Characteristics of the HIV cascade of care and unsuppressed viral load among gay, bisexual and other men who have sex with men living with HIV across Canada’s three largest cities

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Abstract

Introduction: Treatment as prevention strategies have been variously applied across provinces in Canada. We estimated HIV care cascade indicators and correlates of unsuppressed viral load (VL) among gay, bisexual and other men who have sex with men (GBM) recruited in Vancouver, Toronto and Montreal.

Methods: Sexually active GBM, aged ≥16 years, were recruited through respondent-driven sampling (RDS) from February 2017 to August 2019. Participants completed a Computer-Assisted Self-Interview and tests for HIV and other sexually transmitted infections (STIs). We conducted bivariate analyses comparing RDS-adjusted proportions across cities. We used multivariable logistic regression to examine factors associated with having a measured VL ≥ 200 copies/mL with data pooled from all three cities.

Results: We recruited 1179 participants in Montreal, 517 in Toronto and 753 in Vancouver. The RDS-adjusted HIV prevalence was 14.2% (95% CI 11.1 to 17.2) in Montreal, 22.1% (95% CI 12.4 to 31.8) in Toronto and 20.4% (95% CI 14.5 to 26.3) in Vancouver (p < 0.001). Of participants with confirmed HIV infection, 3.3% were previously undiagnosed in Montreal, 3.2% undiagnosed in Toronto and 0.2% in Vancouver (p = 0.154). In Montreal, 87.6% of GBM living with HIV were receiving antiretroviral therapy (ART) and 10.6% had an unsuppressed VL; in Toronto, 82.6% were receiving ART and 4.0% were unsuppressed; in Vancouver, 88.5% were receiving ART and 2.6 % were unsuppressed (p < 0.001 and 0.009 respectively). Multivariable modelling demonstrated that participants in Vancouver (adjusted odds ratio [AOR]=0.23; 95% CI 0.06 to 0.82), but not Toronto (AOR=0.27; 95% CI 0.07 to 1.03), had lower odds of unsuppressed VL, compared to Montreal, as did older participants (AOR 0.93 per year; 95% CI 0.89 to 0.97), those at high-risk for hazardous drinking (AOR = 0.19; 95% CI 0.05 to 0.70), those with a primary care provider (AOR = 0.11; 95% CI 0.02 to 0.57), and those ever diagnosed with other STIs (AOR = 0.12; 95% CI 0.04 to 0.32).

Conclusions: GBM living in Montreal, Toronto and Vancouver are highly engaged in HIV testing and treatment and all three cities have largely achieved the 90-90-90 targets for GBM. Nevertheless, we identified disparities which can be used to identify GBM who may require additional interventions, in particular younger men and those who are without a regular primary care provider.

Keywords: antiretroviral therapy; HIV; men who have sex with men; virological suppression

1 | INTRODUCTION

Gay, bisexual and other men who have sex with men (GBM) in Canada are disproportionately affected by HIV and other sexually transmitted infections (STIs). In 2016, GBM accounted for 48% of new HIV diagnoses [1] and have consistently accounted for 45% to over 50% annually, despite comprising only 3% to 5% of the population aged 15 years and older [1,2,3,4].

The use of biomedical HIV prevention has been recognized as having the potential to act as a preventive measure at both the individual level [5] and the population level [6,7]. This approach, termed “treatment as prevention” (TasP), has been formally adopted in BC as public policy with additional dedicated funding since 2010 [8]. It is also part of the HIV control strategies in Ontario [9] and Quebec [10], but has not been developed to the same extent in these provinces. As healthcare is primarily a responsibility of provinces, rather than the...
federal government in Canada, policies and programmes to address HIV and other STI prevention, testing, care and treatment vary across provinces.

