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ORIGINAL PAPER

Behavior Change Among HIV-Negative Men Who Have Sex with Men Not Using PrEP in the United States

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Abstract

This study measures changes in condomless anal sex (CAS) among HIV-negative men who have sex with men (MSM) who are not taking pre-exposure prophylaxis (PrEP). It considers the 2014–2019 cycles of the American Men's Internet Survey, a serial, cross-sectional web-based survey of US cisgender MSM aged ≥ 15 years, in which ~ 10% of each year's sample is drawn from the previous year. Among those surveyed for 2 years who remained HIV-negative and off PrEP, reports of having any CAS and of CAS partner number were compared across years. We disaggregated by partner HIV status, and considered demographic predictors. The overall population saw a significant 2.2 percentage-point (pp) increase in reports of any CAS year-over-year. Sub-populations with the largest year-on-year increases were 15–24-year-olds (5.0-pp) and Hispanic respondents (5.1-pp), with interaction (young Hispanic respondents = 12.8-pp). On the relative scale, these numbers correspond to 3.2%, 7.2%, 7.3% and 18.7%, respectively. Absolute increases were concentrated among partners reported as HIV-negative. Multivariable analyses for CAS initiation found effects concentrated among Hispanic and White youth and residents of fringe counties of large metropolitan areas. CAS partner number increases were similarly predicted by Hispanic identity and young age. Although condom use remains more common than PrEP use, increasing CAS among MSM not on PrEP suggests potential new HIV transmission pathways. Concentration of increases among 18–24-year-old MSM portends future increases in the proportion of newly diagnosed HIV that occur among youth. Concentration among young Hispanic MSM will likely expand existing disparities. Although reducing barriers to PrEP remains vital, condom promotion for MSM remains a key public health practice and appears to be missing key audiences. LGBTQ+-inclusive sex education is one avenue for enhancing these efforts.

Keywords HIV-1 · Men who have sex with men · Condoms · Pre-exposure prophylaxis · United States

Introduction

HIV transmission can now be prevented through proactive administration of antiviral medications, either by those who do not have HIV (pre-exposure prophylaxis, or PrEP) or by those who do (treatment-as-prevention, or TasP). Together these have widened the array of strategies that men who have sex with men (MSM) may use to balance intimacy and pleasure against risk of HIV acquisition and transmission, beyond the mainstays of partner reduction and condom

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use. HIV diagnoses have declined significantly in the US since the mid-2010s and the parallel large-scale expansion of PrEP use and of TasP messaging (often referred to as "U = U", for "undetectable" viral load equals "untransmittable" infection) [1, 2]. Concurrently, evidence has grown for declining rates of condom use among MSM on PrEP, both overall and specifically with partners living with HIV [3–5], even though CDC guidance continues to emphasize both PrEP and condoms as components of a comprehensive sexual health plan [6]. Additional evidence shows behavioral shifts among MSM who are virally suppressed, including reduced selection of partners based on concordant HIV status [7]. Such work generally focuses on implications for bacterial STIs, since behavior change among MSM either fully PrEP-adherent or virally suppressed should not significantly impact HIV incidence [8, 9].

Meanwhile, there is a paucity of quantitative research on behavior change among HIV-negative MSM who are *not* taking PrEP (hereafter "HNM-NP"), a group comprising the majority of MSM [10], and those who as a group likely experience the greatest HIV acquisition risk. In the US, condom use was declining among HIV-negative MSM [11] before PrEP ramp-up. Recent research finds continued declines [12], although whether these differ by respondents' PrEP use status is unclear. An Australian study found that the proportion of HNM-NP having condomless anal sex (CAS) with casual partners increased from 30% in 2013 to 41% in 2017 [13], further increasing to 45% in 2019 [14]. We know of no study that has quantified changes in CAS among US HNM-NP.

Two hypotheses for why HNM-NP might have increased CAS over the last decade predict different behavioral signatures. One is a greater reliance on indirect protection from partners, i.e. choosing partners who report PrEP use or viral suppression, or opting for CAS with those partners. Indeed, "U = U" messaging rests on the reliability of this specific form of indirect protection. Reliance on partner PrEP usage would be similarly effective if one were certain that all of one's partners were adherent. However, in practice, not all men on PrEP or treatment are sufficiently adherent for full protection [15–19], and many may not recognize this themselves, or report it accurately to others [20–24].

