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Approval Sheet

HIV Screening Rates Among Men Who Have Sex with Men in the United States

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Epidemiology

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Abstract Cover Page

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2021

Abstract

HIV Screening Rates Among Men Who Have Sex with Men in the United States

By Shiyun Qin

Background. The Centers for Disease Control and Prevention (CDC) recommend men who have sex with men (MSM) receive annual screening for human immunodeficiency virus (HIV), with MSM at higher risk screening every 3 to 6 months. This analysis aimed to quantify the rates and heterogeneity in HIV screening rates among MSM.

Methods. Using cross-sectional survey data from the web-based ARTnet study of MSM in the U.S. between 2017 and 2019, we estimated the prevalence of screening for HIV and yearly screening rates. Poisson regression with robust error variance and negative binomial regression model were used to quantify the demographic, geographic, and behavioral characteristics associated with HIV screening.

Results. Of 4476 HIV-negative or HIV-unknown MSM, 17% had never screened for HIV. The overall screening rate was 1.32 times per year, which met the CDC recommendations. The annual HIV screening rates were substantially lower among MSM with several characteristics: younger MSM (aged 35–44 versus aged 15–24: rate ratio [RR] = 1.87, 95% CI = [1.68, 2.09]), living in micropolitan or noncore areas (large central metro versus noncore: RR = 1.75, 95% CI = [1.43, 2.13]), and lower education levels (college degree or higher versus high school degree or lower: RR = 2.19, 95% CI = [1.96, 2.45]. Use of HIV PrEP was associated with significantly higher HIV screening rates (non-current users versus never users: adjusted rate ratio [aRR] = 1.86, 95% CI = [1.66, 2.08]; current users versus never users: aRR = 2.72, 95% CI = [2.55-2.90]). Casual network degree and one-time partnership rates were also positively associated with screening rates (aRR = 1.17 [1.14, 1.20] and 1.06 [1.05, 1.07], respectively).

Conclusions. Overall CDC recommendations for annual HIV screening were met, but significant gaps remained. Targeted screening activities towards these groups and health education campaigns to increase HIV screening engagement are needed.

Keywords. HIV; screening; testing; men who have sex with men; PrEP

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Acknowledgement

I would like to express the deepest appreciation to my thesis advisor, Dr. Samuel M. Jenness. Without his guidance and persistent help, this thesis would have never been accomplished. In addition, I would like to thank everyone from EpiModel Research Lab for advice and technical support. Finally, I must express my very profound gratitude to my parents, and to my friends, for providing me with unfailing support and continuous encouragement during the quarantine and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

INTRODUCTION

In 2018, the rate of diagnoses of HIV in United States was 11.5 per 100,000 persons, which slightly decreased from 2014.[1] In 2019, the U.S. Government released Ending the HIV Epidemic: A Plan for the United States, which aimed to reduce HIV infections by 90% by 2030.[2] Men who have sex with men (MSM) have been disproportionately affected by HIV. In the United States, MSM accounted for 69% for new diagnoses of HIV in 2018,[1] but only 4% of the US adult male population.[3] The relative risk of HIV transmission among MSM was estimated to be 3.2 times the risk among heterosexual persons.[4] Because HIV has a long clinical latency period before the development of symptomatic AIDS, persons who are unaware of the infection can continue to transmit HIV when not actively seeking for medical care. Wawer et al. estimated that the risk of HIV transmission during acute infection (Stage 1), the time between infection and development of detectable antibodies, is 7.25 times the risk during chronic HIV infection.[5] Compared to other HIV prevention interventions (e.g., HIV treatment, behavioral interventions, linkage and retention assistance), screening is a highly economical and effective way to avert transmission.[6,7]

HIV screening is critical for early diagnosis and prompting linkage to care for antiretroviral therapy (ART) and supportive health services that prevent secondary transmission. The U.S. Centers for Disease Control and Prevention (CDC) recommends that all the persons aged 13 to 64 years receive routine HIV screened; persons at high risk of infection, including MSM, should be screened at least once a year.[8] Prior modeling studies suggested that increasing screening frequency for MSM to every 3–6 months would be beneficial to avert HIV infections and would be cost-effective compared with annual screening.[9–11] However, a systematic review from CDC reported that the evidence for changing the recommendation was not sufficient due to uncertainty

of model parameters.[6,12] Directing screening for MSM at higher risk of acquiring infection, including those who changed partners more frequently (e.g., MSM who reported ≥ 3 new partners since their last test), was estimated to be 5 times more efficient to improve health impact compared to a homogenous time interval for HIV screening.[13]

Understanding the pattern of HIV screening among MSM is critical to evaluate the adherence to CDC recommendations. A meta-analysis of studies published from 2005 to 2013 reported that an average of 15% of MSM had never tested for HIV.[14] Multiple internet-based studies highlighted several factors that may be associated with the prevalence of never testing, including younger age, black race or Hispanic ethnicity, more unprotected anal partners, living outside of large metropolitan areas, and limited healthcare access.[14–17] Few studies have estimated the yearly screening rates of HIV among MSM to investigate the heterogeneity in screening by demographic and behavioral factors. By quantifying the differences in screening rates, subgroups of the population can be targeted in future interventions. Estimation of screening rates may also be helpful for parameterizing future modeling studies in the transmission dynamics of HIV.

