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HIV community viral load and factors associated with elevated viremia among a community-based sample of men who have sex with men (MSM) in Vancouver, Canada

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Abstract

Background—We developed estimates of community viral load (VL) and risk factors for unsuppressed VL from a cross-sectional study of men who have sex with men (MSM) in Vancouver, Canada.

Methods—MSM were recruited from February 25, 2012 – February 28, 2014 using Respondent-Driven Sampling (RDS). Participants completed a computer assisted self-interview questionnaire and a nurse-administered point-of-care HIV test. For HIV positive participants, we conducted VL and CD4 cell counts. We used RDS-weighted analysis to obtain population estimates of key variables and multivariable logistic regression to examine factors associated with having a VL ≥ 200 copies/mL among HIV-positive participants.

Results—We recruited 719 participants, of whom 119 (16.6%) were seeds. Our estimate of the population HIV prevalence was 23.4% (95% CI 15.8 – 31.0%) after RDS-adjustments. We estimated that 18.6% (95% confidence interval [CI] 8.8 – 30.4%) of HIV-positive MSM in Vancouver had a VL ≥ 200 copies/mL. Having an unsuppressed VL was associated with non-Caucasian ethnicity (adjusted odds ratio [AOR]= 4.34; 95% CI 1.67 – 11.1); an annual income of $< \$15,000$ CAD (AOR=6.43; 95%CI 2.08–19.9); using GHB in the previous six months

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(AOR=4.85; 95%CI 1.79–13.2); unprotected anal intercourse with a known HIV negative or unknown serostatus partner (AOR=3.13; 95%CI 1.10–8.90); and disclosing one's HIV serostatus $\geq 50\%$ of the time (AOR=7.04; 95%CI 1.01–49.1).

Conclusion—Despite a high prevalence of HIV, we estimated that a small proportion of HIV positive MSM have undiagnosed HIV and unsuppressed VL. Our results highlight the importance of continued work to address health inequities using a social determinants of health framework.

Keywords

men who have sex with men (MSM); community viral load; treatment as prevention; risky sex

Introduction

Antiretroviral therapy (ART) has been conclusively shown to decrease the risk of sexual HIV transmission among heterosexual[1] and homosexual couples[2]. Evidence from British Columbia[3] and elsewhere[4–6] has demonstrated that the expansion of access to antiretroviral therapy (ART) can result in population-level reductions in HIV incidence. Beginning in 2006, the province of British Columbia, has progressively expanded ART access initially through changes in the guidelines for earlier initiation of ART [7–10]. Furthermore, in 2010 the provincial government initiated a more extensive program called Seek and Treat to Optimize Prevention for HIV (STOP-HIV), designed to enhance HIV testing among individuals at risk for acquiring HIV and better link HIV-positive individuals to effective care and treatment.

Men who have sex with men (MSM) represent the most affected HIV risk group both in Canada[11] and in the province of British Columbia[12]. While HIV surveillance data demonstrated declines in the number of new HIV cases associated with injection drug use over the past 5 years, the numbers of new diagnoses occurring among MSM in the province has remained relatively constant over the past decade between 150 and 180 each year[12]. In 2012, 63% of new HIV diagnoses in British Columbia occurred among MSM. HIV appears to be endemic among MSM in Vancouver, with an estimated prevalence of 18% measured in a cross-sectional survey conducted in 2008–09[13]. There is some concern that promotion of “treatment as prevention”(or TasP) may be leading to increased risk for HIV acquisition among MSM through reduced-use of condoms or other risk-reduction measures[14, 15] or by increasing other risky behaviour such as illicit drug-use[16].

Given the well-defined associations of illicit drug use, mental health conditions and risky sexual behaviour with HIV acquisition among HIV negative MSM[17], we hypothesized that these factors may also be associated with HIV transmission risk among HIV positive MSM in Vancouver. Consequently, we designed a study to measure HIV prevalence, the proportion of undiagnosed infection, population viral load (VL), and risk factors for unsuppressed VL using cross-sectional data from MSM in Vancouver. Furthermore, we sought to compare drug-use and risky sexual behaviour between self-identified HIV negative or unknown and HIV positive MSM in Vancouver in order to ascertain whether the extent to which these behaviours overlap to drive HIV transmission.