The second potential explanation is a broader shift in condom use norms among MSM. Condoms were the main HIV prevention tool available for decades, and as such, MSM developed a strong (but certainly not monolithic) normative value around their usage, colloquially called the "condom code" [25]. Advances such as PrEP and U = U mean that the condom code is less relevant as a universal norm, and with beliefs around health decision-making typically spreading through social networks [26], new norms could expand over time to reach MSM other than those who have adopted newer forms of biomedical protection [27, 28]. This explanation, if true, would yield increasing CAS with partners generally, not just those on PrEP or virally suppressed. Such changes could drive new HIV transmissions, regardless of whether they are explicitly caused by PrEP expansion.

We further hypothesize that such shifts could vary along two key dimensions relating to different normative contexts and ongoing HIV disparities: age and race/ethnicity. Specifically, CAS increases are predicted to be largest for the youngest cohort, whose sexual health philosophies and perceptions of MSM cultural norms are newly forming [29]. If so, this could portend increasing early-life HIV risk. For race/ethnicity, the effect is harder to predict; depending on its direction, it could interact with existing structural factors to exacerbate HIV disparities.

Efforts to investigate these hypotheses face a challenge with confounding. In the absence of individual-level behavior change, any amount of disproportionate adoption of PrEP by MSM at higher risk for HIV acquisition (as appears to occur [30–32]) will cause the remaining HNM-NP population to increasingly comprise men who would otherwise be at lower risk. Individual behavior change within that HNM-NP population would then occur on top of this substrate of population-level risk decline, making it difficult to detect. Whether the two combined effects would yield overall stable, increasing or decreasing behaviors at the population level for HNM-NP would depend on the relative magnitude of the two effects. Longitudinal data on HNM-NP can help disentangle these, by allowing one to examine behavior change at the individual rather than just the population level.

This paper examines behavior change among HNM-NP over the period 2014–2019, an interval of major PrEP expansion in the US [10, 33]. Data are drawn from the American Men's Internet Survey (AMIS), which contains a sub-sample of respondents repeated across consecutive years. Analyses examine trends overall and by key demographic covariates, and disaggregate by respondents' knowledge or perception of partner HIV status, allowing for insight into whether changes are occurring selectively or generally, and thus to their potential causes.

Methods

Data are drawn from the 2014 to 2019 cycles of AMIS, a serial, cross-sectional web-based survey of cisgender MSM aged ≥ 15 years, administered by Emory University's PRISM Health; additional methodological details have been published elsewhere [34, 35]. The study is conducted annually with ~ 10,000 respondents/year; each year ~ 10% of the previous year's sample self-selects into re-enrollment. Online recruitment protocols remain consistent across years, facilitating analysis of trends. Rounds from 2020 onward were excluded given confounding effects

from the COVID-19 pandemic. We re-coded several AMIS variables a priori based on power considerations, including creating a four-level race/ethnicity variable: Hispanic (any race) and Black, White, and Another race (all non-Hispanic). Additional data-processing details are in the online supplement. Unfortunately, AMIS does not include information on the respondent's perception of partner biomedical prevention usage (PrEP or TasP) over this time period; as far as we can determine, no large-scale study of US MSM with a longitudinal component from this pivotal time period does.

Our analyses used a series of restricted subsets of the data, described and named with abbreviations in Table 1; Fig. S1 visualizes relationships among analyses. All work occurred in R v.4.1.0, using an alpha-level of 0.05. Comparisons with a direction of effect hypothesized a priori used one-tailed tests; all others used two-tailed tests.

The analysis began by estimating the proportion of HNM-NP (defined in Table 1) respondents who reported having CAS each year, and conducted a one-tailed Cochran–Armitage trend test to identify significant increases over time, within the full sample and stratified by age and race/ethnicity. While measuring the trend here is an important first step, we reiterate that it should logically represent the combined effect of differential selection into PrEP use and potential behavior change. The next step thus tested whether there is indeed evidence for selectivity of the HNM-NP population into PrEP use in our data; this entailed the subset of HNM-NP respondents with a second year of data, comparing CAS rates in the first year for those subsequently initiating PrEP vs. not.