In this study, we performed a cross-sectional analysis on HIV screening rates among MSM in the United States. Our primary objective was to characterize the screening patterns of MSM who never previously tested for HIV in order to identify the disparities associated with certain demographic, geographic subgroups or persons with specific sexual behaviors. Our secondary objective was to characterize the gap in annual HIV screening rates among MSM and determine the association with demographic, geographic and behavioral factors.

METHODS

Study Design. This analysis used data from the ARTnet study, which was an internet-based cross-sectional study. The ARTnet study enrolled MSM in the United States from 2017 to 2019.

MSM were recruited from the participants of American Men's Internet Study (AMIS), a parent national study that recruited MSM online through banner ads placed on websites or social network applications.[18] After completing AMIS, eligible MSM were invited to participate in ARTnet. Data were collected in two waves: from July 2017 to February 2018 and from September 2018 to January 2019. Eligibility criteria for ARTnet included male sex at birth, current male identity, lifetime history of sexual activity with another man, and age between 15 and 65.[19] Participant responses were deduplicated within and across survey waves based on IP and email address, which formed a sample size of 4904 unique participants who reported on 16198 reported partners.[20] The study was approved by Emory University Institutional Review Board.

Measures. We restricted participants in this analysis to only be MSM who were HIV-negative or HIV-unknown. Participants were classified as HIV-unknown if they reported never tested for HIV, had indeterminate test results, or never received test results.[20] Participants were asked "Have you ever been tested for HIV?", "In the past 2 years (since [MONTH/YEAR]), how many times have you been tested for HIV?", and then they were asked to specify the month and year in the question "When did you have your most recent HIV test? If you don't know the exact month, please enter your best guess." Based on these three questions, MSM were classified as "Never Screened", "Screened over 2 years ago", "Screened in 1–2 years" and "Screened within 1 year." Per-year HIV screening rates were estimated based on reported frequency of HIV screening in 2 years before the study. We calculated the per-year screening rates by dividing the frequency answered to the second question by two. Participants with screening rates of zero or missing were considered as never screened in the previous 2 years.

Covariates considered in this analysis included age groups, race/ethnicity, geography, education level, health insurance, PrEP (pre-exposure prophylaxis) use, screening for non-HIV STIs in the past 12 months, and sexual behaviors. Geography was determined by ZIP code and aggregated into by two measures: census region and urbanicity level, with the latter defined by NCHS 2013.[21] Sexual behavior was collected by asking participants about their five most recent partners in the past year before the survey. Behavior was represented by 5 variables in this analysis: main degree, casual degree, total degree, weekly anal intercourse (AI) rates within persistent partnership, and weekly rate of one-time partnership. Degree was defined as the number of persistent partnerships on the day of the survey. Partnerships are considered main if respondents reported that they consider this partner as a "boyfriend, significant other, or life partner." Partnerships are classified as casual if respondents reported that they have had sex with someone for more than once but did not consider as a main partner. Both main and casual are considered as persistent partnerships. Weekly rates of one-time partnerships were calculated by subtracting the total main and casual partners from the total number of partners in the past year and dividing by 52.[20]

Statistical Analysis. This analysis quantified the difference in HIV screening with demographic, geographic, and behavioral factors. Descriptive analyses of independent variables were performed for categorical predictors (by counts and proportions) and continuous predictors (by means, standard deviations, and medians). Summary HIV screening rates were stratified by each category of predictors with means, standard deviations, and medians. After our descriptive analysis of the sample, we characterized the pattern of MSM who never previously screened for HIV, and then quantified the differences in demographic, geographic, and behavioral subgroups. In order to avoid overestimation, the prevalence ratios of never (versus ever) screened were

estimated using unadjusted Poisson regression with robust error variance. Due to the right-skewed distribution and overdispersion of yearly HIV screening rates, unadjusted bivariable negative binomial regression models were used to compare the association between screening rates and covariates (age groups, race/ethnicity, geography, education level, health insurance, PrEP use history, and sexual behaviors). Multivariable negative binomial regression models were conducted on 8 primary predictors, which included health insurance, PrEP use history, STI screening rates, and the 5 sexual behavior variables (main degree, casual degree, total degree, AI rate and one-time partnership). Control variables that we hypothesized would confound the association were selected for each model per directed acyclic graph theory and literature review. All of the 8 exposure models were adjusted for age, race/ethnicity, urbanicity level, and education level; 7 of them were also adjusted for health insurance. We also adjusted for history of PrEP use in the behavioral exposure models, and we adjusted for AI rate in the total degree model. All analyses were conducted in R 4.0.3.

