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## Correlations Between Community-Level HIV Preexposure Prophylaxis Coverage and Individual-Level Sexual Behaviors among US Men Who Have Sex with Men

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### Abstract

**Objective:** To evaluate if community-level HIV PrEP coverage is correlated with individual sexual behaviors.

**Design:** We used demographic, behavioral, and sexual network data from ARTnet, a 2017–2019 study of US MSM.

**Methods:** Multivariable regression models with a Bayesian modeling framework were used to estimate associations between area-level PrEP coverage and seven sexual behavior outcomes (number of total, main, and casual male partners [network degree]; count of one-time partnerships; consistent condom use in one-time partnerships; and frequency of casual partnership anal sex (total and condomless)), controlling for individual PrEP use.

**Results:** PrEP coverage ranged from 10.3% (Philadelphia) to 38.9% (San Francisco). Total degree was highest in Miami (1.35) and lowest in Denver (0.78), while the count of one-time partners was highest in San Francisco (11.7/year) and lowest in Detroit (1.5/year). Adjusting for individual PrEP use and demographics, community PrEP coverage correlated with total degree (aIRR=1.73; 95% CrI, 0.92–3.44), casual degree (aIRR=2.05; 95% CrI, 0.90–5.07), and count of one-time partnerships (aIRR=1.90; 95% CrI, 0.46–8.54). Without adjustment for individual PrEP use, these associations strengthened. There were weaker or no associations with consistent condom use in one-time partnerships (aIRR=1.68; 95% CrI, 0.86–3.35), main degree (aIRR=1.21;

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#### CONFLICTS OF INTEREST

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95% CrI, 0.48–3.20), and frequency of casual partnership condomless anal sex (aIRR=0.23; 95% CrI, 0.01–3.60).

**Conclusion:** Most correlations between community PrEP coverage and sexual behavior were explained by individual PrEP use. However, some residual associations remained after controlling for individual PrEP use, suggesting that PrEP coverage may partially drive community-level differences in sexual behaviors.

### Keywords

HIV; MSM; preexposure prophylaxis; risk compensation; sexual behavior

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## INTRODUCTION

The prevention of human immunodeficiency virus (HIV) remains a major public health challenge both globally and in the US. The rate of HIV diagnoses in the US remains high, with nearly 40,000 reported cases in 2019 [1]. Men who have sex with men (MSM) experience increased risk of HIV: despite representing less than 5% of the US population, MSM account for nearly 70% of all diagnoses [1]. Preexposure prophylaxis (PrEP) significantly reduces the risk of HIV acquisition [2], but, despite substantially increasing levels of PrEP use [3], its impact on population-level HIV incidence in the US has been modest [4,5]. Empirical effects are weaker than projections by mathematical models estimating incidence by PrEP coverage level [6].

Gaps between projected and actual HIV rates in the context of PrEP coverage may be attributable to racial and ethnic disparities in PrEP use [3], which are driven by social and structural factors, such as inequitable access to healthcare and medical mistrust resulting from mistreatment in the healthcare system [7,8]. The disconnect between projected and actual HIV rates may also be driven by changes in sexual behaviors after PrEP initiation, often referred to as behavioral “risk compensation” [9,10]. Persons may engage in more condomless sex after initiating PrEP because PrEP reduces the risk of acquiring HIV [9]. A recent systematic review found broad evidence for increased condomless sex after participants commence PrEP [11]. While behavioral changes because of PrEP have few implications for HIV incidence among active, adherent PrEP users, they can increase HIV acquisition in cases of suboptimal adherence or unplanned PrEP discontinuation [12]. Further, behavioral changes increase the risk of acquiring other sexually transmitted infections (STIs) [11].

Other PrEP-related changes in behavior may also contribute to the modest population-level impact of PrEP. With the continually increasing scale-up of PrEP, changes in risk behavior may also occur among individuals not using PrEP but living in cities with high PrEP coverage. This phenomenon, referred to as “community-level risk compensation” [9], could occur when individuals who are not on PrEP feel less likely to acquire HIV if others in their community are protected and modify their behavior as a result. Resulting behavioral modifications could include the number of sexual partners, the frequency of partnership formation, or the use of condoms. Behavioral changes among PrEP non-users may be akin to unvaccinated individuals feeling indirectly protected from vaccine-preventable diseases if

vaccinated community members are protected [13]. These behavioral changes could impact HIV incidence because PrEP coverage is unequally distributed, even in communities where total PrEP coverage is high [3].