In 2014, UNAIDS formally proposed targets for HIV-related health services, known as 90-90-90, whereby countries should aspire to have 90% of people living with HIV (PLWH) aware of their diagnosis, 90% of these individuals should be receiving ART and 90% of these should have achieved virological suppression [11]. The government of Canada formally adopted these targets in 2014 and estimated then that approximately 80% of PLWH had been diagnosed, of whom 76% were receiving ART and 89% of these had achieved virological suppression [12]. Sustained virological suppression is the ultimate goal of the care cascade in that it maximizes the benefits of ART for PLWH [13] and eliminates the risk of onward HIV transmission [5]. Previous research has identified sociodemographic factors such as age, ethnicity and income [14,15], as being associated with virological suppression, as well as measures of mental health and substance use [15–17].

We designed a study to compare the GBM populations in Montreal, Toronto and Vancouver, by recruiting representative community-based samples. We estimated HIV care cascade indicators across all three cities and examined factors associated with having an unsuppressed viral load (VL). Our primary interest was to examine if there were differences in HIV-related outcomes for GBM populations in these cities and whether access to specific health services were associated with achieving virological suppression.

2 METHODS

Participants were recruited using respondent-driven sampling (RDS) in Montreal, Toronto and Vancouver from 1 February 2017 to 31 August 2019. RDS is a formalized chain recruitment method [18] by which participants are recruited through their own social networks. To be eligible GBM needed to identify as a man (cis- or transgender), be aged ≥16 years old, report having sex with another man in the previous six months and be able to complete a survey in either English or French (if a participant from Montreal) and agree to study procedures, including biological sampling. Furthermore, participants were required to either have been invited into the study as a “seed” participant or be in receipt of a valid invitation (see below) obtained from another participant whom they knew personally. The initial targeted sample size was 720 participants per site, in order to provide comparable data for the three cities. We also compared sociodemographic, health status, use of health services and individual characteristics, including reported substance-use. Mental health symptoms were measured by the Hospital Anxiety and Depression Scale (HADS) [19], using both the anxiety ($\alpha = 0.84$) and depression ($\alpha = 0.76$) sub-scales. Alcohol use was measured by the Alcohol Use Disorders Identification Test-Congise (AUDIT-C) scale [20]. Study protocols were approved by institutional review boards of Research Institute of the McGill University Health Centre, Ryerson University, The University of Toronto, St. Michael’s Hospital, the University of British Columbia and the University of Victoria.

We conducted bivariate analyses comparing RDS-adjusted proportions across cities using RDS-II weights [21], using Pearson’s chi-squared test for categorical variables and Type III Wald chi-squared test (from a weighted logistic regression) for continuous variables. RDS-II weights, which are inversely proportional to the size of participants’ social network, were based on the question “How many men who have sex with men aged 16 years or older, including trans men, do you know who live or work in the Metro Vancouver/Greater Toronto/Metro Montreal area?” An upper limit of network-size was fixed at 150 based on empirical research by Dunbar et al [22].

Among individuals self-reporting as HIV negative or unknown, we compared reports of their most recent HIV test and the number of tests in the previous year. For confirmed PLWH, we compared the proportions previously undiagnosed, the proportions currently receiving HIV treatment and the proportions with a plasma VL measured <200 copies/mL [23] across the three cities. We also compared sociodemographic, health service access, substance-use behaviour and mental health symptoms among PLWH across cities. We then conducted a pooled analysis of all PLWH across all three cities using multivariable logistic regression to examine factors associated with having an unsuppressed VL ($\geq 200$ copies/mL) [23].
Variables were weighted using the RDS II-derived weights from each city and city was used as a potential explanatory variable in the model. Variables of interest in the univariable models with a value of p < 0.2 were included for consideration in the multivariable model. For several variables, including age, AUDIT-C scores and HADS scores, we considered both continuous and categorical variables for inclusion in the final model. Only observations with complete data were included in the multivariable model. There is no consensus as to whether RDS weights should be used when conducting regression analyses in RDS studies [24]. However, an analysis conducted by members of our study team found that weighted logistic regression methods consistently outperform unweighted methods in terms of bias and precision when explanatory variables are correlated with the network size reported by participants [25]. As such, we have chosen to apply RDS weights to our regression analysis. The final model was selected based on potential candidate variables from the literature and using a backward selection technique, whereby the least significant (i.e., highest Type III p-value) variable was dropped until the final model reached the optimal (minimum) Akaike Information Criterion. All analyses were performed using SAS® Version 9.4 (SAS Corporation, Cary, NC, USA).