RESULTS

After removing responses from HIV-positive participants, 4476 MSM were included in this analysis. Table 1 presents the characteristics and average HIV screening rates of the study sample. Overall, 29.3% of MSM were aged 15–24, most of them were non-Hispanic White, which accounted for 72.4% of total. 35.9% lived in the South region of US and 42.4% were in large central metros. About half of MSM had college or higher education (56.7%); only 7.8% had no health insurance; 5.4% had taken PrEP before but were non-current PrEP user, and 19.1% were currently taking PrEP to prevent HIV infection. On average, MSM had a main degree of 0.41, and casual degree of 0.56, with weekly one-time partnership acquisition rate of 0.08, and weekly rate of 1.82 for anal intercourse acts within persistent (main and casual) partnerships. The

overall mean screening rate was 1.32 tests per year, while there was substantial right skewness in the distribution. Screening rates was lower among MSM who were aged 15–24; lived in micropolitan or noncore areas; had high school or lower education level; or never had STI screening in the past year. As showed in Figure 1, HIV screening rates were lowest among MSM aged 15–24 compared to other age groups and were highest among MSM age 35-44. Comparing races, the screening rates were slightly higher among white MSM, but the difference was not significant.

Table 2 shows the prevalence of never versus ever having an HIV test. MSM who had ever screened accounted for 82.8% of the total. Compared to other age groups, MSM aged 15–24 had the highest prevalence of never screening (38.7%), which was 6.08 times the prevalence among MSM aged 35–44. (95% CI = 4.45, 8.30). MSM aged 55–65 had low levels of never screening but had the highest levels of being screened over 2 years ago, opposite to MSM aged 15-24. (Figure 2) The prevalence was similar among Hispanic and other race, and both were lower than white and black (Hispanic vs black: PR = 1.65, 95%CI = 1.13, 2.42; other versus black: PR = 1.66, 95% CI = 1.12, 2.47). Comparing the disparity in regions, MSM lived in Midwest region had higher percentage of never having screened, which was 36% more than Northeast region (PR = 1.36, 95% CI = 1.11, 1.68). MSM in large central metro areas were most likely to have ever screened, and the prevalence declined with urbanicity level. Similarly, the proportion of never screened increased as educational level decreased, the prevalence among those who had high school or lower education was about 5 times higher than that among MSM who had college or higher education (PR = 5.87, 95% CI = 5.03, 6.84). Further, most of MSM who screened for a non-HIV STI in the past year (97.2%) had previously tested for HIV as well. In general, MSM who screened for HIV had more sexual partners. The prevalence of never screening was

estimated to be 25% and 32% lower when main and casual degree increased by 1 respectively (PR = 0.75, 95% CI = 0.65, 0.86; PR = 0.68, 95% CI = 0.62, 0.76). When weekly rate of one-time partnerships increased by 0.1, the rate of never screened declined by 27% (PR = 0.73, 95% CI = 0.62, 0.86).

In an unadjusted analysis of per-year HIV screening rates (Table 3), the screening rate was higher among MSM who: were aged 35–44 versus aged 15–24 (RR = 1.87, 95% CI = 1.68, 2.09); lived in large central metro areas versus noncore areas (RR = 1.75, 95% CI = 1.43, 2.13); had college or higher education versus high school or lower (RR = 2.19, 95% CI = 1.96, 2.45). Further, compared to MSM with no health insurance, those who had insurance screened for HIV more frequently, yet the difference was not statistically significant between public and private insurance (Public vs None: RR = 1.21, 95% CI = 1.04, 1.40; Private vs None: RR = 1.23, 95% CI = 1.08, 1.40). MSM who ever used PrEP had higher rates of screening: the screening rates among current PrEP user were about 3 times the rates among those who never used PrEP (RR = 2.79; 95% CI = 2.62, 2.98). Additionally, HIV screening rates were highly associated with non-HIV STI screening rates: MSM who screening for an STI had 3.29 (95%CI = 3.10, 3.50) times the HIV screening rates of MSM who had no STI tests. For behavioral factors, HIV screening rates increased with degree increased: rates increased by 33% with each 1 unit increase in casual degree (RR = 1.33, 95% CI = 1.29, 1.37), but the rate ratio decreased by 0.02 when main degree was also included (RR = 1.31, 95% CI = 1.27, 1.35). When weekly rate of one-time partnership increased by 0.1, the HIV screening rates were estimated to increase by 16% (RR = 1.16, 95% CI = 1.15, 1.17).

After adjusting for confounders, the disparity in HIV screening rates associated with PrEP use history, STI screening rates, and AI rate were similar to the unadjusted model results. (Table

4) The rate ratio for MSM with public insurance (versus none) was higher than the rate ratio for those with private insurance (versus none) after controlling for age, race/ethnicity, urbanicity level, and education level (Public: aRR = 1.29, 95% CI = 1.11, 1.49; Private: aRR = 1.13, 95% CI = 1.00, 1.29). After adjusting for demographics, geographics, health insurance status and PrEP use history, the differences associated with casual degree, total degree, and one-time partnership rates were less substantial, decreasing from 1.33 to 1.17, 1.31 to 1.14, and 1.16 to 1.06, respectively.