Few studies have directly quantified evidence for community-level changes in behavior associated with PrEP coverage. Previous studies have used participant-reported population-level condom use after wide-scale PrEP introduction to indicate community-level behavioral changes, but did not distinguish behavioral changes among those directly versus indirectly protected by PrEP [14,15]. One study examined trends in anal intercourse and condom use among MSM not on PrEP during PrEP implementation projects in Australia, but only used data from two cities [16]. Another study examined trends in HIV prevention strategies among MSM from seven Australian states/territories, but did not compare behavioral differences and PrEP coverage between communities [17]. Previous studies have not estimated PrEP-related community-level behavioral changes using multiple behavioral outcomes and comparing multiple communities; this approach is necessary as PrEP coverage may prompt modifications to a range of behaviors and patterns may vary by community.

In this study, we examined the associations between community-level PrEP use and seven behavioral indicators (including sexual network outcomes) to determine whether PrEP-related community-level behavioral differences exist independent of individual-level PrEP use. We hypothesized that communities with high PrEP coverage would have higher sexual network connectivity (e.g., higher rate of one-time partnership acquisition and number of persistent partners) and lower condom use, even after adjusting for individual-level PrEP use. Our broader goal was to elucidate the indirect effects of PrEP on sexual behaviors among US MSM to guide effective HIV and STI prevention efforts.

## METHODS

### Study Design.

We used data from ARTnet, a cross-sectional web-based US study of MSM conducted during 2017–2019 [18]. ARTnet eligibility criteria included male sex at birth, current male identity, lifetime history of sexual activity with another man, and age 15–65 years. The study collected data on demographic and clinical characteristics, sexual behaviors, and egocentric network structures [18]. The Emory University IRB approved the study.

### Measures.

Participants were asked summary questions about their overall number of male partnerships within three types in the past year: main (“boyfriend, significant other, or life partner”), casual (non-main partner they have had sex with more than once), and one-time. They were then asked partner-specific questions for up to their five most recent partners (<5% of participants reported having 5 ongoing partners). Questions included attributes of the partner (e.g., demographics) and the partnership (e.g., start/end dates, frequency of sexual activity).

From these partnership data, we calculated total, main, and casual network degree. Degree was the number of persistent anal intercourse partners, for each partnership type (main, casual, and one-time), on the day of the survey (i.e., current ongoing partners). We calculated one-time partnership acquisition rates by subtracting the reported main and casual partners from the total partners, and we evaluated consistent condom use in one-time partnerships. We calculated the frequency of casual partnership anal sex by summing the weekly number of anal sex acts with and without condoms reported with ongoing casual partners. Individual PrEP information was based on self-reported current use.

Our analysis was restricted to MSM who had ever had an HIV test and who self-reported as HIV-negative. Based on ZIP code of residence and by matching against county databases, individuals were classified as residing in one of 15 metropolitan statistical areas (major cities) or nine US census divisions. Cities and census division were mutually exclusive (e.g., New England excluded the Boston MSA). This choice was made because community-level factors of interest may differ by urbanicity. Community PrEP coverage was calculated for each area; this represents the proportion of HIV-negative MSM in each geographic area currently on PrEP. We validated our ARTnet estimates of community PrEP coverage to National HIV Behavioral Surveillance System (NHBS) estimates in the Appendix.

### Statistical Analyses.

All analyses were conducted using R 4.0.3. Descriptive demographic and behavioral variables were stratified by city/division. We used hierarchical Bayesian modeling in which individuals were nested within their geographic areas, for two reasons. First, we used the Bayesian models to jointly estimate the outcomes of interest and community PrEP coverage with a binomial model of individual PrEP. This multilevel design by community accounted for the sample differences in the number of respondents by community. Our model outcomes were total, main, and casual degree; count of one-time partners in the past year; consistent condom use in one-time partnerships; and frequency of casual partnership anal sex (with and without condoms). Second, recent developments in epidemiology suggest that p-values often damage the interpretation of epidemiologic data and should not be used to evaluate associations [19]. Therefore, we did not present p-values nor only deem 95% confidence intervals that did not contain 1.0 as epidemiologically meaningful. Instead, we reported Bayesian 95% credible intervals and the proportion of posterior distributions above the null value (1.00) for each model. We interpreted results as signaling a meaningful pattern if the majority of the posterior distributions from the simulations indicated a positive association. Weakly informative prior distributions were placed on all model parameters. Models were fit with the *rethinking* R package, which uses the STAN Markov Chain Monte Carlo Sampler to estimate model coefficients [20,21].