3 | RESULTS

We recruited a total of 1179 participants in Montreal, 517 in Toronto and 753 in Vancouver, from 27, 96 and 117 seed participants respectively. A total of 6822 invitations were issued to participants in Montreal, 3078 in Toronto and 4424 in Vancouver. The mean, median and ranges of recruitment waves were 6.67, 6 and 0 to 17 in Montreal, 2.67, 2 and 0 to 12 in Toronto and 2.67, 2 and 0 to 10 in Vancouver. Further details on RDS-specific recruitment outcomes are published elsewhere [26]. The study samples reached equilibrium for all of the key variables for which we monitored. The RDS-adjusted HIV prevalence based on serological testing or documentation was 14.2% (95%CI 11.1 to 17.2); in Montreal; 22.1% (95% CI 12.4 to 31.8) in Toronto, and 20.4% (95% CI 14.5 to 26.3) in Vancouver (p < 0.001) (Table 1). Of participants who were found to be HIV negative at enrolment, 82% to 89% of those were receiving treatment, and of those who were retained in the final multivariable model.

The highest proportion of participants who self-identified as Canadian (69.7%; 95% CI 59.2 to 80.2; p < 0.001) and whom were born in Canada (77.6%; 95% CI 67.8 to 87.5; p = 0.003) with Vancouver having the lowest proportion reporting Canadian ethnicity (41.8%; 95% CI 26.3 to 57.4; p < 0.001) and Toronto having the lowest proportion born in Canada (62.1%; 95% CI 36.2 to 88.0; p = 0.003). In terms of health services, the proportions of PLWH who reported having access to a family doctor, ranged from 90.3% in Montreal to 99.4% in Toronto (p < 0.001). The median number of times participants had been tested for an STI in the past 2 years was highest in Toronto (5: Interquartile range [IQR] 3 to 8) and lowest in Vancouver (median of 2: IQR 1 to 5, p = 0.022), but differences in the proportion of participants who had ever been diagnosed with an STI (other than HIV) were not statistically significant (range of 80.3% to 88.4% across sites; p = 0.224).

In terms of substance use, Montreal had the highest proportion of participants classified at high risk for heavy drinking or abuse/dependence (40.5%; 95% CI 29.2 to 51.7) (p = 0.032), whereas Vancouver had the highest proportion of participants reporting methamphetamine use in the past six months (36.9%; 95% CI 21.5 to 52.2) (p < 0.001). Vancouver also had the highest proportion of reported opioid use in the previous six months, compared with 2.3% (95% CI 0.0 to 4.7) in Toronto and 10.3% in Montreal (95% CI 3.8 to 16.8) (p = 0.002).

Among all 421 PLWH in the three cities with valid VL results, 27 (6.4% non-RDS adjusted) had measured VLs > 200 copies/mL. Our multivariable model (Table 3), based on 398 observations with complete data found that older age was associated with lower odds of unsuppressed VL (adjusted odds ratio [AOR] 0.93 per year; 95% CI 0.89 to 0.97), as was residing in Vancouver (AOR = 0.23; 95% CI 0.06 to 0.82) relative to Toronto. Toronto also had a lower odds compared to Montreal, but this was not statistically significant (AOR = 0.27; 95% CI 0.07 to 1.03). Having a primary care provider (AOR = 0.11; 95% CI 0.02 to 0.57), and ever being diagnosed with another STI (AOR = 0.12; 95% CI 0.04 to 0.32) also had lower odds of an unsuppressed VL. Participants with high-risk scores AUDIT-C scores, also had lower odds of having an unsuppressed VL (AOR = 0.19; 95% CI 0.05 to 0.70). No measures of mental health symptoms or diagnoses were retained in the final multivariable model.