DISCUSSION

In this national study of MSM, we examined the pattern and factors associated with the prevalence of never screening for HIV and annual HIV screening rates. Overall, about 17% of MSM had never tested, but the average screening rates met the CDC recommendation of annual screening. However, there were significant variations in these outcomes by demographic, geographic, and behavioral factors. About one third of MSM aged 15–24 had never tested for HIV, and the average screening rates were lower than recommendation for several groups of MSM: younger MSM (aged 15–24); MSM living in micropolitan or noncore areas; MSM with lower education levels; and MSM without health insurance. Further, MSM with more casual or one-time partners screened more frequently, consistent with CDC recommendations. Sexually active MSM with multiple partners have higher risk of acquiring HIV infection and therefore would benefit from more frequent than annual screening (e.g., screening every 3–6 months).[9–11,13] Therefore, HIV screening efforts should be targeted to these subpopulations.

A recent systematic review estimated that between 5% and 34% of MSM had never been tested for HIV, with an average of 15%,[14] which is close to our estimate of this outcome. Multiple studies supported that MSM in young age had a high proportion of never testing and

were lack of awareness of HIV status.[14,17,22] The potential reason for low HIV screening among young MSM includes recent infection, underestimation of potential risk, and lack of healthcare access.[1] This subgroup may be benefit from directing prevention and intervention information towards them through social media, in order to promote HIV screening.[23–25]

We found other demographic and geographic factors associated with HIV screening rates, consistent with previous literature. Several studies found that MSM who graduated from college had more frequent screening for HIV compare to those with lower education,[16,26] while Noble et al. thought that the evidence was not sufficient due to undefined potential confounders, such as age, income, and region.[14] We found that the screening rates were substantially higher among MSM with college degree or higher levels of education, and the difference remained meaningful after adjusting on age and urbanicity level. Additionally, the disparity associated with urbanicity level and health insurance were also significant in our study. Moreover, Clark et al. estimated that racial/ethnic minorities have lower screening rates than white MSM,[22] which contradicts Wray et al.'s finding that the odds of having screened within 12 months was lower among white MSM.[26] In our study, the screening rates were slightly higher among black MSM compare to others, but the gap was not substantial. Future studies are needed to better understand and respond to these gaps.

Behaviorally, sexually active MSM with more partners screened for HIV more frequently, especially for those with higher casual degree and one-time partnerships. From 2014 to 2017, PrEP awareness and PrEP use increased among MSM.[27] Although studies have shown the safety and effectiveness of oral pre-exposure prophylaxis (PrEP) against HIV,[28,29] it raises the concern of behavioral risk compensation, including decrease in condom usage, increase in number of sexual partners, and decreased screening rates. This could result in an ongoing risk of acquiring

other STIs.[30,31] Thus, a history of PrEP use was selected as a potential confounder in our study. After adjusting for confounders, the magnitude of the associations with sexual network factors all decreased. Considering the increasing risk of contracting STI, health education and regular STI screening during PrEP care visits are necessary.[32]

Routinely screening for HIV among HIV-negative or HIV-unknown MSM is a critical and cost-effective intervention to reduce new infection. Younger MSM continue to be at high risk of infection but with consistently lower HIV screening rates, which increase the chances of asymptomatic transmission within this group. Younger MSM and MSM with lower education levels may require targeted health education efforts. Some MSM may also have limited access to effective health care, especially for those with no health insurance and live in smaller cities and rural areas (micropolitan or noncore urbanicity levels). On the other hand, although screening is a highly effective intervention, adherence to the screening recommendation may be affected by social factors, including stigma, homophobia, and discrimination. These could be associated with physical and mental health problems that discourage MSM from seeking high-quality health services.[1,6] Additional screening efforts should be directed to these groups most in need.

Limitations. There were several limitations to this study. First, since we used data from a convenience sample using web-based recruitment methods, ARTnet does not necessarily represent the general population of MSM in demographic, geographic, and behavioral characteristics. Compared to the participants in a venue-based study, participants in web-based samples are more likely to be non-Hispanic white, have higher income, have more risk sexual behavior, and lower rates of HIV screening.[33,34] The racial disparity in HIV screening rates we observed differed from prior studies; this may be due to the sample bias. Data may need to be weighted to account for biases in the future. Additionally, since data were collected through a

self-reported survey, there were potential recall and misclassification biases, including misreporting testing frequency and misunderstanding the questions. Participants may be less likely to report sexual behavior patterns due to social desirability biases. Degree might be underestimated because of the restriction of reporting no more than 5 partners. Third, the screening rates used in this analysis was calculated based on the self-reported testing frequency within the past 2 years, which may not be an accurate estimation of the yearly screening rate. The queried interval is less likely to be corresponded to the recommended intervals.[35] Fourth, after stratifying on demographic and geographic predictors, the sample size in some groups may be small, resulting in wide confidence intervals. Finally, the associations between HIV screening rate and predictors might be biased due to undefined confounders. For instance, the disparity in education level and health insurance might be confounded by socioeconomical factors.