We used a multi-step approach to estimate individual-level versus community-level PrEP-related differences in sexual behaviors. First, to model individual-level PrEP-related behavior differences, we used multivariable regression to estimate incidence rate ratios (IRRs) between individual-level PrEP use and the outcomes of interest, adjusting for demographic confounders (age and race/ethnicity). IRRs represent the ratio of the rate of the outcomes of interest (degree, partners, or consistent condom use, for the past

year) comparing the exposure scenarios. Second, to estimate community-level PrEP-related differences in behaviors, we examined PrEP coverage and behavior outcomes by city/division and used multivariable regression to estimate IRRs for the association between community PrEP coverage and the outcomes of interest. We ran these models first adjusting for demographics only, then for demographics plus individual PrEP status. This strategy allowed us to evaluate the magnitude of the impact of individual-level PrEP status on the associations between community PrEP coverage and behavior. For models of network degree and consistent condom use in one-time partnerships, Poisson regression was used. Due to overdispersion, negative binomial regression was used for the count of one-time partners and frequency of casual partnership anal sex; prevalence ratios that approximate IRRs were generated. Our analysis code is available at <https://github.com/EpiModel/PrEPCommunityLevelBehaviors>.

## RESULTS

Of the 3,259 HIV-negative MSM in our study, 631 (19.4%) reported current PrEP use, 178 (5.5%) reported previous but not current PrEP use, and the remaining 2,450 (75.2%) reported never using PrEP (Table 1). Participants ranged in age from 15–65 years, with an average age of 37.3 years. Approximately 74.3% of participants were non-Hispanic white, 12.9% were Hispanic, 4.1% were non-Hispanic Black, and 8.7% were non-Hispanic other race. Overall, 76.4% were privately insured. Participants were from across the US, with the most represented census divisions being the South Atlantic (21.5%) and the Pacific (17.2%) divisions.

PrEP use varied by city/division (Table 2). PrEP-eligible men living in San Francisco and Seattle had the highest current PrEP use (38.9% and 33.8%, respectively) and men in Philadelphia and Detroit had the lowest (10.3% and 10.9%, respectively). PrEP use did not vary by race/ethnicity: current PrEP use was 19.4% among non-Hispanic white MSM, 20.9% among non-Hispanic Black MSM, and 19.2% among Hispanic MSM. Behavioral differences were observed by city/division; summary measures of behavioral outcomes stratified by city/division are shown in Table 3.

Behavioral outcomes also varied by reported PrEP use. For example, men currently on PrEP had an average casual degree of 1.17 (standard deviation [SD]: 1.23), whereas men not on PrEP had an average casual degree of 0.48 (SD: 0.90) (Table 3, Supplemental Table 1). Men currently on PrEP had a higher average count of one-time partnerships over the past year and weekly frequency of casual partnership condomless anal sex (12.8; SD: 21.3 and 0.54; SD: 1.76, respectively) compared to PrEP non-users (2.8; SD: 7.2 and 0.16; SD 0.92, respectively).

We found evidence of individual-level PrEP-related behavioral differences for multiple outcomes. Adjusting for demographics, individual PrEP use was associated with a higher total degree (adjusted IRR [aIRR]=1.70; 95% CrI, 1.57–1.83), casual degree (aIRR=2.34; 95% CrI, 2.14–2.56), count of one-time partners (aIRR=4.62; 95% CrI, 3.94–5.44), frequency of casual partnership anal sex (aIRR=2.55; 95% CrI, 1.70–3.94), and frequency of casual partnership condomless anal sex (aIRR=3.39; 95% CrI, 2.18–5.47), and with a

lower prevalence of consistent condom use in one-time partnerships (aIRR=0.60; 95% CrI, 0.53–0.69) (Table 4). No association was observed between individual PrEP use and main degree (aIRR=0.96; 95% CrI, 0.84–1.10).