4 | DISCUSSION

Our RDS-weighted analysis has demonstrated that GBM in Montreal, Toronto and Vancouver are highly engaged in HIV testing and treatment. While we did find some statistically significant differences across the three cities, the magnitude of these differences was quite small. We found that PLWH in Vancouver had lower odds of having an unsuppressed VL, compared with Montreal, but even in Montreal, only 10% of PLWH (whether diagnosed or not) had VL measurements ≥200 copies/mL. This suggests that policies and services to engage GBM at risk for acquiring HIV and those living with HIV have been largely successful across all three cities. In terms of the UNAIDS targets for this population, 97% to 99.8% of GBM living with HIV in our study were diagnosed, 82% to 89% of those were receiving treatment, and of those
receiving ART, 94% to 99% had a suppressed VL. While the ART uptake values were all below 90%, we suspect that this may be due to underreporting of treatment status, as 18 participants were found to have a suppressed VL despite reporting not being on treatment.

Between 67.5 and 70.4% of HIV-negative or unknown serostatus participants reported having been tested for HIV in the past year, and only 7% to 12% of participants reported never being tested. Previous research has shown that, in Vancouver, less frequent HIV testing among GBM is associated with less HIV risk behaviour [27]. As such, previously undiagnosed HIV infections were very rare in the current study, ranging 0.2% of PLWH in Vancouver to 3% in Montreal and Toronto. These proportions of undiagnosed infections are far lower than the national estimate of undiagnosed HIV infections (13%) released by the Public Health Agency of Canada (PHAC) in 2018 [28]. However, these PHAC estimates do not disaggregate by HIV exposure category and no primary data collection which could be used to measure the undiagnosed fraction in GBM has been published in Canada in more than 10 years [29]. While it is reasonable to assume that GBM living in these metropolitan areas are perhaps more engaged in HIV and STI care than other GBM in these provinces, it is also important to note that HIV is highly concentrated in the urban cores of these three cities in each province, with over 70% of HIV diagnoses found in these metropolitan areas being among GBM [30-32]. Notably PHAC estimates for the proportion of all PLWH receiving ART (85%) and those with virological suppression (94%) [26] are similar to what we found in our study, for GBM living with HIV.

When examining the pooled analysis of GBM living with HIV with unsuppressed VL, we found that, similar to other North American studies, younger GBM living with HIV were less likely to have a suppressed VL [14,15]. Of note, unlike recent studies from the United States [15,17], but similar to another study from Canada [14], we did not find that ethnicity was

| Table 1. HIV care cascade characteristics of GBM recruited in Montreal, Toronto and Vancouver in the Engage study |
|---------------------------------------------------------------|
| **Montreal (N = 1179)** | **Toronto (N = 517)** | **Vancouver (N = 753)** |
|--------------------------|-----------------------|------------------------|
| HIV serostatus based on testing or documentation | | |
| Negative/unknown | 964 (81.8) | 417 (80.7) | 621 (82.5) |
| Positive | 215 (18.2) | 100 (19.3) | 132 (17.5) |
| Among HIV serostatus negative or unknown Last tested for HIV | | |
| Within 1 year | 688 (71.4) | 330 (79.3) | 501 (80.7) |
| >1 year ago | 218 (22.6) | 69 (16.6) | 86 (13.9) |
| Never tested or unsure | 58 (6.0) | 17 (4.1) | 34 (5.5) |
| If tested within the past two years, number of times tested Median (IQR) | | |
| 3 (2 to 5) | 4 (2 to 6) | 4 (3 to 7) |
| Among HIV-positive participants HIV diagnosis status | | |
| Known positive | 211 (98.1) | 98 (98.0) | 131 (99.2) |
| Previously undiagnosed | 4 (1.9) | 2 (0.0) | 1 (0.8) |
| Use of medication for HIV | | |
| Currently receiving HIV medication | 193 (89.8) | 95 (96.0) | 123 (93.2) |
| Not currently receiving HIV medication, but has in the past | 4 (1.9) | 0 (0.0) | 3 (2.3) |
| Never taken HIV medication | 18 (8.4) | 4 (4.0) | 6 (4.6) |
| Plasma HIV viral load among all HIV-positive participants | | |
| <200 copies/mL | 183 (91.0) | 88 (95.7) | 123 (96.1) |
| ≥200 copies/mL | 18 (9.0) | 4 (4.4) | 5 (3.9) |
| Plasma HIV viral load among those receiving HIV medication | | |
| <200 copies/mL | 174 (94.6) | 85 (97.7) | 117 (96.7) |
| ≥200 copies/mL | 10 (5.4) | 2 (2.3) | 4 (3.3) |

