., Vicodin, OxyContin, Tylenol 3], alcohol, tobacco, cannabis, and poppers), individuals in this class had the highest probability of using every drug included in our latent class model.

#### *Multinomial multivariable regression results*

Figure 1 shows the proportion of men in each class who reported each of our primary outcomes of interest. Multinomial multivariable regression results are in Table 3 for men living with HIV and Table 4 for HIV-negative/unknown men. Compared with men living with HIV in the limited drug use class, no significant differences in ART, PEP, or PrEP awareness were observed, except for men living with HIV in the prescription drugs class being less likely to know about the preventive benefits of PrEP (aOR = 0.41, 95% CI = 0.20–0.85). Likewise, there was no difference in viral load/ART adherence between the limited drug use class and the other classes. For HIV-negative/unknown men, those in the common (aOR = 1.24, 95% CI = 1.11–1.40) and sex drugs classes (aOR = 3.94, 95% CI = 2.60,5.98) were more likely to know that ART can

reduce viral load and prevention transmission compared with HIV-negative/unknown men in the limited drug use class. Similarly, HIV-negative/unknown men in the conventional, sex, and prescription drugs classes were more likely to know that PEP can be taken to reduce the risk of HIV acquisition. Compared with the HIV-negative/unknown men in the limited drug use class, men the other classes were more likely to know about the preventive benefits of PrEP and be

interested in or currently taking PrEP. **Figure 1.** Proportions of men in each class reporting each outcome, stratified by HIV status. **Table 3.** Descriptive, bivariable, and multivariable results for awareness of ART, PEP, and PrEP and for viral load adherence and undetectability among men living with HIV, compared with limited drugs class ( $N=669$ ). (Table view)

	Descriptives		Bivariable	Multivariable				
	Overall		$\chi^2$	Common	Club drugs	Sex drugs	Prescription	Polydrugs
	n	%	<i>p</i> -value	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<i>Model 1: Knows ART can reduce viral load and prevent HIV transmission</i>								
No	29	4.3	0.46	Ref	Ref	Ref	Ref	Ref
Yes	640	95.7		1.86 (0.70, 4.95)	0.32 (0.06, 1.75)	1.92 (0.50, 7.40)	0.98 (0.24, 3.93)	1.50 (0.15, 15.35)
<i>Model 2: Knows PEP can be taken after sex to reduce risk of HIV Acquisition</i>								
No	83	12.4	0.47	Ref	Ref	Ref	Ref	Ref
Yes	586	87.6		1.48 (0.81, 2.72)	0.55 (0.16, 1.92)	1.22 (0.60, 2.51)	0.96 (0.42, 2.16)	5.09 (0.59, 43.75)
<i>Model 3: Knows PrEP can prevent HIV Acquisition</i>								
No	94	14.1	0.06	Ref	Ref	Ref	Ref	Ref
Yes	575	86.0		0.91 (0.51, 1.64)	2.07 (0.26, 16.69)	0.79 (0.40, 1.59)	<b>0.41 (0.20, 0.85)</b>	0.48 (0.16, 1.49)
<i>Model 4: Viral Load Detectability &amp; ART Adherence Adherence</i>								

	Descriptives		Bivariable		Multivariable			
	Overall		$\chi^2$	Common	Club drugs	Sex drugs	Prescription	Polydrugs
	n	%	<i>p</i> -value	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Not on medication OR detectable	68	10.2	0.75	Ref	Ref	Ref	Ref	Ref
On medication AND undetectable	601	89.8		1.23 (0.63, 2.42)	1.04 (0.26, 4.19)	1.91 (0.55, 2.61)	2.00 (0.62, 6.44)	1.23 (0.33, 4.62)

Each model is adjusted for age, years living with HIV, relationship status, ethnicity, income, nationality, rural vs. urban residential location, and province/region of residence.

**Table 4.** Descriptive, bivariable, and multivariable results for awareness of ART, PEP, and PrEP, and interest in PrEP among HIV-Negative/Unknown status men, compared with limited drugs class (*N* = 7184). ([Table view](#))

	Descriptive		Bivariable		Multivariable			
	Overall		$\chi^2$	Common	Club drugs	Sex drugs	Prescription	Polydrugs
	n	%	<i>p</i> -value	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)

*Model 5: Knows ART can reduce viral load and prevent HIV transmission*

No	2361	32.9	<b>&lt;0.0001</b>	Ref	Ref	Ref	Ref	Ref
Yes	4823	67.1		<b>1.24 (1.11, 1.40)</b>	1.15 (0.89, 1.49)	<b>3.94 (2.60, 5.98)</b>	1.01 (0.84, 1.21)	1.24 (0.66, 2.34)