Conclusions. This study explored the pattern and disparities in HIV screening among MSM in US. Overall, 83% of MSM had ever tested for HIV, the yearly screening rate met CDC recommendations on average, but several groups did not meet these guidelines: MSM aged 15–24, living in micropolitan and noncore areas, or with lower education levels. Although MSM with more casual and one-time partnerships had higher screening rate, they could benefit from more than annual screening. Targeting screening strategies and increasing HIV/STI education campaigns towards these subgroups will help in meeting the Ending the HIV Epidemic targets for HIV incidence reduction.

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Table 1. Sample Characteristics and Average Yearly HIV Screening Rates of ARTnet Participants Who Were HIV-negative or HIV-unknown

	Total[a]		HIV Screening Rate (per year)[b]		
	N or Mean (Median)	% or SD	Mean	SD	Median
Total Sample	4476	100.0	1.32	1.63	1
Age					
15-24	1313	29.3	0.89	1.68	0.5
25-34	1201	26.8	1.55	1.65	1
35-44	613	13.7	1.66	1.71	1
45-54	689	15.4	1.54	1.46	1
55-65	660	14.8	1.22	1.37	1
Race / Ethnicity					
Black (non-Hispanic)	202	4.5	1.30	1.61	1
Hispanic	621	13.9	1.52	1.49	1
Other (non-Hispanic)	414	9.3	1.31	1.45	1
White (non-Hispanic)	3239	72.4	1.42	2.06	1
Region[c]					
Northeast	805	18.0	1.34	1.50	1
Midwest	925	20.7	1.22	1.57	1
South	1608	35.9	1.27	1.75	1
West	1138	25.4	1.45	1.60	1
Urbanicity Level[d]					
Large Central Metro	1896	42.4	1.59	1.67	1
Large Fringe Metro	963	21.5	1.26	1.98	1
Medium Metro	850	19.0	1.09	1.39	0.5
Small Metro	400	8.9	1.11	1.18	1
Micropolitan	216	4.8	0.82	0.97	0.5
Noncore	151	3.4	0.91	1.17	0.5
Highest Level of Education					
High school or lower	576	13.0	0.71	1.47	0
Some college	1350	30.3	1.15	1.50	1
College or higher	2523	56.7	1.56	1.69	1
Health Insurance					
None	334	7.8	1.13	1.53	0.5
Public	733	17.0	1.36	2.14	1
Private	3236	75.2	1.38	1.53	1
PrEP Use History					
Never	2519	75.5	1.13	1.31	1
Non-current	179	5.4	2.15	1.40	2
Current	638	19.1	3.15	1.54	3
Screened for STI in the Past 12 Months					
No	2297	54.2	0.65	1.08	0.5
Yes	1940	45.8	2.16	1.83	2
Main Degree	0.41 (0)	0.53			
Casual Degree	0.56 (0)	0.97			
Total Degree[e]	0.96 (1)	1.04			
AI Rate[f]	1.82 (0.72)	4.51			
One-time Partnership[g]	0.08 (0.019)	0.23			

Abbreviations: HIV, human immunodeficiency virus; SD, standard deviation; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection; AI, anal intercourse.

[a] Totals may not add up to sample total due to missing data for health insurance, PrEP use history, screening for STI in the past 12 months, AI rate and one-time partnership rate.

[b] Per-year HIV screening rate was calculated based on the self-reported HIV screening frequency in the previous 2 year before survey.

[c] Census regions: https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.

[d] NCHS 2013: https://www.cdc.gov/nchs/images/popbridge/URv3.png.

[e] Degree was defined as the number of persistent partnerships on the survey day, total degree was the sum of main degree and casual degree

[f] Weekly anal intercourse rate within persistent partnerships, which include both main and casual types

[g] One-time partnership was defined by weekly rate

Table 2. Bivariable Comparison of Never Versus Ever Previously Screened for HIV with Demographic and Behavioral Factors Among Men Who Have Sex with Men Who Were HIV-negative or HIV-unknown