*Includes those not previously diagnosed.*
| Sociodemographics | Montreal (N = 215) | Toronto (N = 100) | Vancouver (N = 132) | p value |
|-------------------|-------------------|-------------------|---------------------|---------|
| **Age**           |                   |                   |                     |         |
| <30               | 13 (6.1)          | 24 (24.0)         | 10 (7.6)            | <0.001  |
| 30 to 44          | 56 (26.1)         | 40 (40.0)         | 44 (33.3)           |         |
| 45+               | 146 (67.9)        | 36 (36.0)         | 78 (59.1)           |         |
| **Annual income** |                   |                   |                     |         |
| <$30,000          | 149 (69.3)        | 46 (46.0)         | 76 (57.6)           | <0.001  |
| $30,000 to $59,999| 52 (24.2)         | 85 (85.0)         | 117 (88.6)          |         |
| $60,000+          | 14 (6.5)          | 18 (18.0)         | 14 (10.6)           |         |
| **Ethnicity**     |                   |                   |                     |         |
| Canadian          | 161 (74.9)        | 46 (46.0)         | 76 (57.6)           | <0.001  |
| European          | 19 (8.8)          | 21 (21.0)         | 18 (13.6)           |         |
| Aboriginal        | 2 (0.9)           | 0 (0.0)           | 11 (8.3)            |         |
| Asian             | 3 (1.4)           | 6 (6.0)           | 7 (5.3)             |         |
| African/Caribbean/Black | 8 (3.7) | 8 (8.0)       | 3 (2.3)             |         |
| Mixed race        | 4 (1.9)           | 3 (3.0)           | 3 (2.3)             |         |
| Other             | 18 (8.4)          | 16 (16.0)         | 14 (10.6)           |         |
| **Born in Canada**|                   |                   |                     |         |
| No                | 36 (16.7)         | 34 (34.0)         | 38 (28.8)           | 0.003   |
| Yes               | 179 (83.3)        | 66 (66.0)         | 94 (71.2)           |         |
| **Sexual identity** |                 |                   |                     |         |
| Gay               | 186 (86.5)        | 86 (86.0)         | 117 (88.6)          | <0.001  |
| Bisexual          | 14 (6.5)          | 6 (6.0)           | 5 (3.8)             |         |
| Other             | 15 (7.0)          | 8 (8.0)           | 10 (7.6)            |         |
| **Gender identity** |                 |                   |                     |         |
| Cis-gender        | 199 (92.6)        | 98 (98.0)         | 121 (91.7)          | 0.002   |
| Trans or other    | 16 (7.4)          | 2 (2.0)           | 11 (8.3)            |         |
| **Education level** |                 |                   |                     |         |
| High school or less | 67 (31.2)     | 15 (15.0)         | 31 (23.5)           | 0.086   |
| Greater than high school | 148 (68.8) | 85 (85.0) | 101 (76.5) |         |
| **Employed**      |                   |                   |                     |         |
| No                | 106 (49.3)        | 43 (43.0)         | 61 (46.2)           | 0.121   |
| Yes               | 109 (50.7)        | 57 (57.0)         | 71 (53.8)           |         |
| **Health services** |                 |                   |                     |         |
| Has a primary healthcare provider | 18 (8.4) | 2 (2.0)       | 7 (5.3)            | <0.001  |
| Number of times tested for STIs in past two years | 4 (2 to 7) | 4 (3 to 7) | 4 (2 to 8) | 0.022   |
| Substance use     |                   |                   |                     |         |
| AUDIT-C scale score |                 |                   |                     |         |
| Low risk (score <4) | 111 (55.0)   | 56 (57.1)         | 77 (62.1)           | 0.032   |
| High risk (score ≥4) | 91 (45.1)   | 42 (42.9)         | 47 (37.9)           |         |
| Methamphetamine use in past six months | 145 (71.1) | 63 (63.0) | 79 (59.9) | <0.001  |
| Yes               | 59 (28.9)         | 37 (37.0)         | 53 (40.2)           |         |
between AUD and reduced adherence to treatment and five seven prospective cohort studies found an association adherence among PLWH in general (not only GBM), five of the effects of alcohol-use disorder (AUD) on HIV treatment suppressed VL, which was unexpected. In a systematic review of HIV virological suppression among GBM [15,17]. In our study, mental health and substance use are associated with a lack of mission if not adherent to their ART.

