Population-Level Sexual Mixing By HIV Status and Pre-exposure Prophylaxis Use Among Men Who Have Sex with Men in Montreal, Canada: Implications for HIV Prevention

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Running head: Sexual Mixing By HIV Status and PrEP Use Among MSM

Abstract

There are limited data on population-level mixing patterns by HIV status or pre-exposure prophylaxis (PrEP) use. Using cross-sectional survey data (*Engage*, 2017-2018) of 1137 men who have sex with men ≥16 year-old in Montreal, we compared observed seroconcordance in the past-6-month sexual partnerships to what would have been observed by chance if zero individuals serosort. Of 5 recent partnerships where both individuals were HIV-negative, we compared observed concordance in PrEP use to the counterfactual if zero individuals selected partners based on PrEP use. We estimated the concordance by chance using a balancing-partnerships approach assuming proportionate-mixing. HIV-positive respondents had a higher proportion of HIV-positive partners (66.4% (95% confidence interval: 64.0%-68.6%)) than by chance (23.9%(23.1%-24.7%)). HIV-negative respondents (both on and not on PrEP) had higher proportions of HIV-negative partners (82.9%(81.1%-84.7%), and 90.7%(89.6%-91.7%), respectively) compared with by chance (76.1%(75.3%-76.9%)); but those on PrEP had a higher proportion of HIV-positive partners than those not on PrEP (17.1%(15.3%-18.9%) vs. 9.3%(8.3%-10.4%)). Those on PrEP also had a higher proportion of partners on PrEP among their HIV-negative partners (50.6%(42.5%-58.8%)) than by chance (28.5%(27.5%-29.4%)). The relationship between PrEP and sexual-mixing patterns demonstrated by less population-level serosorting among those on PrEP and PrEP-matching warrants consideration during PrEP roll-out.

Key words: HIV; sexual mixing patterns; serosorting; PrEP; MSM; PrEP-matching

Abbreviations: PrEP: pre-exposure prophylaxis; MSM: men who have sex with men; RDS: respondent-driven sampling

Gay, bisexual, and other men who have sex with men (MSM) are disproportionately at risk of HIV acquisition.(1) In several epidemic contexts including Canada, seroadaptive practices are adopted by some MSM as a strategy to reduce HIV risk.(2-6) Seroadaptive practices consider one's own and a partner's HIV status in deciding with whom to have sex, such as choosing sexual partners of the same HIV status (individual-level serosorting), alongside sexual positioning and/or condom use.(2-6)

With the scale-up of HIV pre-exposure prophylaxis (PrEP) and antiretroviral treatment for HIV-positive individuals leading to viral suppression, serosorting and related patterns of 'who has sex with whom' may be changing.(7-9) Qualitative evidence suggests that PrEP may reduce stigma and anxiety around sex within serodiscordant partnerships and lead to less serosorting.(10) Conversely, PrEP use may be associated with increased stigma if those on PrEP are perceived to have multiple sexual partners, and/or by equating PrEP use with condomless anal sex, thus leading to preferential partner selection by PrEP use.(10) There is also emerging evidence of 'biomed-matching', which refers to preferentially selecting sexual partners who are using the same biomedical prevention strategy as oneself, such as individual-level PrEP-matching wherein both partners are using PrEP.(7, 9)

Preferential partner selection by any attribute at the individual-level can influence the population-level sexual mixing patterns, which in turn influence HIV transmission.(11, 12) Individual-level serosorting may be the most effective among partnerships in which both partners are certain about HIV status. Individuals may be unaware/uncertain about

their own and/or partners' HIV status, thus limiting serosorting effectiveness.(13) At the population-level, individuals' serosorting may result in fewer serodiscordant partnerships. For instance, in settings with low levels of undiagnosed HIV, this could mean fewer onward HIV transmissions in the context of condomless sex within seroconcordant partnerships.(11) Consequently, population-level mixing patterns can further influence the impact of HIV prevention strategies at the population-level.(14) Moqueet *et al.* found that assumptions of no serosorting could underestimate the population-level impact of PrEP on HIV incidence reduction compared with incorporating serosorting in the HIV transmission model.(14)