Methods

Participants in this study, known as the Momentum Health Study, were recruited using respondent driven sampling (RDS) either as directly recruited “seeds” (see below) or from other participants in the study with multiple waves of recruitment to reach different social networks. RDS is a formalized chain referral method of recruiting study participants from minority or marginalized populations, where standard population sampling is not feasible [18, 19]. RDS begins by purposefully selecting a small number “seeds” to initiate the chains of peer referrals. Initial seeds were recruited from community agency or study team contacts in Vancouver, through participants identified through our formative work [20] and through our community advisory board (CAB). We also used advertisements on mobile smartphone applications or websites used by MSM to allow individuals not known by agencies, study staff or our CAB to volunteer to participate as seeds. We selected seeds to ensure as diverse a sample as possible with respect to age, ethnicity and income-level. Training on peer recruitment was conducted in-person with a study research assistant. Participants were requested to select potential recruits who would be eligible for the study and would be willing to participate. Each seed and subsequent study participant was given up to six coupons (either electronic or laminated paper) to offer to other acquaintances, whom they knew to be MSM, as invitations for study participation. There was no maximum time referral period. Participants who presented to the study office were screened in-person in a private office by a research assistant. MSM were considered eligible if they were a seed or had a valid coupon obtained from another study participant whom they personally knew, had not purchased the coupon, and were not coerced to participate by their recruiter. Additional eligibility criteria included: age ≥ 16 years, gender identify as a man (regardless of their sex at birth), reported having had sex with a man in the past six months, able to complete questionnaire in English, and residence in Metro Vancouver. In tandem with a custom-built participant database, RDSCM v3.0 software was used to manage coupons, record recruiter-recruit relationships, track compensation, and ensure valid coupons were redeemed only once. We monitored the characteristics of study enrollees as recruitment progressed to ensure that the study sample reached equilibrium for the following key characteristics: HIV serostatus, ethnicity, sexual orientation, age-group and income. Participants were given a \$50 honorarium (all figures in Canadian dollars) for participation and a further \$10 for each individual who participated through the use of one of their coupons. Participants also had the option of entering a monthly draw for a \$250 gift card or a six-monthly draw for a \$2000 travel voucher, instead of the cash honoraria.

After completing informed consent procedures, study participants completed a self-administered computer-based survey and a nurse-administered clinical survey. The surveys collected information on demographics, sexual risk and drug using behaviour using a six-month recall time-frame, and health service utilization and previous testing for HIV and other sexually transmitted infections. The survey also included the Hospital Anxiety and Depression scale[21] to measure participants’ current mental health symptomatology.

The study nurse also administered a point-of-care HIV test (Insti™ Rapid HIV-1/HIV-2 test, Biolytical Laboratories, Richmond, Canada), or for study participants who self-reported as being HIV positive, confirmed their HIV status with a previous laboratory report. We also

conducted VL and CD4 cell count testing for HIV positive participants at the St. Paul's Hospital Laboratories. VL was measured using the Roche Amplicor Monitor assay (Roche Diagnostics, Laval, Canada) with the ultrasensitive adaptation. CD4 cell counts were measured by flow cytometry, followed by fluorescent monoclonal antibody analysis (Beckman Coulter, Mississauga, Canada). The Momentum study received ethical and scientific review from the Research Ethics Boards of the University of British Columbia, Simon Fraser University, the University of Victoria, and the Public Health Agency of Canada.

Data for the current analysis were obtained from participants who enrolled from February 25, 2012 – February 28, 2014. We performed descriptive statistics with proportions adjusted using RDS weights calculated from the MSM network size of participants and homophily between recruits and the individuals who recruited them, using RDSTAT v4.9. A participant's network size was determined using the following questions asked on the computer-assisted self-interview questionnaire: "Of the MSM you know in the Vancouver area and whom you have seen or spoken to in the past month, how many do you know comfortably enough to give a study voucher inviting their participation (in the study)?" The RDS-derived weights were then imported into SAS (version 9.3, SAS Corporation Cary, NC, USA) for inclusion in the bivariate and logistic regression analyses. We compared sexual and drug-use behaviour between participants who self-identified as HIV positive with those who were HIV negative or unknown using the Kruskal-Wallis or Wilcoxon Rank Sum Tests for continuous variables and the Chi-Square test for categorical variables. We also used RDSAT-exported weights to examine sociodemographic, sexual behaviour, drug-use and mental health function factors associated with having a VL ≥ 200 copies/mL among HIV-positive MSM in multivariable logistic regression. Model selections were conducted using a backward stepwise elimination technique based on two criteria (Akaike Information Criterion (AIC) and Type III p-values) until the final model reached the optimum (minimum) AIC.

Results

We screened 835 potential recruits and enrolled 719 eligible participants, of whom 119 (16.6%) were seeds. Figure 1 demonstrates the recruitment chains for the study sample. A total of 30 seeds were initially recruited with another 89 added later in order to maintain recruitment. Participants reported knowing a median of 10 MSM in Vancouver ((Q1–Q3: 5–20) to whom they would feel comfortable giving a coupon. A total of 3712 coupons were distributed, of which 708 (19%) were returned by potential study participants. A total of 50 seeds (42%) did not recruit any participants and 24 (20%) recruited only one other participant. The remaining 576 non-seeds were recruited through 45 chains which were a median of 3 generations long, with a median total of 7 recruits per chain. The longest chain was 16 generations and recruited 77 participants in total.