We also found evidence that some community-level behavioral differences may have occurred independent of individual-level PrEP use. Adjusting for demographics, community PrEP coverage was associated with higher total degree (aIRR=3.55; 95% CrI, 1.87–7.54), casual degree (aIRR=6.99; 95% CrI, 3.04–19.36), and count of one-time partners (aIRR=34.42; 95% CrI, 9.98–144.11) (Table 5). Adjusting for demographics and individual PrEP, the primary associations with community PrEP coverage were attenuated for total degree (aIRR=1.73; 95% CrI, 0.92–3.44), casual degree (aIRR=2.05; 95% CrI, 0.90–8.54), and count of one-time partners (aIRR=1.90, 95% CrI, 0.46–8.54) (adjustment for individual PrEP reduced these aIRRs by 52%, 71%, and 94%, respectively). However, important patterns remained after adjustment for individual PrEP: for the associations between community PrEP coverage and total degree, casual degree, and count of one-time partners, approximately 95%, 95%, and 82% of posterior distributions resulting from model simulations were above 1.00, signaling a positive relationship between community PrEP coverage and these outcomes. Community PrEP coverage was also related to consistent condom use (aIRR=1.68; 95% CrI, 0.86–3.35) in the fully adjusted model, although with greater uncertainty. No association was observed between community PrEP coverage and main degree (aIRR=1.21; 95% CrI, 0.48–3.20), frequency of casual partnership anal sex (aIRR=0.63; 95% CrI, 0.04–9.78), or frequency of casual partnership condomless anal sex (aIRR=0.23; 95% CrI, 0.01–3.60) in the fully adjusted model.

## DISCUSSION

This study provides evidence of the potential correlation between community PrEP coverage and individual-level sexual behaviors among US MSM. Sexual behavior may be influenced by broader PrEP coverage at the community level independent of individual PrEP use. Individual PrEP use explained much of the difference in behavior between individuals, but we observed meaningful differences in sexual network degree, condom use, and one-time partnership formation by community PrEP coverage even after adjusting for individual PrEP use. If these associations are causal, our findings would support the theory that MSM in communities with high PrEP coverage may have altered their behavior due to the scale-up of PrEP in their communities. This draws attention to the need for HIV prevention programs that facilitate PrEP access, initiation, and persistence, as well as STI prevention programs, among MSM not using PrEP in cities with higher or increasing PrEP coverage.

Consistent with prior studies [11], we found that individual PrEP use was linked to differences in sexual behavior. Specifically, PrEP users had more one-time partners, used condoms less often, had more frequent casual partnership anal sex (both with and without condoms), and had increased sexual network casual degree. Because PrEP directly protects an HIV-negative individual from HIV acquisition, this decrease in risk may influence changes to sexual behaviors (i.e., “net prevention coverage” as defined by Holt et al. [17]). However, the directionality may go both ways, because sexual behaviors such as condomless

sex and multiple partners are indications for starting PrEP [22]; the behaviors observed among PrEP users in our study may have preceded PrEP initiation.

Our results additionally complement the studies examining changes in sexual behavior among PrEP non-users living in cities with high PrEP coverage [14–17]. Our study expands on this work by evaluating other sexual behaviors, including sexual network features. PrEP may be unequally distributed across a sexual network. Network features play a key role in HIV dynamics and are crucial for evaluating PrEP [3,23]. Using multiple behavioral and network measures, we found that community PrEP coverage correlated with differences in sexual behavior. While most of the observed associations between community PrEP coverage and sexual behaviors were linked to individual PrEP use, some meaningful (but attenuated) relationships remained after adjusting for individual PrEP use. For PrEP non-users, high PrEP coverage in their community may indirectly protect them from HIV acquisition, but this protection is weaker than the direct protection they would receive from PrEP.

Our main degree findings also support the hypothesis that PrEP use and coverage may drive changes to sexual behaviors. We found that both individual PrEP use and community PrEP coverage were not associated with main degree (unlike casual degree), demonstrating that PrEP use and coverage may not be correlated with changes to all types of sexual behaviors (such as long-term partnership formation).

One unexpected finding was that community-level PrEP coverage was associated with more condom use with one-time partners after adjusting for individual-level PrEP and demographics. In communities with high PrEP coverage, we would anticipate less condom use. We observed this on an individual level: individual PrEP use was related to less condom use in one-time partnerships. Our findings suggest that communities with high PrEP use may also experience higher levels of other preventive behaviors.

Additionally, we found that frequency of casual partnership anal sex and frequency of casual partnership condomless anal sex were associated with individual PrEP use, but not community PrEP coverage. We believe that this may be due to the heterogeneity in frequency of casual partnership anal sex observed by city/division, suggesting that there may be other factors operating at the community-level that impact behavior.