Despite compelling evidence of individual-level serosorting, there is no empirical estimate that quantifies population-level sexual mixing by HIV status nor its relationship with PrEP use. Existing studies often measured individual-level serosorting, by examining the proportions of MSM who only had seroconcordant partners or who intended to serosort.(2-5, 15-24) A few studies measured the proportion of seroconcordant partnerships in the sexual-network.(5, 19, 23) However, to quantify the extent to which the observed partnership distribution reflects preferential partner selection, the observed patterns must be compared with what would have been observed in the absence of individuals' preferential mixing - by chance alone.(25)

Using cross-sectional survey data of MSM in Montreal, Canada, we aimed to i) quantify population-level serosorting by comparing observed partnership distribution by HIV status to that expected by chance; ii) quantify population-level serosorting among HIV-

negative MSM stratified by PrEP use; and iii) quantify population-level PrEP-matching by comparing observed partnership distribution by PrEP use to that expected by chance.

METHODS

Study design and subjects

We obtained data (Feb 7th 2017 to June 15th 2018 (n=1179)) from *Engage-Montreal*, a cross-sectional survey of MSM in Montreal. Cisgender and transgender men aged ≥16 years who had sex with another man in the past 6 months were recruited using respondent-driven sampling (RDS).(26, 27) RDS is an adapted form of chain referral method of recruiting study participants.(26, 27) Details on the recruitment procedures for *Engage-Montreal* have been documented elsewhere.(28) Participants completed a computer-assisted self-interview, which included questions on sexual behaviours in the past 6 months. We included respondents who reported ≥1 anal or oral male sex partners in the past 6 months in our analyses, and excluded respondents who only had vaginal/frontal sex with another man in the past 6 months (n=4). We excluded respondents who did not report (different from reporting 'unaware') HIV status for all of their sexual partners (n=38).

Measures

As per terminology for social/sexual-network data, we hereafter refer to respondents as egos, and their sexual partners as alters.(29) Egos' HIV status was determined by self-

report of their most recent HIV test results prior to the current study, and was classified as positive, negative, and unknown (never tested/did not receive or were unsure about results/preferred not answering).

Alters' HIV status was classified based on egos' responses to two sets of questions (**Web Appendix 1**). One question asked about the aggregate numbers of anal or oral sex partners in the past 6 months by alters' HIV status (e.g., *'of the men you had oral or anal sex with in the past 6 months, how many were HIV-positive'*), which did not separate anal sex from oral sex partners. Responses to these questions were used for our primary analyses on all anal or oral sex partners in the past 6 months. The other event-level questions (**Web Appendix 1**) asked about each of the up to 5 most recent male sexual partners in the past 6 months (e.g., *'the most recent time you had sex with the partner named above, did you know what his HIV status was BEFORE you guys had sex'*; respondents could select if they were certain about their answers (frequency of each response is shown in **Web Appendix 2 (Web Table 1 and Web Table 2)**). We classified uncertain as unknown, to be consistent with the set of questions on the partnerships in the past 6 months (**Web Appendix 1**). Event-level questions were asked to distinguish the type of sex (anal or oral or both) within each partnership (**Web Appendix 1**). For each ego, event-level data were aggregated to derive total numbers of recent anal or oral sex partners by alters' HIV status, and separately for recent anal sex partners. These event-level measures were used in our sensitivity analyses.

HIV-negative egos' PrEP use in the past 6 months (yes/no) was ascertained based on self-report of PrEP use anytime in the past 6 months. We also used event-level data to determine PrEP use at last sex (yes/no/unknown) for both egos and alters (e.g., *'the most recent time you had sex with the partner named above, were you using PrEP? Was your partner using PrEP'*) (**Web Appendix 1**).