*Model 6: Knows PEP can be taken after sex to reduce risk of HIV Acquisition*

	Descriptive		Bivariable	Multivariable				
	Overall		$\chi^2$	Common	Club drugs	Sex drugs	Prescription	Polydrugs
	n	%	<i>p</i> -value	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
No	3294	45.9	<b>&lt;0.0001</b>	Ref	Ref	Ref	Ref	Ref
Yes	3890	54.2		<b>1.16 (1.04, 1.30)</b>	1.24 (0.98, 1.58)	<b>2.70 (1.97, 3.69)</b>	<b>1.25 (1.05, 1.50)</b>	1.19 (0.67, 2.14)
<i>Model 7: Knows PrEP can prevent HIV Acquisition</i>								
No	3257	45.3	<b>&lt;0.0001</b>	Ref	Ref	Ref	Ref	Ref
Yes	3927	54.7		<b>1.24 (1.11, 1.38)</b>	<b>1.48 (1.16, 1.89)</b>	<b>2.76 (2.03, 3.76)</b>	<b>1.40 (1.17, 1.67)</b>	<b>2.30 (1.22, 4.32)</b>
<i>Model 8: Interested in Taking PrEP</i>								
Not interested	3693	51.4	<b>&lt;0.0001</b>	Ref	Ref	Ref	Ref	Ref
Interested or has been/is on PrEP	3491	48.6		<b>1.30 (1.16, 1.44)</b>	<b>1.42 (1.13, 1.78)</b>	<b>3.98 (2.95, 5.37)</b>	<b>1.65 (1.39, 1.97)</b>	<b>3.07 (1.65, 5.71)</b>

Each model is adjusted for age, ethnicity, income, nationality, relationship status, rural vs. urban residential location, and province/region of residence.

## Discussion

### *Primary findings*

Although other studies of latent substance use among SGMM have documented the association between substance use patterns and HIV risk behaviours (Lim et al., [2015](#); McCarty-Caplan et al., [2014](#); Noor, Ross, Lai, & Risser, [2014](#)), we believe this to be the first study to examine how these patterns of substance use relate to knowledge, interest, and uptake of biomedical prevention strategies such as PrEP. Notably, we found that for HIV-negative men in particular, latent patterns of sex, club, prescription and polydrug use are significantly associated with

elevated awareness of and interest in these prevention strategies. In particular, compared with men in the limited drug use class, HIV-negative men in the other classes were significantly more likely to report knowing about PrEP and being interested in taking PrEP. This finding supports results from other studies suggesting that SGMM who engage in sexual behaviours with greater likelihood of HIV transmission seek strategies that minimize transmission but that do not dilute the pleasure associated with their sexual practices (Card et al., [2016](#); Grace et al., [2015](#)). Our findings reemphasize the role that social and sexual networks play in shaping the diffusion of prevention strategies (Adam, Husbands, Murray, & Maxwell, [2008](#); Card, Armstrong, Lachowsky, et al., [2017](#)).

We must also note that for men living with HIV, few indicators of biomedical prevention awareness or uptake differed between the limited use and other drug use classes. Participants living with HIV in the prescription drugs class were less likely to know about the preventive benefits of TasP, a finding that may reflect more on the date of data collection (2014, before the acceptance of PrEP by many health care providers) than on the diffusion of biomedical information within this network. Substance use class does not appear to be a barrier to diffusion of biomedical competence for people living with HIV. This suggests that the healthcare system (or natural social networks) is probably doing well at educating people living with HIV, regardless of substance use patterns.

### *Limitations*

This study has several limitations. First, our data were collected through an online sexual health survey of SGMM in Canada. Therefore, we can only generalize our results to individuals who participate in online surveys shared by SGMM organizations or who use sexual networking applications. Second, some questions in our survey, such as HIV seropositivity and viral load, may be susceptible to social desirability bias. Third, the cross-sectional nature of this study makes it impossible to flesh out the causal and nuanced relationships among variables, such as the possibility that SGMM on PrEP are more likely to use drugs. Fourth, while our analyses capture the early diffusion of PrEP, awareness has increased since 2014 (Mosley et al., [2018](#); Walters, Reilly, Neaigus, & Braunstein, [2017](#)). Nevertheless, our results provide an important case study of the diffusion of biomedical prevention information between latent classes of substance use. Fifth, in this study, we did not conduct serological viral load testing. Rather, viral suppression was self reported by participants. In Canada, viral suppression is defined as having a consistent viral load of less than <200 copies/ml. However, it is impossible to know if healthcare providers accurately convey this information to their participants or whether a different cut off is used. Sixth, the outcome variables used to assess knowledge about biomedical prevention options have not been previously validated. Participants were told that these statements were true out of ethical concern to ensure awareness of PrEP, PEP, and U = U through this community-

based survey. Given the potential sensitivity of these topics, participants may have felt pressured to answer that they were aware.

## Conclusion

In conclusion, our study highlights variation in SGMM's knowledge, awareness, interest, and uptake of biomedical prevention strategies related to patterns of substance use, particularly for HIV-negative and unknown status men. These findings suggest that SGMM who use drugs are more likely to be aware of and interested in these prevention strategies.

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