Research examining both the direct and indirect effects of PrEP scale-up is important for developing effective HIV prevention programs. While increasing PrEP coverage in a community can protect individuals either directly through PrEP use or indirectly by lower incidence of HIV in their community, behavioral changes resulting from increased community-level PrEP coverage may mitigate some of these potential benefits. Increased rates of one-time partnerships, for example, can increase the risk of HIV acquisition among PrEP non-users.

This study provides some empirical evidence that community-level differences in behavior may be correlated with PrEP coverage. Our findings suggest that MSM are making informed decisions regarding their behavioral risk and sexual wellbeing, and that these decisions may be affected by population-level factors. Sexual behavior decisions do not occur only at an

individual level, but also at a dyadic, network, and community level. Individual decisions about sexual behavior are not independent of partner behaviors; dyadic decisions impact PrEP eligibility, use, and resulting sexual behaviors [24].

Community-level differences in sexual behavior related to PrEP coverage highlight the importance of eliminating barriers to PrEP use for all. MSM indicated for but not currently on PrEP are more likely to be Black [25], and Black MSM experience a disproportionately high risk of HIV because of network factors and socioeconomic inequities [1,7]. Lower PrEP use among Black MSM may be driven by racial bias among providers, who may consider Black patients more likely to engage in condomless sex if prescribed PrEP, making them less willing to prescribe it to them [26]. Our findings underscore the need for public health programs focused on increasing PrEP access and use, particularly in subpopulations underserved by PrEP programs to date. Further, our results do not suggest that communities with high overall PrEP coverage should be deprioritized, but rather that HIV prevention efforts continue in all communities, especially in those that have experienced barriers to access.

Behavioral studies are necessary to understand the effects of PrEP use but require consideration of how sexual behaviors and norms operate in a community. While PrEP non-users living in communities with high PrEP coverage may alter their behaviors because they perceive indirect protection against HIV, this assumes that MSM know that others in their community are using PrEP. This may not be the case given the potential stigma associated with PrEP [27]. Additionally, other factors may be operating at a community level beyond PrEP-related behaviors, including general culture around sexual behavior or differences in sexual networks by community. Community-level factors including neighborhood gay presence, peer support for condom use, and social network norms and attitudes may drive HIV prevention behavior [28–30]. This may partially explain our unexpected finding that community-level PrEP use was associated with more condom use with one-time partners; communities with high PrEP use may experience higher levels of other preventive behaviors because of social norms related to HIV prevention. Furthermore, differences in community sexual norms may have predated PrEP uptake, which PrEP-era behavioral studies may not fully capture. Lastly, community-level viral suppression may be related to both PrEP use and community-level behaviors (e.g., communities with high PrEP coverage may also have high viral suppression). These issues should be considered when interpreting studies examining community-level differences related to PrEP coverage.

### **Limitations.**

First, the data used for this analysis are cross-sectional, with limited ability to establish causal relationships between community PrEP coverage and sexual behavior. Future studies should use longitudinal data to further examine the relationship between PrEP coverage and behavioral outcomes. Second, our study used self-reported outcomes, so underreporting of behaviors may have occurred; this potential was reduced because these data were collected via web-based survey [31]. Third, our results are dependent on the accuracy of PrEP coverage. To reduce the potential impact of this on our findings, we estimated community PrEP coverage using a binomial model of individual PrEP within a



multilevel Bayesian model, which retained the uncertainty of PrEP coverage estimation. Additionally, we found that the patterns of community PrEP coverage were comparable to NHBS estimates. Fourth, our analysis only represented HIV-negative MSM. Future studies examining community-level practices should also consider community-level practices of MSM living with HIV. Finally, ARTnet is not representative of all US MSM; non-Hispanic white men were overrepresented in the study population (74.3% versus 63.1% [32]) and most study participants were privately insured. Generalizability of our results therefore may be more limited for Black MSM, Hispanic MSM, and MSM who are not privately insured. This study used web-based, non-stratified convenience sample methods to maximize the sample size of adult MSM, with all the strengths and weaknesses that this entails; additional studies that focus on or purposefully over-sample Black and Hispanic MSM should provide additional clarity for these high-priority populations, now that the overall correlations have been identified.

### Conclusions.

This is the first study to consider variable HIV PrEP coverage and sexual behaviors of US MSM using a variety of sexual behavior outcomes. Using multiple behavioral outcomes, we provided some evidence for the hypothesis that sexual behavior may differ with variations in community PrEP coverage independent of individual PrEP use. Studies addressing this topic are increasingly relevant as PrEP use becomes more common. Ongoing assessment of community-level PrEP-related sexual behaviors is needed to guide public health recommendations, with supplemental HIV and STI prevention efforts focused on mitigating the potential effects of both individual- and community-level behavioral changes among PrEP users, their sexual partners not using PrEP, and the broader communities where PrEP coverage is high or increasing.

### Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

### FUNDING

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**Table 1.**

Characteristics of HIV-negative ARTnet Participants Stratified by PrEP Use, 2017–2019

	Total	Current PrEP Use	Non-Current PrEP Use	Never Used PrEP
Total persons	3,259 (100.0%)	631 (19.4%)	178 (5.5%)	2450 (75.2%)
Race/ethnicity				
Black, non-Hispanic	134 (4.1%)	28 (4.4%)	4 (2.2%)	102 (4.2%)
Hispanic	422 (12.9%)	81 (12.8%)	23 (12.9%)	318 (13%)
Other, non-Hispanic	283 (8.7%)	53 (8.4%)	11 (6.2%)	219 (8.9%)
White, non-Hispanic	2,420 (74.3%)	469 (74.3%)	140 (78.7%)	1,811 (73.9%)
Age (yr)				
15–24	713 (21.9%)	71 (11.3%)	36 (5.7%)	606 (24.7%)
25–34	947 (29.1%)	196 (31.1%)	76 (42.7%)	675 (27.6%)
35–44	518 (15.9%)	122 (19.3%)	26 (14.6%)	370 (16.3%)
45–54	573 (17.6%)	149 (23.6%)	24 (13.5%)	400 (16.3%)
55–65	508 (15.6%)	93 (14.7%)	16 (9.0%)	399 (16.3%)
Census division				
New England	165 (5.1%)	31 (4.9%)	16 (9%)	118 (4.8%)
Middle Atlantic	442 (13.6%)	92 (14.6%)	20 (11.2%)	330 (13.5%)
South Atlantic	701 (21.5%)	119 (18.9%)	35 (19.7%)	547 (22.3%)
East South Central	132 (4.1%)	19 (3%)	6 (3.4%)	107 (4.4%)
West South Central	323 (9.9%)	61 (9.7%)	11 (6.2%)	251 (10.2%)
East North Central	466 (14.3%)	92 (14.6%)	25 (14%)	349 (14.2%)
West North Central	187 (5.7%)	32 (5.1%)	13 (7.3%)	142 (5.8%)
Mountain	281 (8.6%)	30 (4.8%)	21 (11.8%)	230 (9.4%)
Pacific	562 (17.2%)	155 (24.6%)	31 (17.4%)	376 (15.3%)
Health insurance				
Private	2,441 (76.4%)	516 (82.2%)	128 (71.9%)	1,797 (75.2%)
Public	514 (16.1%)	94 (15%)	33 (18.5%)	387 (16.2%)
None	242 (7.6%)	18 (2.9%)	17 (9.6%)	207 (8.7%)
Average total degree <sup>a</sup>	1.04 (SD 1.07)	1.58 (SD 1.28)	0.98 (SD 0.88)	0.91 (SD 0.97)
Median total degree	1.00	1.00	1.00	1.00
Average count of one-time				
partnerships over the past year	4.73 (SD 12.1)	12.8 (SD 21.3)	5.62 (SD 11.9)	2.57 (SD 6.7)
Median count of one-time				
partnerships over the past year	1.00	5.00	2.00	0.00
Average frequency of casual				
partnership anal sex, per week	0.32 (SD 1.40)	0.61 (SD 1.81)	0.30 (SD 1.36)	0.24 (SD 1.26)
Average frequency of casual				
partnership condomless anal sex, per week	0.24 (SD 1.14)	0.54 (SD 1.76)	0.26 (SD 1.35)	0.16 (0.88)
Screened for an STI in past 12 months				
Yes	1,677 (54.4%)	547 (89.1%)	122 (70.9%)	1,008 (43.8%)

	<b>Total</b>	<b>Current PrEP Use</b>	<b>Non-Current PrEP Use</b>	<b>Never Used PrEP</b>
No	1,408 (45.6%)	67 (10.9%)	50 (28.1%)	1,291 (56.2%)
Screened for HIV in past 12 months				
Yes	2,106 (71.9%)	561 (98.2%)	129 (79.6%)	1,416 (64.5%)
No	822 (28.1%)	10 (1.8%)	33 (20.4%)	779 (35.5%)

PrEP, pre-exposure prophylaxis; SD, standard deviation; STI, sexually transmitted infection

<sup>a</sup>Total degree is the number of persistent male partners, including main and casual partners, over the past year, measured on the day of the survey completion.