Statistical analysis

We described sociodemographic, sexual behavioural, and health system engagement characteristics of our study sample. We calculated RDS-adjusted estimates with the 95% empirical likelihood-based confidence intervals, using the *Volz and Heckathorn* method (RDS-II estimates, calculated using R 'RDS' package), by which individuals were weighted by the inverse of their self-reported network size (survey question in **Web Appendix 1**).(30)

Analysis: serosorting. We first estimated the distribution of partnerships by alters' HIV status by chance alone if zero individuals serosort (**Web Appendix 3 (Equation 1)**). This counterfactual cannot be observed, and was instead estimated under the proportionate-mixing assumption using a balancing-partnerships approach commonly used in mathematical models of HIV.(25) Proportionate-mixing assumes that by chance alone, the distribution of partnerships 'available' by a given attribute depends on the prevalence of this attribute and the heterogeneity in partner numbers by this attribute.(25) We then calculated the partnership distribution by alters' HIV status by

chance conditional on knowing alters' HIV status.

We calculated the observed past-6-month partnership distributions by alters' HIV status for HIV-positive, negative, and egos of unknown-status separately using **Equation 2 in Web Appendix 3**. The observed partnership distributions by alters' HIV status conditional on knowing alters' HIV status were also calculated among the subset of alters whose HIV status were known.

We compared the observed partnership distributions conditional on knowing alters' HIV status to those expected by chance, using chi-squared tests, for egos with HIV-positive, negative, and unknown-status, separately. To quantify the extent of serosorting, we calculated the excess fraction of seroconcordance beyond chance by subtracting the seroconcordance by chance from the observed seroconcordance and then dividing by the observed seroconcordance.

Analysis: serosorting stratified by PrEP use. We calculated the observed partnership distributions by alters' HIV status for HIV-negative egos using **Equation 2 in Web Appendix 3**, stratified by egos' past-6-month PrEP use. For HIV-negative egos on PrEP, and those not on PrEP, we compared their observed partnership distributions by alters' HIV status to each other, and separately, to the partnership distribution by alters' HIV status by chance, using chi-squared tests.

Analysis: PrEP-matching. We first estimated the distribution of HIV-negative partnerships by alters' PrEP use under proportionate-mixing assumption, using **Equation 3 in Web Appendix 3** (based on egos' past-6-month PrEP use data). We then calculated the observed partnership distributions by alters' PrEP use using event-level data, stratified by egos' PrEP use, reflecting PrEP use at last sex within recent anal or oral sex partnerships, in which both partners were HIV-negative (**Web Appendix 3 (Equation 4)**). The observed partnership distributions by alters' PrEP use conditional on knowing alters' PrEP use were also calculated by restricting **Equation 4 in Web Appendix 3** to the subset of alters whose PrEP use were known.

We compared the observed partnership distributions conditional on knowing alters' PrEP use to those expected by chance, using chi-squared tests, for HIV-negative egos who used PrEP at last sex and those who did not, separately. Finally, we calculated the excess fraction of concordance in PrEP use beyond by chance.

Sensitivity analyses

Although there are established adjustment methods for RDS sampling to generate population-representative individual-level estimates,(30) it is unknown how RDS sampling would influence population-level sexual mixing estimates. Thus, to examine the sensitivity of our results to the sampling strategy, we repeated our analyses on an RDS-weighted sample (equivalent size as the original sample). We computed RDS weights using the *Volz and Heckathorn* method.(30)

To assess the sensitivity of our results to the differences in how event-level and past-6-month data were recalled and reported, and to the inclusion of oral sex only partners, we repeated analyses of aims 1 and 2 using event-level data on recent anal or oral sex partners, and separately for recent anal sex partners only to generate the observed partnership distributions by alters' HIV status. We also repeated the aim 2 analyses, stratifying by egos' PrEP use at last sex, instead of in the past 6 months. Lastly, we repeated the aim 3 analysis restricting to recent anal sex partners.

We used R version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria) for analyses, and calculated confidence intervals (CIs) assuming binomial distributions. All statistical significance tests were two sided.

Ethics

The following ethics boards approved the study: Ryerson University, St. Michael's Hospital, University of Toronto, University of Windsor, University of British Columbia, University of Victoria, the Simon Fraser University, and the Research Institute of the McGill University Health Centre.