	Never Screened		Ever Screened			
	N or Mean (Median)	% or SD	N or Mean (Median)	% or SD	PR	95% CI
Total Sample	768	17.2	3708	82.8	-	-
Age						
15-24	508	38.7	805	61.3	6.08	(4.45, 8.30)
25-34	135	11.2	1066	88.8	1.77	(1.25, 2.49)
35-44	39	6.4	574	93.6	-	-
45-54	41	6.0	648	94.1	0.94	(0.61, 1.43)
55-65	45	6.8	615	93.2	1.07	(0.71, 1.62)
Race / Ethnicity						
Black (non-Hispanic)	27	13.4	175	86.6	-	-
Hispanic	137	22.1	484	78.0	1.65	(1.13, 2.42)
Other (non-Hispanic)	92	22.2	322	77.8	1.66	(1.12, 2.47)
White (non-Hispanic)	512	15.8	2727	84.2	1.18	(0.83, 1.70)
Region						
Northeast	120	14.9	685	85.1	-	-
Midwest	188	20.3	737	79.7	1.36	(1.11, 1.68)
South	273	17.0	1335	83.0	1.14	(0.93, 1.39)
West	187	16.4	951	83.6	1.10	(0.89, 1.36)
Urbanicity Level						
Large Central Metro	243	12.8	1653	87.2	-	-
Large Fringe Metro	189	19.6	774	80.4	1.53	(1.29, 1.82)
Medium Metro	159	18.7	691	81.3	1.46	(1.22, 1.75)
Small Metro	78	19.5	322	80.5	1.52	(1.21, 1.92)
Micropolitan	57	26.4	159	73.6	2.06	(1.60, 2.65)
Noncore	42	27.8	109	72.2	2.17	(1.64, 2.88)
Highest Level of Education						
High school or lower	284	49.3	292	50.7	5.87	(5.03, 6.84)
Some college	263	19.5	1087	80.5	2.32	(1.96, 2.74)
College or higher	212	8.4	2311	91.6	-	-
Health Insurance						
None	55	16.5	279	83.5	-	-
Public	141	19.2	592	80.8	1.17	(0.88, 1.55)
Private	470	14.5	2766	85.5	0.88	(0.68, 1.14)
PrEP Use History						
Never	69	2.7	2450	97.3	-	-
Non-current	1	0.6	178	99.4	0.20	(0.03, 1.46)
Current	7	1.1	631	98.9	0.40	(0.18, 0.87)
Screened for STI in the Past 12 Months						
No	678	29.5	1619	70.5	-	-
Yes	54	2.8	1886	97.2	0.09	(0.07, 0.12)
Main Degree	0.33 (0)	0.52	0.42 (0)	0.53	0.75	(0.65, 0.86)
Casual Degree	0.30 (0)	0.69	0.61 (0)	1.01	0.68	(0.62, 0.76)
Total Degree[a]	0.63 (1)	0.79	1.03 (1)	1.07	0.67	(0.61, 0.73)
AI Rate[b]	2.04 (0.58)	7.36	1.79 (0.75)	3.79	1.01	(0.99, 1.02)
One-time Partnership[c]	0.03 (0)	0.12	0.09 (0.02)	0.24	0.73	(0.62, 0.86)

Abbreviations: HIV, human immunodeficiency virus; SD, standard deviation; PR, prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection; AI, anal intercourse.

[a] Degree was defined as the number of persistent partnerships on the survey day, total degree was the sum of main degree and casual degree

[b] Weekly anal intercourse rate within persistent partnerships, which include both main and casual types

[c] The prevalence ratio between two groups that weekly one-time partnership rate increase by 0.1.

Table 3. Bivariable Association of Per-year HIV Screening Rate with Demographic and Behavioral Factors Among Men Who Have Sex with Men Who Were HIV-negative or HIV-unknown in the United States

	RR	95% CI
Total Sample	-	-
Age		
15-24	-	-
25-34	1.75	(1.59, 1.91)
35-44	1.87	(1.68, 2.09)
45-54	1.74	(1.56, 1.93)
55-65	1.37	(1.23, 1.53)
Race / Ethnicity		
Black (non-Hispanic)	-	-
Hispanic	0.87	(0.72, 1.04)
Other (non-Hispanic)	0.94	(0.77, 1.14)
White (non-Hispanic)	0.85	(0.73, 1.01)
Region		
Northeast	0.93	(0.83, 1.03)
Midwest	0.84	(0.76, 0.93)
South	0.88	(0.80, 0.96)
West	-	-
Urbanicity Level		
Large Central Metro	1.75	(1.43, 2.13)
Large Fringe Metro	1.38	(1.12, 1.70)
Medium Metro	1.20	(0.98, 1.48)
Small Metro	1.22	(0.98, 1.53)
Micropolitan	0.90	(0.70, 1.16)
Noncore	-	-
Highest Level of Education		
High school or lower	-	-
Some college	1.62	(1.43, 1.82)
College or higher	2.19	(1.96, 2.45)
Health Insurance		
None	-	-
Public	1.21	(1.04, 1.40)
Private	1.23	(1.08, 1.40)
PrEP Use History		
Never	-	-
Non-current	1.91	(1.70, 2.14)
Current	2.79	(2.62, 2.98)
Screened for STI in the Past 12 Months		
No	-	-
Yes	3.29	(3.10, 3.50)
Main Degree	1.06	(0.99, 1.13)
Casual Degree	1.33	(1.29, 1.37)
Total Degree[a]	1.31	(1.27, 1.35)
AI Rate[b]	1.02	(1.01, 1.02)
One-time Partnership[c]	1.16	(1.15, 1.17)

Abbreviations: HIV, human immunodeficiency virus; PrEP, pre-exposure prophylaxis; RR, rate ratio; CI, confidence interval; STI, sexually transmitted infection; AI, anal intercourse.