recognizing that they may be at greater risk of onward trans-nosed with an STI may be more motivated to adhere to ART the same time. As well, men who have been previously diag-nosed with an STI likely reflects access and ability of healthcare that benefits of PLWH. Similarly, having been care, having a primary care provider likely facilitates a continu-

umstances where specialists may be providing HIV-specific care, having a primary care provider likely facilitates a continuity of healthcare that benefits of PLWH. Similarly, having been previously diagnosed with an STI likely reflects access and motivation to undertake STI testing, where questions regarding HIV treatment and adherence may also be addressed at the same time. As well, men who have been previously diagnosed with an STI may be more motivated to adhere to ART recognizing that they may be at greater risk of onward transmission if not adherent to their ART.

Other studies have found that syndemic factors related to mental health and substance use are associated with a lack of HIV virological suppression among GBM [15,17]. In our study, we did not find independent associations between measures of mental health symptoms or diagnosed disorders and lack of VL suppression, although some measures were associated with this outcome in univariable analyses. This suggests that other factors in our model, possibly having access to a family doctor or older age may explain the lack of these associations in our final model.

We also did not find associations with recent use of methamphetamine, cocaine, ecstasy, opioids or any injection drugs and our outcome. We did, however, find an association with high-risk AUDIT-C scores and a reduced odds of unsuppressed VL, which was unexpected. In a systematic review of the effects of alcohol-use disorder (AUD) on HIV treatment adherence among PLWH in general (not only GBM), five of seven prospective cohort studies found an association between AUD and reduced adherence to treatment and five other studies have found associations between AUD and increased VL [33]. It is worth noting that not all studies which have examined these outcomes have found associations between AUD and HIV-related outcomes [34] and there are wide variations as to how alcohol use and treatment adherence are measured, but we are unaware of other studies showing that high-risk consumption may be protective. GBM who had scores for high-risk drinking on the full AUDIT scale in Vancouver have been shown to have higher levels of social support and are more likely to read gay newspapers or community magazines [30]. This may lead such men who are living with HIV to be more aware and more motivated to seek HIV treatment and adhere to their prescribed regimen.