RESULTS

A total of 1137 respondents were included for analyses. Their median age was 34 years [interquartile range, 27-49 years]. The majority of respondents self-identified as gay (81.5%). Over a third (38.0%) self-identified as 'Non-French/English Canadian' and 0.9% as 'Aboriginal or Indigenous'. Overall, 207 (18.2%) self-reported as HIV-positive, 831 (73.1%) as HIV-negative, and 99 (8.7%) as of unknown-status. Respectively, they reported a median of 5 [3-15], 5 [3-10], and 3 [2-6] anal or oral sex partners in the past 6 months (P<0.001). The majority of HIV-positive respondents reported currently using antiretroviral therapy (n=190 (96.4%)), of whom 174 (91.6%) were virally suppressed. A total of 112 HIV-negative respondents (13.5%) reported using PrEP in the past 6 months. **Table 1** shows RDS-adjusted estimates of the study sample characteristics.

Population-level serosorting

Respondents reported information on 11,883 anal or oral sex partnerships in the past 6 months (**Table 2**). By chance, the partnership distributions with alters of HIV-negative, positive, and unknown-status were 72.1%, 22.7%, and 5.2%, respectively. However, 43.7% of observed partnerships comprised alters' of unknown-status. Conditional on knowing alters' HIV status, the partnership distributions by chance with alters' of HIV-negative and HIV-positive status were 76.1% and 23.9%, respectively (**Table 2)**. HIV-positive egos had a higher proportion of HIV-positive alters compared with by chance (66.4% vs. 23.9%, P<0.001)(**Table 2**). HIV-negative egos and egos with unknown-HIV status both had higher proportions of alters with an HIV-negative status compared with

by chance (87.9% and 92.7%, respectively, vs. 76.1%, both *P*<0.001)(**Table 2**). The excess fractions of HIV-positive seroconcordance and HIV-negative seroconcordance beyond by chance were 64.0% and 13.4%, respectively.

Population-level serosorting stratified by PrEP use

Among HIV-negative egos, those used PrEP in the past 6 months had a lower proportion of alters whose HIV status were unknown to egos, compared with those who did not use (30.6% vs. 49.5%, *P*<0.001) (**Table 3**). Conditional on knowing alters' HIV status, HIV-negative egos who used PrEP and those who did not use both had lower proportions of HIV-positive alters, compared with by chance (17.1% and 9.3%, respectively, vs. 23.9%; *P*<0.001); however, the proportion of HIV-positive alters was higher among those who used PrEP compared with those who did not use (17.1% vs. 9.3%; *P*<0.001)(**Table 3**). The excess fractions of HIV-negative seroconcordance beyond chance were 8.9% and 16.1% for HIV-negative egos on and not on PrEP, respectively.

Population-level PrEP-matching

HIV-negative respondents reported information on 1312 recent anal or oral sex partnerships with another HIV-negative man (**Table 4**). By chance, the partnership distributions with HIV-negative alters who used PrEP and those did not use PrEP were 28.5%, and 71.5%, respectively (**Table 4**). However, in 10.1% of observed recent HIV-

negative partnerships, HIV-negative egos did not know about alters' PrEP use status. Conditional on knowing alters' PrEP use status, HIV-negative egos on PrEP had a higher proportion of HIV-negative alters who used PrEP at last sex compared with by chance (50.6% vs. 28.5%, *P*<0.001). Those not on PrEP had a higher proportion of HIV-negative alters who did not use PrEP, compared with by chance (80.3% vs. 71.5%, *P*<0.001) (**Table 4**). The excess fractions of concordance in PrEP use, and in no PrEP use, beyond chance were 43.7% and 11.0%, respectively.