[a] Degree was defined as the number of persistent partnerships on the survey day, total degree was the sum of main degree and casual degree

[b] Weekly anal intercourse rate within persistent partnerships, which include both main and casual types

[c] The rate ratio between two groups that weekly one-time partnership rate increase by 0.1.

Table 4. Multivariable Association of Per-year HIV Screening Rate with Health Insurance, PrEP and STI Screening History and Behavioral Factors Among Men Who Have Sex with Men Who Were HIV-negative or HIV-unknown in the United States

	aRR	95% CI
Health Insurance[a]		
None	-	-
Public	1.29	(1.11, 1.49)
Private	1.13	(1.00, 1.29)
PrEP Use History[a,b]		
Never	-	-
Non-current	1.86	(1.66, 2.08)
Current	2.72	(2.55, 2.90)
Screened for STI in the Past 12 Months[a,b]		
No	-	-
Yes	3.00	(2.82, 3.19)
Main Degree[a,b,c]	0.96	(0.91, 1.01)
Casual Degree[a,b,c]	1.17	(1.14, 1.20)
Total Degree[a,b,c]	1.14	(1.11,1.17)
AI Rate[a,b,c,d]	1.01	(1.00, 1.02)
One-time Partnership[a,b,c,e]	1.06	(1.05, 1.07)

Abbreviations: HIV, human immunodeficiency virus; aRR, adjusted rate ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection; AI, anal intercourse.

[a] Adjusted for age, race/ethnicity, urbanicity level, and highest level of education.

[b] Adjusted for health insurance.

[c] Adjusted for PrEP use history.

[d] Adjusted for total degree.

[e] The rate ratio between two groups that weekly one-time partnership rate increase by 0.1.

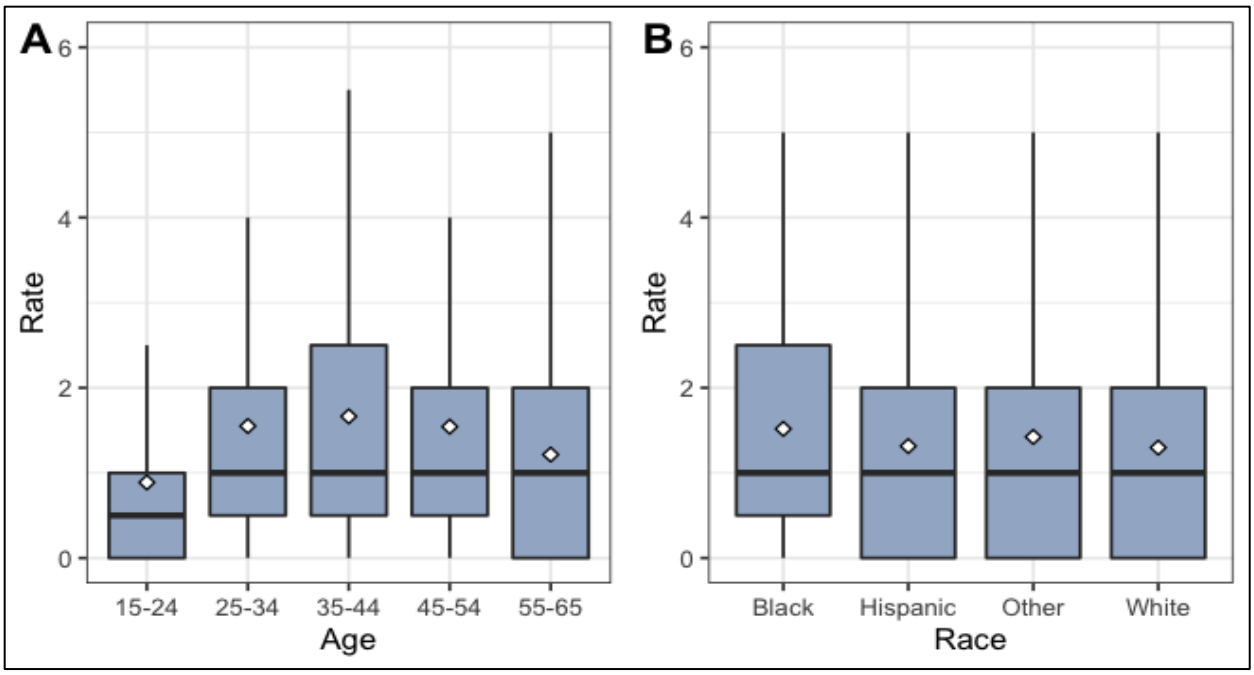

Figure 1. **Per-year HIV screening rate by demographical factors among men who have sex with men who were HIV-negative or HIV-unknown in the United States.** (A) On average, rate for HIV screening per year increased when age increased, and it reached the peak at age 35-44 years old, then began to decrease afterward. (B) The screening rate was slightly higher among black MSM than the others, but there was no significant difference among races.