This study has a number of strengths, as well as several limitations. First, we used RDS as our recruitment strategy to overcome of some of the limitations of generating representa-tive research samples of GBM in Canadian cities, which have typically used clinic-based samples, convenience samples, or on-line surveys or time-location sampling from venues or events [29]. Furthermore, the study teams in each city used harmonized study protocols with the same general recruit-
ment strategies, study procedures and data collection tools. Nevertheless, study implementation varied by city, with Mon-
treal able to recruit a larger sample, with fewer seed partici-
pants and more waves of recruitment than Toronto and Vancouver. As such, some of the differences we have observed between the city samples may be due to differences in the characteristics arising from differences in implementa-
tion. We have conducted analyses to identify differences in sociodemographic characteristics or motivations for study par-ticipation among participants in the study across the three cities [35], but have been unable to identify reasons as to why the RDS process was more successful in Montreal than the other two cities As well, conducting pooled regression analy-

ses using RDS-recruited samples, violates one of the key assumptions of RDS [21], in that the participants are drawn from a distinct networked population. However, our pooled analysis did not seek to ascertain pooled prevalence esti-
mates; instead, we sought to examine correlates of unsup-
pressed viral load.

| Injection drug use in past six months | Montreal (N = 215) | Toronto (N = 100) | Vancouver (N = 132) | p value |
|--------------------------------------|-------------------|-------------------|---------------------|---------|
| No                                   | N (%)             | RDS% (95% CI)     | N (%)               | RDS% (95% CI) | N (%)               | RDS% (95% CI) | p value |
| No                                   | 174 (83.3)        | 82.6 (73.5 to 91.6) | 83 (83.0)           | 94.2 (89.5 to 98.9) | 109 (82.6)        | 89.0 (80.4 to 97.7) | 0.013 |
| Yes                                  | 35 (16.8)         | 17.4 (8.4 to 26.5) | 17 (17.0)           | 5.8 (1.1 to 10.5) | 23 (17.4)        | 11.0 (2.3 to 19.6) | p value |
| Cocaine use in past six months       |                   |                   |                     |                     |                   |                   |
| No                                   | 159 (78.7)        | 81.9 (73.6 to 90.3) | 74 (74.8)           | 92.3 (86.5 to 98.0) | 102 (78.5)       | 81.6 (69.0 to 94.2) | 0.043 |
| Yes                                  | 43 (21.3)         | 18.1 (9.7 to 26.4) | 25 (25.3)           | 7.7 (2.0 to 13.5) | 28 (21.5)        | 18.4 (5.8 to 31.0) | p value |
| Ecstasy use in past six months       |                   |                   |                     |                     |                   |                   |
| No                                   | 158 (77.1)        | 82.1 (74.1 to 90.1) | 76 (76.8)           | 92.6 (86.9 to 98.4) | 96 (74.4)        | 79.8 (66.7 to 92.8) | 0.021 |
| Yes                                  | 47 (22.9)         | 17.9 (9.9 to 25.9) | 23 (23.2)           | 7.4 (1.6 to 13.1) | 33 (25.6)        | 20.2 (7.2 to 33.3) | p value |
| Opioid use in past six months        |                   |                   |                     |                     |                   |                   |
| No                                   | 178 (87.7)        | 89.7 (83.2 to 96.2) | 90 (91.8)           | 97.7 (95.3 to 100) | 114 (87.7)       | 83.3 (71.2 to 95.3) | 0.002 |
| Yes                                  | 25 (12.3)         | 10.3 (3.8 to 16.8) | 8 (8.2)             | 2.3 (0.0 to 4.7)  | 16 (12.3)        | 16.7 (4.7 to 28.8) | p value |
Table 3. Logistic regression analysis of factors associated with having a VL ≥ 200 copies/mL among 421 participants living with HIV in the Engage Study