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**Table 2.**

PrEP Usage by Region/City for HIV-negative ARTnet Participants, 2017–2019

	Total	Currently on PrEP	Not on PrEP (Includes Non-Current and Never Used PrEP)
Total	3,259	631 (19.4%)	2,628 (80.6%)
Census division/city <sup>a</sup>			
Northeast			
New England	87	14 (16.1%)	73 (83.9%)
Boston	78	17 (21.8%)	61 (78.2%)
Middle Atlantic	159	28 (17.6%)	131 (82.4%)
New York City	211	56 (26.5%)	155 (73.5%)
Philadelphia	78	8 (10.3%)	70 (89.7%)
South			
South Atlantic	371	45 (12.1%)	326 (87.9%)
Atlanta	136	32 (23.5%)	104 (76.5%)
Miami	55	7 (12.7%)	48 (87.3%)
Washington, DC	133	35 (26.3%)	98 (73.7%)
East South Central	132	19 (14.4%)	113 (85.6%)
West South Central	166	27 (16.3%)	139 (83.7%)
Dallas	84	17 (20.2%)	67 (79.8%)
Houston	73	17 (23.3%)	56 (76.7%)
Midwest			
East North Central	284	47 (16.5%)	237 (83.5%)
Chicago	136	40 (29.4%)	96 (70.6%)
Detroit	46	5 (10.9%)	41 (89.1%)
West North Central	187	32 (17.1%)	155 (82.9%)
West			
Mountain	226	24 (10.6%)	202 (89.4%)
Denver	55	6 (10.9%)	49 (89.1%)
Pacific	214	48 (22.4%)	166 (77.6%)
Los Angeles	132	36 (27.3%)	96 (72.7%)
San Diego	49	10 (20.4%)	39 (79.6%)
San Francisco	90	35 (38.9%)	55 (61.1%)
Seattle	77	26 (33.8%)	51 (66.2%)

PrEP: pre-exposure prophylaxis

<sup>a</sup>Regions include the nine US Census Bureau divisions but exclude the major listed cities within these divisions, where relevant. The New England division excludes Boston; the Middle Atlantic division excludes New York City and Philadelphia; the South Atlantic division excludes Atlanta, Miami, and Washington, DC; the East South Central division has no exclusions; the West South Central division excludes Dallas and Houston; the East North Central division excludes Chicago and Detroit; the West North Central division has no exclusions; the Mountain division excludes Denver; the Pacific division excludes Los Angeles, San Diego, San Francisco, and Seattle.

**Table 3.**

Sexual Network and Sexual Behavior Parameters for HIV-negative ARTnet Participants by Region/City, 2017–2019

	Average Main Degree <sup>a</sup>	Average Casual Degree	Average Total Degree	Average Count of One-Time Partnerships	Proportion of Individuals Who Always Used Condoms in One-time Partnership(s)	Average Weekly Frequency of Casual Partnership Anal Sex	Average Weekly Frequency of Casual Partnership Condomless Anal Sex
Total	0.43	0.61	1.04	4.73	0.44	0.32	0.24
Census division/city <sup>b</sup>							
Northeast							
New England	0.41	0.45	0.86	3.32	0.42	0.41	0.10
Boston	0.42	0.54	0.96	3.59	0.57	0.21	0.18
Middle Atlantic	0.44	0.59	1.03	4.83	0.51	0.22	0.19
New York City	0.38	0.67	1.06	5.35	0.54	0.57	0.35
Philadelphia	0.42	0.51	0.94	2.22	0.47	0.33	0.29
South							
South Atlantic	0.42	0.59	1.02	3.62	0.43	0.30	0.23
Atlanta	0.44	0.55	0.99	4.39	0.54	0.21	0.12
Miami	0.46	0.89	1.35	7.07	0.57	0.46	0.43
Washington, DC	0.44	0.68	1.13	5.45	0.44	0.28	0.19
East South Central	0.52	0.48	1.00	2.48	0.36	0.25	0.19
West South Central	0.50	0.63	1.13	4.54	0.44	0.33	0.25
Dallas	0.33	0.58	0.92	4.13	0.58	0.22	0.16
Houston	0.40	0.73	1.12	6.52	0.41	0.50	0.43
Midwest							
East North Central	0.45	0.57	1.01	4.05	0.42	0.32	0.26
Chicago	0.40	0.81	1.21	7.10	0.41	0.35	0.29
Detroit	0.35	0.52	0.87	1.54	0.61	0.40	0.37
West North Central	0.44	0.57	1.01	4.95	0.38	0.42	0.37
West							
Mountain	0.37	0.43	0.80	4.53	0.40	0.24	0.18
Denver	0.40	0.38	0.78	2.64	0.62	0.13	0.04
Pacific	0.43	0.75	1.18	6.00	0.36	0.34	0.21
Los Angeles	0.46	0.70	1.16	4.48	0.46	0.19	0.14
San Diego	0.39	0.55	0.94	3.61	0.41	0.27	0.25
San Francisco	0.44	0.88	1.32	11.70	0.30	0.34	0.30
Seattle	0.43	0.69	1.12	5.56	0.31	0.27	0.24