The crude and RDS-weighted proportions of the demographic and HIV-related characteristics of the sample are shown in Table 1. The adjusted values represent our estimates for the population from which our sample was drawn. For example, the youngest study participant recruited was 19 years old. After adjusting for the RDS sampling design,

we estimated that 34.0% (95% CI 25.3–42.8) of MSM in Vancouver were aged 19 – 29 years old, 37.1% (95% CI 30.3 – 44.4) were aged 30 – 44 years and 28.9% (95% CI 21.4–36.8) were aged ≥ 45 years old. We estimated that 68.0% (95% CI 60.5 – 74.1%) self-identified as Caucasian, 10.5% (95% CI 5.8 – 16.2) self-identified as Aboriginal, 9.8% (95% CI 6.5 – 15.2) as Asian, 7.0% (95% CI 2.8 – 11.2) as Latino and 4.7% of other ethnicities (95% CI 2.3 – 7.8). We estimated that 80.7% (95% CI 76.2–85.4) of MSM in Vancouver self-identified as gay, 15.3% as bisexual, and 4.0% as other sexual identities. We estimated that 74.7% of MSM in Vancouver were born in Canada, 46.1% reported their annual income as being $< \$15,000$ per year and 19.0% were students. While the adjusted proportions for all of these parameters varied from those from the crude samples, only for Caucasian ethnicity (75.0% crude and 68.0% adjusted) and income $< \$15,000$ (37.1% crude versus 46.1% adjusted) did the crude proportion not overlap with the 95% confidence interval (CI) of the adjusted proportions.

A total of 93.7% (95% CI 90.9 – 96.0) of MSM in Vancouver reported ever having been tested for HIV. Among those who self-reported as HIV negative or unknown, 78.9% (95% CI 70.7 – 83.9) had received at least one HIV test in the two years prior to study enrollment. The RDS-adjusted HIV prevalence was 23.4% (95% CI 15.8 – 31.0). In terms of the “cascade of care” among all HIV positive participants in the study: 99.4% (95% CI 97.5 – 100.0) of the HIV-positive participants who were aware of their diagnosis; 92.9% (95% CI 82.1 – 98.1) were receiving HIV treatment, and 81.4% (95% CI 69.6 – 91.2) had a VL < 200 copies/mL, or conversely, 18.6% (95% CI 8.8 – 30.4%) had a VL ≥ 200 copies/mL.

Table 2 shows the behavioural characteristics of study participants, with participants classified on their self-reported HIV serostatus. With weighting, we estimated that HIV-negative/unknown MSM in Vancouver were more likely to visit gay bars or clubs than HIV-positive MSM (79.0% vs. 65.5%; $p < 0.001$). However, we estimated that only a minority of both HIV-negative/unknown participants and HIV-positive MSM attended these venues more than once per month (32.4% vs. 22.8%; $p = 0.017$). Further, we estimated that 55.1% of HIV-negative/unknown MSM reported using websites to find sex partners compared with 31.3% of HIV-positive MSM ($p < 0.001$); similar proportions of HIV-negative/unknown MSM and HIV-positive men reported using mobile phone applications for this purpose (58.6% vs. 61.8%; $p = 0.462$).

We found statistically significant differences in the total number of male sex partners ($p = 0.021$) and anal sex partners ($p = 0.005$) reported in the past six months between HIV-negative/unknown MSM and HIV-positive MSM. When specifying anal sex partners, 40.7% (95% CI 34.2 – 47.2%) of HIV-negative/unknown MSM reported 0–2 partners, compared with 36.4% (95% CI 25.2 – 47.5%) of HIV-positive MSM. A smaller proportion of HIV-negative/unknown MSM reported 11–20 partners (7.6% vs. 14.1%) and > 20 partners (7.5% vs. 15.2%).

We estimated that the majority of HIV-negative/unknown (58.9%; 95% CI 52.8–65.0%) and HIV-positive MSM (73.4%; 95% CI 64.4 – 82.4%) ($p < 0.001$) reported having had unprotected anal intercourse (UAI) at least once in the previous six months, but only 31.3% (95% CI 25.8 – 36.8%) of HIV-negative/unknown participants and 44.7% (95% CI 33.8 –

55.5%) of HIV-positive MSM ($p=0.002$) reported having UAI with a known serodiscordant or unknown serostatus partner, our definition of “risky sex”. As well, 80.2% (95% CI 73.2 – 87.3%) of HIV-negative/unknown MSM and 71.0% (95% CI 59.3 – 82.7%) of HIV-positive MSM ($p=0.037$) reported *disclosing* their own serostatus $\geq 50\%$ of the time to sexual partners. However, only 55.1% (95% CI 49.0 – 61.1%) of HIV-negative/unknown MSM and 47.1% (95% CI 57.7 – 57.7%) of HIV-positive MSM ($p=0.070$) reported *asking* about their partners’ HIV serostatus $\geq 50\%$ of the time.

We estimated significant differences in the use of most mood-altering substances between HIV-negative/unknown and HIV-positive MSM. We estimate that HIV-negative/unknown MSM were more likely to use ecstasy (23.6%) than HIV-positive participants (14.2%; $p<0.001$), and that this is one of the most commonly reported substances used by HIV-negative/unknown MSM. Poppers were also commonly used by HIV negative/unknown MSM (28.3%) and HIV-positive MSM (48.3%; $p<0.001$). HIV positive MSM were also more likely to report recent use of crystal methamphetamine (32.6 vs. 12.4%; $p<0.001$).