| Demographics                      | Univariable logistic | Multivariable logistic |
|-----------------------------------|----------------------|------------------------|
|                                   | Odds ratio (OR) 95% CI| Adjusted OR 95% CI     |
| Age                               | 0.94 0.91 0.97       | 0.93 0.89 0.97         |
| Annual income                     |                      |                        |
| <$30,000                          | Ref                  |                        |
| ≥$30,000                          | 1.04 0.45 2.39       |                        |
| Ethnicity – Canadian or European  |                      |                        |
| Yes                               | Ref                  |                        |
| No                                | 1.06 0.44 2.56       |                        |
| Born in Canada                    |                      |                        |
| No                                | Ref                  |                        |
| Yes                               | 0.52 0.23 1.17       |                        |
| Education level                   |                      |                        |
| High school or less               | Ref                  |                        |
| Greater than high school          | 2.05 0.76 5.52       |                        |
| Currently employed                |                      |                        |
| No                                | Ref                  |                        |
| Yes                               | 0.91 0.41 1.99       |                        |
| City                              |                      |                        |
| Montreal                          | Ref                  | Ref                    |
| Toronto                           | 0.36 0.12 1.10       | 0.27 0.07 1.03         |
| Vancouver                         | 0.22 0.07 0.73       | 0.23 0.06 0.82         |
| Sexual behaviour                  |                      |                        |
| No anal sex in P6 M               | Ref                  |                        |
| No reported CAS in P6 M           | 0.49 0.16 1.54       |                        |
| Only reported CAS with same serostatus partners in P6 M | 0.02 0.00 3.53 |              |
| Reported CAS with opposite or unknown serostatus partners | 0.77 0.28 2.12 | |
| Health services                   |                      |                        |
| Has a primary healthcare provider |                      |                        |
| No                                | Ref                  | Ref                    |
| Yes                               | 0.08 0.02 0.25       | 0.11 0.02 0.57         |
| Tested for STIs in past two years |                      |                        |
| No                                | Ref                  |                        |
| Yes                               | 1.12 0.44 2.82       |                        |
| Ever diagnosed with an STI        |                      |                        |
| No                                | Ref                  | Ref                    |
| Yes                               | 0.16 0.07 0.35       | 0.12 0.04 0.32         |
| Mental health                     |                      |                        |
| HADS score anxiety sub-scale      | 1.11 1.03 1.19       |                        |
| HADS score depression sub-scale   | 1.09 0.99 1.18       |                        |
| Self-reported mental health in past six months | Ref | |
| Excellent/very good               |                      |                        |
| Good                              | 1.27 0.38 4.26       |                        |
| Fair/poor                         | 3.73 1.54 9.05       |                        |
| Previously diagnosed with anxiety disorder | No | Ref |
| Yes                               | 2.41 1.06 5.45       |                        |
| Previously diagnosed with depressive or bipolar disorder | No | Ref |
| Yes                               | 1.74 0.73 4.16       |                        |
5 | CONCLUSIONS

We found that GBM living with HIV in Canada’s three largest population centres were rarely unaware of their HIV status and are highly engaged in HIV treatment. Nevertheless, we have identified disparities which can be used to identify GBM who may require additional interventions to maximize the benefits of HIV treatment, in particular younger men and those who may not have a regular primary care provider. GBM populations continue to be a core group in Canada’s concentrated HIV epidemic and while improvements in HIV prevention, care and treatment are still possible, it appears that HIV policies and programmes in these three cities have been effective in reaching the 90-90-90 targets. This bodes well for future reductions in HIV diagnoses (and incidence) for GBM, a phenomenon which is currently being observed in BC, where the number of diagnoses among GBM recorded in 2017 was the lowest since the mid-1980s [30]. However, this also suggests that further improvements to the HIV care cascade, possibly 95-95-95 and the expansion of publicly funded pre-exposure prophylaxis programmes [36] for HIV, which is still limited in Canada [37] may be needed to further reduce HIV infections for GBM.

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COMPETING INTERESTS

None of the authors have any competing interests to declare.

AUTHORS’ CONTRIBUTIONS

DMM, NL, JC, GL, JJ and TAH designed the study. HA, AL and AL supervised data collection and study implementation. JB was responsible for managing the study database and developed the analytic dataset. ZC and LW conducted the analyses. SSW, SSS and JS helped to develop the analysis plan. DMM developed the first draft of the manuscript and all authors provided input into and have approved the final version.

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