Sensitivity analyses

RDS-weighted analyses produced similar results as the un-weighted analyses. The RDS-weighted proportion of HIV-negative alters, conditional on knowing alters' HIV status, was 81.5% by chance (**Web Appendix 4 (Web Table 3)**) and slightly higher than the un-weighted estimate (76.1%). The observed proportions of HIV-negative alters were also higher across all subgroups after adjusting for weights (**Web Appendix 4 (Web Table 3 and Web Table 4)**). Thus, the RDS-adjusted excess fractions (vs. un-weighted) of seroconcordance beyond by chance were 69.9% (vs. 64.0%), 8.4% (vs. 8.9%), and 10.7% (vs. 16.1%) for individuals who were HIV-positive, HIV-negative on PrEP, and HIV-negative not on PrEP, respectively. The RDS-adjusted excess fraction (vs. un-weighted) of concordance in PrEP use beyond chance was 42.1% (**Web Appendix 4 (Web Table 5)**) (vs. 43.7%). Our results were not sensitive to differences in event-level and past-6-month data, nor to the inclusion of oral sex partners (**Web Appendix 5 (Web Table 6, Web Table 7 and Web Table 8)**).

DISCUSSION

We found evidence of population-level serosorting among HIV-positive MSM and HIV-negative MSM in Montreal, Canada, including those who used PrEP. However, there was less serosorting among HIV-negative MSM who used PrEP compared with those who did not. We also found evidence of population-level PrEP-matching among HIV-negative MSM. Our empirical estimates of population-level serosorting and PrEP-matching could help in the study of HIV transmission dynamics, and in the population-level evaluation of combination HIV prevention strategies which use HIV transmission models.(11, 12, 14, 31)

Our findings of population-level serosorting are consistent with prior studies which demonstrated serosorting intention or behaviours among MSM in high-income settings.(2-4, 6, 15-18, 20, 21, 23, 24) Our population-level measures complement individual-level measures of sexual mixing by addressing the limitations of measuring individuals' intention to preferentially select partners, a measure shown to have low agreement with individual behaviours;(20, 23, 24) or measuring individuals' sexual partnering behaviours, which does not distinguish intended behaviours from what could be unintentional (by chance).(2, 3, 15-18, 21) Additionally, our estimates of excess fractions of concordance allowed us to quantify the extent of serosorting and PrEP-matching attributable to individuals' preference beyond by chance. Specifically, a strength of our analyses is that we estimated the partnership distribution by chance under proportionate-mixing assumption,(25) which accounted for the heterogeneity in sexual partner numbers by HIV status and PrEP use.(22)

We found less population-level serosorting among those who used PrEP. This finding aligns with individual-level measure data in Canada, which found MSM on PrEP reported a higher proportion of HIV-diagnosed partners after starting PrEP.(32) Moreover, we found evidence of population-level PrEP-matching, suggesting potential partner preference by PrEP use. Similarly, Grov *et al.* found that compared with HIV-negative MSM not on PrEP, those on PrEP reported a larger proportion of partners on PrEP, and a smaller proportion of partners not on PrEP (41% vs. 22%, 28% vs. 44%, respectively).(7) Martinez *et al.* found HIV-negative MSM on PrEP expressed preference toward PrEP users over non-PrEP users while looking for sexual partners online.(8) Nevertheless, we cannot deduce the PrEP use was a causal factor in partner selection, as PrEP-matching may reflect individuals' preferential partner selection by factors other than PrEP which are associated with PrEP use (e.g., health literacy, HIV risk behaviours, insurance-status).(33, 34)

We found that at the population-level, awareness of partners' HIV status was higher among MSM who used PrEP compared with those who did not use. This finding contrasts some qualitative evidence which suggests that individuals were less likely to discuss HIV status with partners after initiating PrEP.(10) However, our results may reflect an early adopter effect in our sample. As PrEP scale-up began in Montreal in 2016 following the approval of 'Truvada' as PrEP by Health Canada, MSM who used PrEP in our study represent early adopters of PrEP, who may have been more empowered around discussion of HIV status, potentially through prior engagement in HIV prevention services and strategies.(33) With PrEP roll-out, the patterns of

population-level sexual mixing are likely to be evolving over time and warrant monitoring, as communities re-assemble biomedical evidence and apply it to HIV risk management.(35)