Among HIV-positive MSM, our final multivariable regression model found that having an unsuppressed VL was associated with non-Caucasian ethnicity (adjusted odds ratio [AOR] = 4.34; 95% CI 1.67–11.1), reporting an annual income of $<\$15,000$ (AOR=6.43; 95%CI 2.08–19.9) and using GHB in the previous six months (AOR=4.85; 95% CI 1.79–13.2) (Table 4). Unsuppressed VL was also independently associated with reporting UAI with a known HIV negative or unknown serostatus partner (AOR=3.13; 95% CI 1.10–8.90), as well as disclosing one’s HIV serostatus $\geq 50\%$ of the time to sexual partners (AOR=7.04; 95% CI 1.01–49.1). The above model had the lowest AIC of other potential candidates (=132.5). However, other multivariable models which replaced GHB-use with reported use of crystal methamphetamine in the previous six months or included both of these drug-use variables had very similar AIC values (=133.8 and =132.9, respectively) (data not shown).

Discussion

Using a community-based sample of MSM recruited through RDS, we estimated that the population prevalence of HIV among MSM in Vancouver ranges between 16 to 31%, with a point estimate of 23.5%. However, we also estimated that between 9 and 30% (point estimate 18.6%) of HIV-positive MSM in Vancouver had a measured VL of ≥ 200 copies/mL. This suggests that, despite the high prevalence of HIV in this population, there are a small proportion of individuals who have a significant risk of transmitting HIV to their sexual partners. Furthermore, it appears that for MSM residing in Greater Vancouver, the UNAIDS targets of 90% diagnosed, 90% treated and 90% achieving virologic suppression[22] have already been achieved, since the outcome of 90-90-90 results in 73% of HIV positive individuals achieving virologic suppression, and in our study we estimate that 81% of HIV positive MSM have a $VL \leq 200$ copies/mL. The rather high HIV prevalence observed here can be seen as a testament to the effectiveness of the HIV treatment program in BC, resulting in few HIV-infected individuals dying of the disease and therefore surviving [23] to be included in studies such as ours.

Despite this achievement, the number of new HIV diagnoses among MSM in the province of BC has remained relatively stable over the past decade at between 150 – 180 per year [12]. The exact reasons for this are unclear, but may be related to persistent marginalization and stigma felt by gay and bisexual men which has led to ongoing mental health and substance use problems[24]. Another factor could be ongoing population growth, since the population of Vancouver has grown by about 11% over since 2005[25]. Furthermore, BC has continued to experience annual increases in syphilis and other STIs among MSM for the past several years[26], which suggests that the use of condoms and other more general STI prevention measures may be declining. However, we also found that those HIV-positive MSM with unsuppressed VL are more likely to report risky sexual behaviour and to use GHB and/or crystal methamphetamine than other HIV-positive men; factors that have been shown to increase their risk of HIV transmission. These factors may be mitigated somewhat by the observation that these individuals more frequently disclose their own HIV serostatus to their sexual partners than virologically suppressed HIV-positive men, suggesting that they may be taking other actions to reduce the risk of onward transmission of HIV. Men with unsuppressed VL are also more likely to have low incomes and be of non-Caucasian ethnicity, which indicate the importance of continued work to address health inequity using a social determinants of health framework[27]. A recent report of a large (over 4000 patients) sample of HIV-infected adults receiving HIV care in the United States, of whom approximately 45% were MSM, did not find an association with lack of virologic suppression (also defined as ≥ 200 copies/mL) and risky sex[28]. However, such a study design will systematically miss HIV-infected individuals who are not diagnosed and/or not linked to care and therefore cannot be seen as representative of HIV-infected individuals at risk of HIV transmission. Somewhat surprisingly, we did not find any association between unsuppressed VL and measures of anxiety or depression, in contrast with other studies [29, 30]. We have previously found that that our measures of drug use and mental health symptoms are highly associated, which may have contributed to this lack of effect in our study.

As this is a cross-sectional analysis, we are unable to determine the direction of the association of the relationship between HIV transmission risk behaviour and HIV viral load. However, it seems reasonable to hypothesize that lower income, non-white MSM are less likely to have access to appropriate HIV care or to maintain adherence to therapy[31], as well as engage in behaviour which put them at higher risk for HIV transmission[32]. Engaging such men in appropriate HIV care and treatment should be prioritized to reduce further the community VL of HIV in this setting.

This level of 18.6% of HIV-positive MSM with unsuppressed VL is lower than was reported in a 2010 study in New York City, where the overall proportion of HIV-positive MSM with detectable VL (defined as a VL ≥ 400 copies/mL) was found to be 41.4% among participants in the HIV surveillance registry with at least one VL in 2008[33]. In a clinic-based study from the US, the proportion of HIV-positive MSM with VLs ≥ 200 copies/mL (albeit on all samples taken over one year) was 37% [28]. Recent surveillance for HIV in San Francisco reported that 29% of MSM diagnosed with HIV in 2012 had a VL ≥ 200 copies/mL within one year of diagnosis[34]. However, similar to clinic-based research, studies using HIV surveillance registries are often biased in they only include participants who are already

diagnosed with HIV, thus miss the contribution to community VL posed by undiagnosed individuals. Even more recent data from the San Francisco site of the National HIV Behavioral Surveillance system collected in 2014 found that only 17% of HIV positive MSM had a VL $\geq$ 200 copies/mL (H. Fisher Raymond, personal communication) a similarly low proportion when compared with our study. Both San Francisco[35] and Vancouver[36] are jurisdictions which have implemented system-wide approaches to improving the cascade of care and it is not surprising that they appear to be achieving similar results in terms of virologic suppression among HIV positive MSM.