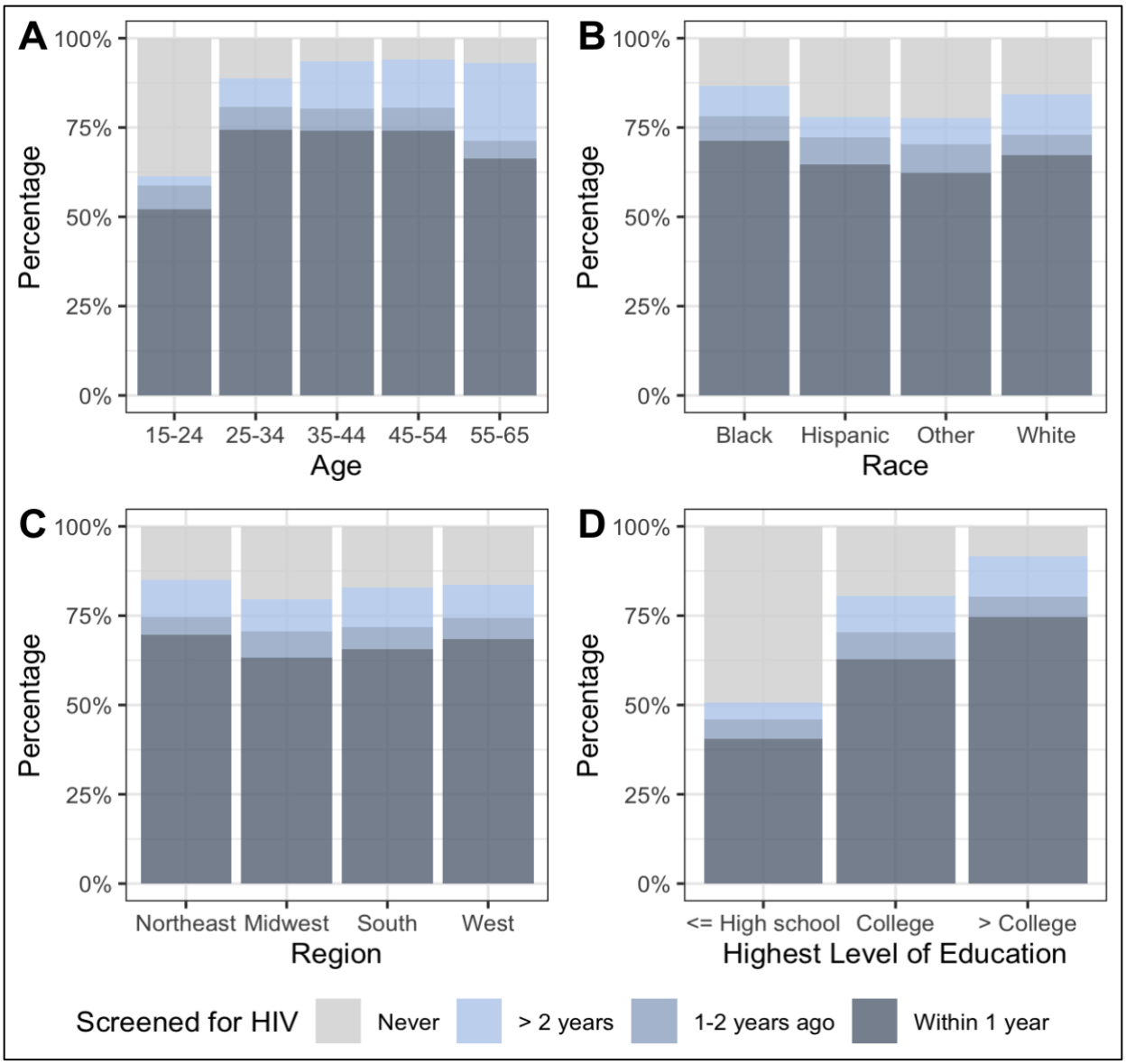

Figure 2. **Disparity in HIV screening among men who have sex with men who were HIV-negative or HIV-unknown in the United States.** (A) Compared to other age groups, MSM aged 15–24 had the lowest screening rate within 1 year (52%) and was highest for never previously screened (39%). MSM aged 55–65 had the highest screening rate for over 2 years ago (22%). (B) The prevalence of never screened for HIV was higher among Hispanic and other race MSM. (C) The percentage of never screened was slightly higher in Midwest region (20%). (D) The proportion of never screened for HIV decreased dramatically as education level increased.