Population-level patterns of PrEP-matching and less serosorting while on PrEP could potentially lead to disparities in HIV prevention benefits between HIV-negative MSM who use PrEP and those who do not. This is because MSM not on PrEP do not directly benefit from the decreased HIV acquisition risk through taking PrEP; and they may be less likely to benefit from partners' PrEP use if they are less likely to have a partner on PrEP due to population-level PrEP-matching. Moreover, their sexual-network reflects a greater extent of serosorting than HIV-negative MSM on PrEP. In a setting where undiagnosed HIV may be high,(11) if serosorting is associated with more condomless sex,(23) HIV-negative MSM not on PrEP may face an even higher HIV acquisition risk.(11) Thus, with potential changes in sexual mixing because of PrEP, it is even more important to ensure high or increased HIV testing to reduce the fraction or person-years of undiagnosed HIV in the population.

Finally, our findings have important implications for the transmission of sexually transmitted bacteria and other viruses. For example, bacterial sexually-transmitted infections such as syphilis and viral infections such as hepatitis C are disproportionately higher among HIV-positive MSM,(36, 37) which could partly be due to population-level serosorting.(38) Our observed patterns of sexual mixing related to PrEP could

potentially modify the difference in rates of sexually-transmitted infections by HIV status.(38)

Our study has several limitations. First, measures of the number and characteristics of sexual partners were subject to recall and reporting bias, especially when respondents were asked to recall information over the period of half a year. However, similar results from event-level and past-6-month data suggest minimal influence of recall bias on the results. Second, population-level PrEP-matching was restricted to recent partnerships and might not reflect the mixing pattern among all past-6-month partnerships. This was restricted by lack of data on all partners' PrEP use status in the past 6 months. Third, we did not simultaneously consider the influence of viral suppression on sexual mixing as only 33 HIV-positive MSM were not virally suppressed in our study, which limited the analytic power. Fourth, although our results suggest individuals' preferential partner selection by HIV status and PrEP use, we cannot infer which subset of MSM intended to do so. For example, even if only HIV-positive MSM intended to serosort, and HIV-negative MSM did not, we would still observe serosorting at the population-level for both subgroups as a result of partnership-balancing. Therefore, population-level measures of sexual mixing complement but cannot replace individual-level measures of preferential partner selection. Fifth, our approach is limited by the extent to which it subsumes layers of heterogeneity that could be associated with differences in preferential partner selection, including race, age, and socioeconomic-status.(39) Future studies can apply the same approach to examine sexual mixing by these attributes. Sixth, we cannot ascertain the temporality in the relationship we observed due to the cross-sectional

study design. For example, we cannot distinguish whether being part of a certain sexual-network before PrEP uptake influenced the likelihood of PrEP initiation, or whether starting PrEP influenced individuals' sexual-network. Future studies using longitudinal data can be used to examine potential reasons underlying PrEP-matching. Finally, our results from the RDS-weighted analyses are subject to limitations of the RDS recruitment and statistical adjustment methods.(40) For instance, there may be measurement error in respondents' self-reported social network size, which was used to produce weights in RDS-adjusted analysis to account for selection bias.(40)

Our findings demonstrate population-level serosorting among both HIV-negative and HIV-positive MSM, in a setting where the majority of HIV-positive MSM are virally suppressed. Our findings also suggest potential influence of PrEP on sexual mixing patterns as evidenced by less population-level serosorting among those on PrEP and PrEP-matching. These data reinforce the importance of monitoring changes in sexual mixing patterns among MSM to inform PrEP implementation and impact evaluation.

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Table 1. Crude and RDS-adjusted Estimates of Characteristics of Gay, Bisexual and Other Men Who Have Sex With Men in the 2017-2018 *Engage-Montreal* Study (n=1131).