Our study has also provided important information on the similarities and differences in the sexual and drug-use behaviors between HIV-positive and HIV-negative/unknown MSM participants, which are generally associated with greater HIV transmission risk. A relatively large proportion of both groups of participants reported UAI in the previous six months (73% of HIV-positive and 59% of HIV-negative participants). However, the proportions reporting UAI with a known discordant or unknown serostatus partner were much lower (42% of HIV-positive and 31% of HIV-negative/unknown participants). In the 2008–09 study, we found that 63% of HIV-negative/unknown participants reported asking about their partners' serostatus before having sex, similar to the 55% who report doing so the majority of the time in the current study. However, we did find that the proportions of participants disclosing their HIV serostatus to their sexual partners the majority of the time in the current study were quite high: 71% of HIV-positive and 80% of HIV-negative/unknown participants. This suggests that there may be more frequent discussion between MSM in Vancouver about HIV status and greater comfort in disclosing one's HIV status.

As well, we found significant differences in drug using behaviour between HIV-positive and HIV-negative/unknown MSM. The largest differences between the two groups were found for crack cocaine use, reported by 28% of HIV-positive and 9% of HIV-negative participants in the previous six months, and the use of crystal methamphetamine, reported by 33% of HIV-positive and 12% of HIV-negative/unknown participants. The high prevalence of crystal methamphetamine use is particularly worrisome, given that it also was one of the illicit drugs (along with GHB) associated with elevations in plasma VL amongst HIV-positive participants. The use of crystal methamphetamine has been repeatedly shown to be associated with risk of HIV acquisition among MSM [37–39]. It is also possible that the increased use of poppers by HIV-positive men in comparison with HIV-negative/unknown men in our study (48% vs. 28%) is also related to HIV prevention practices by the positive men. Previous research has demonstrated that popper-use is often associated with preference for the anal receptive role for MSM [40]. Consequently, HIV-positive MSM may be using poppers to facilitate this sexual position, recognizing that the risk of transmitting HIV is significantly less likely through the receptive role than the insertive role[41], but this requires further study.

Our study has a number of limitations. Firstly, while we postulate that using RDS to recruit a community-based sample of MSM should result in a more representative sample of the general MSM population of greater Vancouver, when compared with other methods, we cannot be certain that it is truly representative. The advantage of RDS is that the study team can measure and adjust for some known biases that arise through the recruitment process.

However, it is not possible to adjust for all potential sampling biases that may be in our study. In particular, we were unable to recruit any participants under the age of 19 years of age, so our sample is not representative of MSM under that age. We also note challenges in producing long recruitment chains as opposed to many short chains, with long chains being a feature of RDS needed to reach diverse networks and to gain independence from the purposely selected seeds. In addition, many seeds started chains that failed to produce chains at all or beyond one or two generations, affecting the RDS adjustments. Secondly, as mentioned above, analyses are all based on a single study visit for all participants and consequently we cannot be sure of the directions of the associations we uncovered. We will be able to delineate these with longitudinal data from Momentum Health Study participants who enrolled in the prospective cohort. Moreover, some measured outcomes (particularly unsuppressed viral load) were quite uncommon and associated confidence intervals are quite wide. Lastly, we did not detect acute infections among MSM testing HIV-antibody negative. Such men may have very high viral loads and therefore may be at disproportionate risk for onward transmission and the propagation of the epidemic.

In summary, we estimated a high prevalence of HIV among MSM in Vancouver, but very low levels of previously undiagnosed HIV infection and unsuppressed VL, resulting in a low proportion of HIV positive MSM capable of easily transmitting HIV. However, amongst HIV positive individuals the risk of onward transmission appears to be most associated with non-white, low income MSM and additional programs to better engage these individuals in HIV treatment and prevention counseling are needed. Furthermore, the ongoing need to address substance-use among MSM, particularly GHB and crystal methamphetamine is again apparent from our study. A comprehensive approach that addresses overall health and health inequities among gay and bisexual men such as recommended in a recent report from British Columbia[24] would greatly assist such efforts.