**Table 4.** Bivariable and Multivariable Associations of Individual PrEP Usage and Various Outcomes of HIV-negative ARTnet Participants

Outcome	Unadjusted		Adjusted for Age and Race/Ethnicity	
	IRR (95% CrI)	% of Posterior >1.00	IRR (95% CrI)	% of Posterior >1.00
Total degree <sup>a</sup>	1.73 (1.61, 1.86)	100.00	1.70 (1.57, 1.83)	100.00
Main degree	0.94 (0.82, 1.07)	17.65	0.96 (0.84, 1.10)	29.73
Casual degree	2.45 (2.24, 2.69)	100.00	2.34 (2.14, 2.56)	100.00
Count of one-time partners <sup>b</sup>	4.62 (3.94, 5.40)	100.00	4.62 (3.94, 5.44)	100.00
Always using condoms in one-time partnership(s)	0.58 (0.51, 0.66)	0.00	0.60 (0.53, 0.69)	0.00
Frequency of casual partnership anal sex <sup>b,c</sup>	2.44 (1.65, 3.74)	100.00	2.55 (1.70, 3.94)	100.00
Frequency of casual partnership condomless anal sex <sup>b,c</sup>	3.35 (2.12, 5.42)	100.00	3.39 (2.18, 5.47)	100.00

IRR: incidence rate ratio; CrI: credible interval; PrEP: pre-exposure prophylaxis

<sup>a</sup>Degree is the number of persistent male partners measured on the day of the survey completion. Total degree includes both main and casual persistent partners, main degree includes main partners only, and casual degree includes casual partners only.

<sup>b</sup>Because of overdispersion, approximated using negative binomial distribution.

<sup>c</sup>Frequency of anal sex occurring in ongoing, casual partnerships at time of survey completion per week.



**Table 5.**

Multivariable Associations of Community-Level PrEP Usage and Various Outcomes of HIV-negative ARTnet Participants

Outcome	Adjusted for Individual PrEP Use, Age, and Race/Ethnicity		Adjusted for Age and Race/Ethnicity	
	IRR (95% CrI)	% of Posterior >1.00	IRR (95% CrI)	% of Posterior >1.00
Total degree <sup>a</sup>	1.73 (0.92, 3.44)	95.31	3.55 (1.87, 7.54)	100.00
Main degree	1.21 (0.48, 3.20)	66.94	1.16 (0.45, 3.01)	61.98
Casual degree	2.05 (0.90, 5.07)	95.49	6.99 (3.04, 19.36)	100.00
Count of one-time partners <sup>b</sup>	1.90 (0.46, 8.54)	81.76	34.42 (9.98, 144.11)	100.00
Always using condoms in one-time partnership(s)	1.68 (0.86, 3.35)	94.23	0.93 (0.48, 1.78)	41.21
Frequency of casual partnership anal sex <sup>b,c</sup>	0.63 (0.04, 9.78)	37.35	2.15 (0.16, 27.66)	72.36
Frequency of casual partnership condomless anal sex <sup>b,c</sup>	0.23 (0.01, 3.60)	14.30	1.33 (0.09, 19.89)	59.42

IRR: incidence rate ratio; CrI: credible interval; PrEP: pre-exposure prophylaxis

<sup>a</sup>Degree is the number of persistent male partners measured on the day of the survey completion. Total degree includes both main and casual persistent partners, main degree includes main partners only, and casual degree includes casual partners only.

<sup>b</sup>Because of overdispersion, approximated using negative binomial distribution.

<sup>c</sup>Frequency of anal sex occurring in ongoing, casual partnerships at time of survey completion per week.