Characteristics	No. of respondents	Crude %	RDS-adjusted[a] %	RDS-adjusted[a] 95% confidence intervals
Age, years	34 (27, 49)[h]		37.9 (36.6, 39.2)[i]	
Non, French Canadian or English Canadian	427	38.0	46.4	41.2, 51.6
Aboriginal or Indigenous	10	0.9	1.2	0.0, 2.6
Sexual orientation				
Bisexual	91	8.0	12.6	9.1, 16.0
Gay	927	81.5	77.0	72.4, 81.5
Straight	5	0.4	1.7	0.0, 4.1
Other[b]	114	10.0	8.7	5.8, 11.6
Single	820	72.1	73.7	69.1, 78.4
Have a main partner[c]	492	43.3	44.7	39.6, 49.9
Completed university or higher degree	738	64.9	58.8	53.8, 63.7
Employed, current	767	67.5	56.2	51.1, 61.3
Annual income, $CAD				
0, <10k	168	14.8	23.4	18.6, 28.1
10, <30k	482	42.4	42.4	37.3, 47.5
30, <60K	353	31	26.1	21.9, 30.3
60K+	134	11.8	8.1	5.5, 10.7
Anal/oral sex partners, past 6 months	5 (3, 10)[h]		7.2 (5.4, 8.9)[i]	
Anal sex partners, past 6 months	3 (1,7)[h]		4.9 (3.2, 6.7)[i]	
Self, reported HIV status[d]				
Negative	831	73.1	73.4	68.9, 77.8
Positive	207	18.2	13.9	10.5, 17.3
Unknown	99	8.7	12.8	9.4, 16.1
Tested HIV positive by the *Engage* study	208	18.5	14.0	10.5, 17.5
Used PrEP, past 6 months[e]	112	13.5	8.9	5.2, 12.6
Current on ART[f]	190	96.4	97.7	95.2, 100
Virally suppressed[g]	174	91.6	89.7	81.9, 97.3

Abbreviations: RDS, respondent, driven sampling; PrEP, pre- exposure prophylaxis; ART: antiretroviral treatment for HIV, positive individuals.

[a] RDS-II estimator and empirical likelihood-based confidence intervals calculated using R 'RDS' package.

[b] Such as queer, questioning, asexual, pansexual, two, spirit etc.

[c] Person with whom the respondents are in a relationship with and feel most committed to (even if you are in a polyamorous/open/non, monogamous relationship).

[d] Self-report of the most recent HIV test results, where unknown was defined as those who never tested for HIV, ever tested but never received the most recent test results, or were unsure or preferred not to answer.

[e] Among self-reported HIV-negative individuals.

[f] Among self-reported HIV-positive individuals.

[g] Among individuals who self-reported being currently on ART.

[h] Values are expressed as median (interquartile range).

[i] Values are expressed as RDS adjusted mean and 95% empirical likelihood-based confidence interval.

Table 2. Seroconcordance Among Anal or Oral Sex Partnerships in the Past 6 Months As Expected By Chance Under Proportionate Mixing Versus Observed Patterns in the 2017-2018 *Engage-Montreal* Study (No. of Respondents=1137, No. of Partnerships Reported By Respondents=11,883).

			Alters' HIV status as perceived by egos								
						Conditional on awareness of alters' HIV status					
Egos' characteristics			Comparison	Unaware/Unsure		Negative		Positive		*P*-value[a]	
HIV status[b]	No. of respondents	No. of partnerships		%	95% CI	%	95% CI	%	95% CI		
N/A	N/A	N/A	Chance[c]	5.2	4.8, 5.6	76.1	75.3, 76.9	23.9	23.1, 24.7	Reference	
Negative	831	8573	Observed	44.2	43.1, 45.2	87.9	87.0, 88.8	12.1	11.2, 13.0	<0.001	
Positive	207	2695	Observed	39.1	37.3, 41.0	33.6	31.4, 36.0	66.4	64.0, 68.6	<0.001	
Unknown	99	615	Observed	57.9	53.9, 61.8	92.7	88.8, 95.5	7.3	4.5, 11.2	<0.001	

Abbreviations: CI: confidence intervals.

[a] Three chi-squared tests were performed independently stratified by egos' HIV status, to compare observed seroconcerdance to expected seroconcordance, conditional on egos' awareness of alters' HIV status.

[b] Self-report of the most recent HIV test results; unknown was defined as those who never tested for HIV, ever tested but never received the most recent test results, or were unsure or preferred not to answer.