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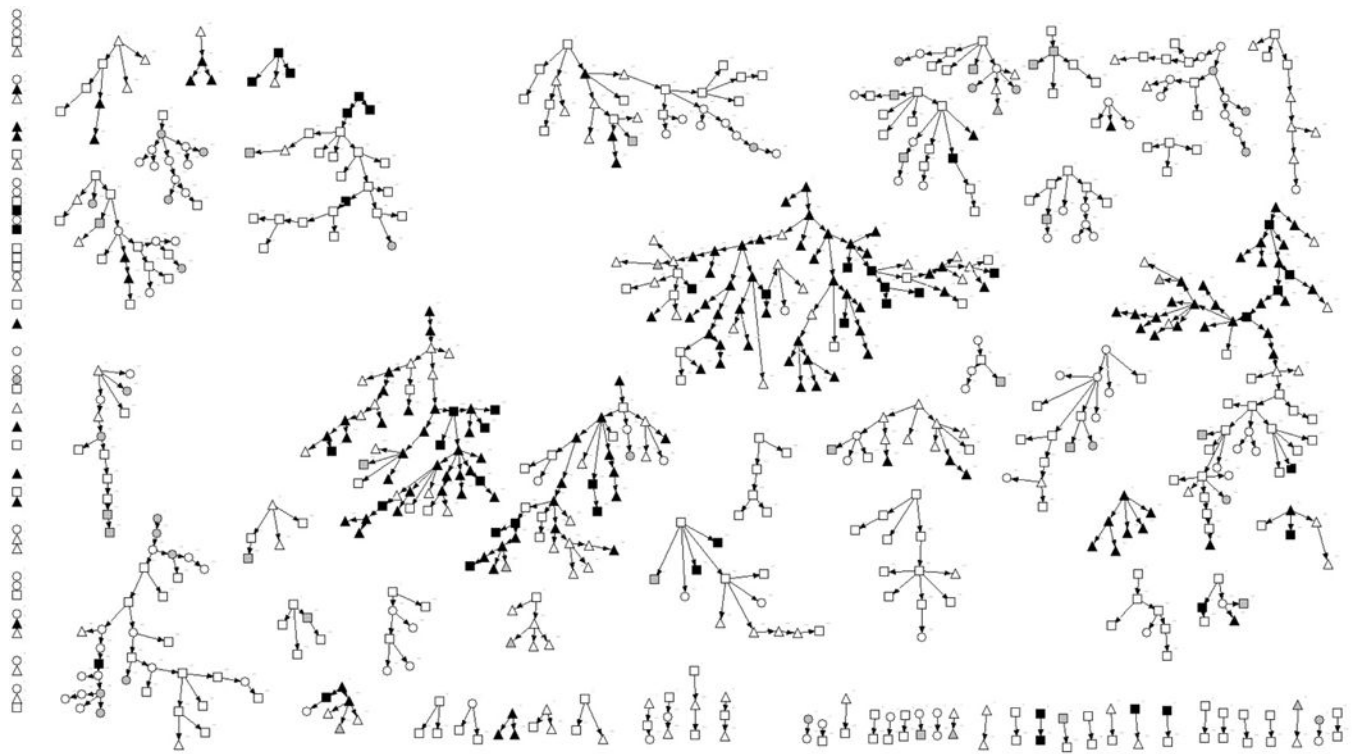


Figure 1. Recruitment chains for the Momentum Study

White = self-reported HIV negative; black = self-reported HIV positive; grey = other Circle = 16–24 years; Square = 25–39 years, Triangle = 40+ years

Table 1

Demographic and HIV characteristics of Momentum Study participants

Characteristic	Category	Total	n	%	RDS %	95% CI
Age	<30	719	275	38.3	34.0	25.3 42.8
	30–44		233	32.4	37.1	30.3 44.4
	45+		211	29.4	28.9	21.4 36.8
Ethnicity	Aboriginal ancestry	719	50	7.0	10.5	5.8 16.2
	Caucasian		539	75.0	68.0	60.5 74.1
	Asian		72	10.0	9.8	6.5 15.2
	Latin American		31	4.3	7.0	2.8 11.2
	Other		27	3.8	4.7	2.3 7.8
Sexual orientation	Gay	719	612	85.1	80.7	76.2 85.4
	Bisexual		66	9.2	15.3	10.7 19.7
	Other		41	5.7	4.0	2.4 6.1
Born in Canada	No	719	162	22.5	25.3	19.5 32.1
	Yes		557	77.5	74.7	67.9 80.5
Current student	No	718	568	79.1	81.0	75.6 85.7
	Yes		150	20.9	19.0	14.3 24.4
Income < \$15k	No	719	452	62.9	53.9	46.8 60.5
	Yes		267	37.1	46.1	39.5 53.2
Neighbourhood of residence	Downtown Vancouver	719	356	49.5	51.9	43.8 59.3
	Elsewhere in Vancouver		223	31.0	30.4	24.0 36.8
	Outside Vancouver		140	19.5	17.7	13.0 24.1
Ever received an HIV test	No	719	39	5.4	6.3	4.0 9.1
	Yes		680	94.6	93.7	90.9 96.0
Tested for HIV in the past 2 years	No	524	89	17.0	21.1	16.1 29.3
	Yes		435	83.0	78.9	70.7 83.9

Characteristic	Category	Total	n	%	RDS %	95% CI
Self-reported result of most recent HIV test	HIV Negative	719	467	65.0	68.6	61.6 75.6
	HIV Positive		195	27.1	22.2	14.7 29.8
	Unknown		57	7.9	9.2	6.5 13.0
Point-of-care HIV test result	HIV Negative	719	520	72.3	76.6	69.0 84.2
	HIV Positive		199	27.7	23.4	15.8 31.0
Aware of HIV positive diagnosis	No	199	4	2.0	0.6	0.0 2.5
	Yes		195	98.0	99.4	97.5 100.0
Receiving HIV treatment	No	199	17	8.5	7.1	1.9 17.9
	Yes		182	91.5	92.9	82.1 98.1
Viral load <200 copies/mL (HIV-positive participants only)	Yes	198	162	81.8	81.4	69.6 91.2
	No		36	18.2	18.6	8.8 30.4
Viral load <50 copies/mL (HIV-positive participants only)	Yes	198	137	69.2	71.6	56.6 81.8
	No		61	30.8	28.4	18.2 43.4
Viral load ≥ 200 copies/mL (For all participants)	No	718	682	95.0	94.6	91.3 97.2
	Yes		36	5.0	5.4	2.8 8.7

Table 2
Bivariate analysis of self-reported sexual behaviour of Momentum participants stratified on the basis of self-reported HIV status

Characteristic	Category	n	%	RDS %	Self-reported HIV positive 95% CI	n	%	RDS %	Self-reported HIV negative or unknown 95% CI	p value
Visited gay bars or clubs past 6 months	No	55	28.2	34.5	23.8 45.2	92	17.6	21.0	15.8 26.2	<0.001
	Yes	140	71.8	65.5	54.8 76.2	432	82.4	79.0	73.8 84.2	
More than one visit per month to gay bars or clubs past 6 months	No	140	71.8	77.2	68.7 85.8	319	60.9	67.6	62.0 73.1	0.017
	Yes	55	28.2	22.8	14.2 31.3	205	39.1	32.4	26.9 38.0	
Used websites to meet guys for sex past 6 months	No	128	65.6	68.7	59.2 78.3	211	40.3	44.9	38.8 51.0	<0.001
	Yes	67	34.4	31.3	21.7 40.8	313	59.7	55.1	49.0 61.2	
Used smartphone apps to meet other guys for sex past 6 months	No	65	33.3	38.2	27.5 49.0	202	38.6	41.4	35.4 47.4	0.462
	Yes	130	66.7	61.8	51.0 72.5	322	61.5	58.6	52.6 64.6	
Number of male sexual partners in the past 6 months	0-2	51	27.4	32.2	21.8 42.5	131	25.6	32.1	26.0 38.2	0.021
	3-5	44	23.7	22.7	13.9 31.5	155	30.3	27.2	22.3 32.2	
	6-10	35	18.8	14.8	8.8 20.9	108	21.1	19.0	14.2 23.8	
	11-20	21	11.3	11.7	4.7 18.7	70	13.7	12.3	8.4 16.3	
	21+	35	18.8	18.6	8.8 28.3	48	9.4	9.3	5.4 13.2	
Number of male anal sex partners in the past 6 months	0-2	53	32.3	36.4	25.2 47.5	176	38.8	40.7	34.2 47.2	0.005
	3-5	41	25.0	21.4	12.8 30.0	130	28.6	27.8	22.3 33.2	
	6-10	23	14.0	12.9	5.3 20.4	80	17.6	16.2	11.3 21.1	
	11-20	21	12.8	14.1	6.1 22.2	40	8.8	7.8	4.1 11.5	
	21+	26	15.9	15.2	5.2 25.3	28	6.2	7.5	3.3 11.7	
Unprotected anal sex in the past 6 months	No	54	27.8	26.6	17.6 35.6	202	38.6	41.1	35.0 47.2	<0.001
	Yes	140	72.2	73.4	64.4 82.4	321	61.4	58.9	52.8 65.0	
Unprotected sex with discordant or unknown serostatus partner	No	106	55.5	55.3	44.5 66.2	335	65.4	68.7	63.2 74.2	0.002
	Yes	85	44.5	44.7	33.8 55.5	177	34.6	31.3	25.8 36.8	

Characteristic	Category	n	%	RDS %	Self-reported HIV positive 95% CI	n	%	RDS %	Self-reported HIV negative or unknown 95% CI	p value
Asks their sexual partner(s) about their HIV status $\geq 50\%$ of the time	No	95	48.7	52.9	42.3 63.6	215	41.0	44.9	38.9 51.0	0.070
	Yes	100	51.3	47.1	36.4 57.7	309	59.0	55.1	49.0 61.1	
Discloses their HIV status to their sexual partner(s) $\geq 50\%$ of the time	No	36	22.9	29.0	17.3 40.7	50	16.7	19.8	12.7 26.8	0.037
	Yes	121	77.1	71.0	59.3 82.7	250	83.3	80.2	73.2 87.3	
Worked as an escort, or in the sex industry in the past 6 months	No	180	92.3	93.5	87.8 99.1	496	94.7	92.2	88.1 96.2	0.579
	Yes	15	7.7	6.5	0.9 12.2	28	5.3	7.8	3.8 11.9	
Any transactional sex in the past 6 months as the provider	No	156	80.0	77.2	67.3 87.2	470	89.7	85.2	80.2 90.2	0.016
	Yes	39	20.0	22.8	12.8 32.7	54	10.3	14.8	9.8 19.8	
Any transactional sex in the past 6 months as the receiver	No	151	77.4	80.4	71.4 89.5	463	88.4	84.9	79.8 89.9	0.174
	Yes	44	22.6	19.6	10.5 28.6	61	11.6	15.1	10.1 20.2	