[c] Reflects the 'total number of anal or oral sex partnerships available by HIV status' under proportionate mixing assumption, which accounts for the number of individuals by HIV status, and different numbers of sexual partners they have.

Table 3. Variability in Seroconcordance Among Anal or Oral Sex Partnerships in the Past 6 Months By Whether or Not an HIV-Negative Respondent Uses PrEP in the Past 6 Months (2017-2018 *Engage-Montreal* Study, No. of HIV-Negative Respondents=831, No. of Partnerships Reported By HIV-Negative Respondents=8573).

			Alters' HIV status perceived by egos								
			Comparison			Conditional on awareness of alters' HIV status					
Egos' characteristics				Unaware/Unsure		Negative		Positive		*P*-value[a]	*P*-value[b]
PrEP, past 6 months[c]	No. of HIV-Negative respondents	No. of partnerships		%	95% CI	%	95% CI	%	95% CI		
N/A	N/A	N/A	Chance[d]	5.2	4.8, 5.6	76.1	75.3, 76.9	23.9	23.1, 24.7	Reference	N/A
No	719	6132	Observed	49.5	48.3, 50.8	90.7	89.6, 91.7	9.3	8.3, 10.4	<0.001	Reference
Yes	112	2441	Observed	30.6	28.8, 32.5	82.9	81.1, 84.7	17.1	15.3, 18.9	<0.001	<0.001

Abbreviations: CI: confidence intervals; PrEP: Pre-exposure Prophylaxis.

[a] Two chi-squared tests were performed independently stratified by respondent's PrEP use to compare observed seroconcordance to expected seroconcerdance, conditional on awareness of alters' HIV status.

[b] A chi-squared test was performed to compare the difference in the two observed seroconcordance by PrEP use conditional on awareness of alters' HIV status.

[c] Base on whether the self-reported date of PrEP use at the most recent time was within the past 6 months.

[d] Reflects the 'total number of anal or oral sex partnerships available by HIV status' under proportionate mixing assumption, which accounts for the number of individuals by HIV status, and different numbers of sexual partners they have.

Table 4. Concordance in PrEP Use between HIV-Negative Egos and HIV-Negative Alters As Expected With Proportionate Mixing Versus Observed Patterns Among Recent Sexual Partnerships (2017-2018 *Engage-Montreal* Study, No. of HIV-Negative Respondents=859, No. of HIV-Negative Recent Anal or Oral Sex Partners Reported by HIV-Negative Respondents=1312).

Egos' characteristics			Alters' PrEP use, last sex[b] as perceived by egos								
			Comparison			Conditional on awareness of alters' PrEP use					
				Unaware/Unsure		No		Yes		*P*-value[a]	*P*-value[b]
PrEP, last sex[c]	No. of HIV-negative respondents	No. of partnerships		%	95% CI	%	95% CI	%	95% CI		
N/A	N/A	N/A	Chance[d]	0.0	0.0, 0.0	71.5	70.6, 72.5	28.5	27.5, 29.4	Reference	N/A
No	765	1136	Observed	9.8	8.1, 11.6	80.3	77.7, 82.7	19.7	17.3, 22.3	<0.001	Reference
Yes	94	176	Observed	12.5	8.0, 18.3	49.4	41.2, 57.5	50.6	42.5, 58.8	<0.001	<0.001

Abbreviations: CI: confidence intervals; PrEP: Pre-exposure Prophylaxis.

[a] Two chi-squared tests were performed independently to compare observed concordance in PrEP use to expected concordance, conditional on awareness of alters' PrEP use.

[b] A chi-squared test was performed to compare the difference in the proportions of partners who use PrEP by respondent's PrEP use conditional on awareness of partner's PrEP use status.

[c] Self-reported PrEP use at the time of the most recent sex with each partner.

[d] Reflects the 'total number of HIV-negative anal or oral sex partnerships available by PrEP use' under proportionate mixing assumption, which accounts for the number of individuals by PrEP use, and different numbers of sexual partners they have.