Self-reported illicit drug use among study participants stratified on the basis of self-reported HIV status

Table 3

Characteristic	Category	Self-reported HIV positive				Self-reported HIV negative or unknown				p value
		n	%	RDS %	95% CI	n	%	RDS %	95% CI	
Any reported injection drug use in the past 6 months	No	127	75.6	79.8	70.8	293	89.3	88.5	82.5	0.0122
	Yes	41	24.4	20.2	11.2	35	10.7	11.5	5.6	17.5
Used poppers in the past 6 months	No	98	50.3	51.7	40.9	355	67.8	71.7	66.4	<.0001
	Yes	97	49.7	48.3	37.6	169	32.3	28.3	23.0	33.6
Used ecstasy in the past 6 months	No	154	79.0	85.8	79.2	389	74.2	76.4	71.4	0.0100
	Yes	41	21.0	14.2	7.7	135	25.8	23.6	18.6	28.6
Used ketamine in the past 6 months	No	160	82.1	85.8	78.8	465	88.7	88.7	84.6	0.3205
	Yes	35	18.0	14.2	7.1	59	11.3	11.3	7.2	15.4
Used GHB in the past 6 months	No	139	71.3	72.8	63.1	454	86.6	86.1	81.5	<.0001
	Yes	56	28.7	27.2	17.5	70	13.4	13.9	9.4	18.5
Used crystal meth in the past 6 months	No	118	60.5	67.4	57.5	465	88.7	87.6	83.2	<.0001
	Yes	77	39.5	32.6	22.7	59	11.3	12.4	7.9	16.8
Used crack cocaine in the past 6 months	No	154	79.0	71.7	60.8	496	94.7	91.4	87.0	<.0001
	Yes	41	21.0	28.3	17.3	28	5.3	8.6	4.2	13.0

Table 4
Logistic regression analysis of factors associated with VL ≥ 200 copies/mL among HIV positive study participants

Characteristic	Category	Univariable		Multivariable	
		OR	95% CI	OR	95% CI
Age	< 45	Ref			
	45+	0.53	0.26 1.09		
Ethnicity	Caucasian	Ref		Ref	
	Non-Caucasian	8.33	3.70 20.0	4.34	1.67 11.1
Sexual orientation	Gay	Ref			
	Bisexual/other	0.42	0.18 0.97		
Born in Canada	No	Ref			
	Yes	0.56	0.24 1.31		
Current student	No	Ref			
	Yes	1.30	0.42 4.08		
Income < \$15k	No	Ref		Ref	
	Yes	5.85	2.35 14.54	6.43	2.08 19.89
Neighbourhood	Downtown/West End	Ref			
	Elsewhere in Vancouver	0.25	0.06 1.07		
	Outside Vancouver	1.76	0.69 4.53		
Any reported injection drug use in the past 6 months	No	Ref			
	Yes	2.13	0.92 4.90		
Unprotected sex with discordant or unknown serostatus partner	No	Ref		Ref	
	Yes	3.26	1.54 6.90	3.13	1.10 8.90
Any transactional sex in the past 6 months as the provider	No	Ref			
	Yes	1.05	0.45 2.46		
Any transactional sex in the past 6 months as the receiver	No	Ref			
	Yes	1.44	0.61 3.37		

Characteristic	Category	Univariable		Multivariable	
		OR	95% CI	OR	95% CI
Used ecstasy in the past 6 months	No	Ref			
	Yes	2.90	1.23 6.82		
Used GHB in the past 6 months	No	Ref		Ref	
	Yes	8.17	3.72 17.93	4.85	1.79 13.2
Used crystal meth in the past 6 months	No	Ref			
	Yes	7.65	3.43 17.06		
Ever visited gay bars or clubs past 6 months	No	Ref			
	Yes	0.32	0.15 0.66		
Number of anal sex partners in the past 6 months	0-2	Ref			
	3-5	1.46	0.52 4.08		
	6-10	0.73	0.18 3.02		
	11-20	2.56	0.86 7.62		
	21+	1.62	0.52 5.04		
Unprotected anal sex in the past 6 months with HIV? partner	No	Ref			
	Yes	4.02	1.88 8.58		
≥50% of the time asks their partner about their HIV status	No	Ref			
	Yes	1.31	0.64 2.68		
≥50% of the time tells their partner about their own HIV status	No	Ref		Ref	
	Yes	7.23	1.29 40.60	7.04	1.01 49.14
HADS Depression scale (continuous)				1.01	0.91 1.12
HADS Depression scale	None/Mild	Ref			
	Moderate/Severe	2.43	0.85 6.96		
HADS Anxiety scale (continuous)				1.03	0.94 1.12

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Characteristic	Category	Univariable		Multivariable	
		OR	95% CI	OR	95% CI
HADS Anxiety Scale	None/Mild	Ref			
	Moderate/Severe	1.49	0.68 3.25		