The remaining analyses focused on the second potential contributor, individual behavior change while remaining off PrEP. This employed the HNM-NP-2Y (Table 1) sample, with one-tailed McNemar tests to compare the proportion reporting CAS. Data were combined into year-on-year analyses regardless of calendar year to obtain power while also maintaining coverage across the period of PrEP scale-up in the US. Comparisons were conducted on the sample overall and by predictors, including a priori interactions between age and race/ethnicity, given our central concern for these dimensions of identity. Analyses were then disaggregated into CAS specifically with partners of positive, negative, and unknown HIV status. Results are reported as absolute (percentage point) differences in proportions reporting CAS between years, since many of the sub-analyses involve small values, and ratios on these are unstable. However, a few key sub-populations are also presented as proportional changes for ease of interpretation.

Individual-level comparisons of those who reported CAS in the second survey year to those who did not were conducted using bivariate logistic regression on the HNM-NP-2Y-NC (Table 1) sub-sample. We call the former "CAS initiation," using the term relative to the previous year and not necessarily the lifetime. Correlates with < 5% missing data were included in a multivariable logistic regression

Table 1 Analytic samples used in analyses, American Men's Internet Survey (AMIS), 2014–2019

Abbreviation[a]	Meaning	Sample size	Description
HNM-NP[b]	HIV-negative MSM, not recently on PrEP	44,923	All respondents who did not report being HIV-positive (i.e. either self-declaring as HIV-negative or not knowing status, referred together in the text as "HIV-negative"), and reported not currently being on PrEP and not having been on PrEP in the previous 12 months (including those who have never been on PrEP)[c]
HNM-NP-2Y	HNM-NP for 2 years	1907	All cases of respondents in the survey for 2 consecutive years and who met the HNM-NP criteria both years
HNM-NP-2Y-NC	HNM-NP-2Y, no CAS	764	All HNM-NP-2Y with respondents who report no CAS in last 12 months at their 1st survey
HNM-NP-2Y-YC	HNM-NP-2Y, yes CAS	1601	All HNM-NP-2Y with respondents who report CAS in the last 12 months at their 1st survey year
HNM-NP-2Y-YC2	HNM-NP-2Y, yes CAS twice	836	All HNM-NP-2Y with respondents who report CAS in the last 12 months at both survey years

CAS condomless anal sex, *MSM* men who have sex with men, *PrEP* pre-exposure prophylaxis

[a]Note that HNM-NP-2Y-NC and HNM-NP-2Y-YC are non-overlapping and together comprise the entirety of HNM-NP-2Y; HNM-NP-2Y2 is in turn a subset of HNM-NP-2Y-YC

[b]Throughout the introduction and discussion of this manuscript, we use the term HNM-NP to refer to the general state of being HIV-negative/untested and not on PrEP. Within our analyses, we define it more strictly to include the criterion of no reported PrEP use in the previous 12 months, to match the time period over which we have reported sexual partnering and behavior data

[c]This sample excludes HIV-negative respondents who reported ever using PrEP but did not specify whether they had used in the last 12 months or for whom data on PrEP use in the last 12 months was not available (N = 4066 [2014 only]; 1542 [2015–2019]). The exceptions are 2014 and 2015, when current PrEP use was not assessed; given how recently PrEP was approved in the US relative to those years, we assumed that those who reported ever using PrEP as having used PrEP in the last 12 months (N = 613)

model, as was the a priori interaction on age and race/ethnicity. Differential adoption of CAS while remaining off PrEP could be counteracted by higher cessation in the same groups, reflecting more temporal variability in risk rather than increasing risk, something one may imagine to be especially true for young MSM. Thus, a parallel analysis on the HNM-NP-2Y-YC (Table 1) sub-sample was used to estimate odds ratios for reporting no CAS in the second survey year ("CAS cessation"). Finally, the HNM-NP-2Y-YC2 (Table 1) sub-sample yielded measures of the 75th, 90th, and 95th quantiles for number of CAS partners in the past 12 months, values selected since partner counts are generally strongly right-tailed. This analysis included only those with ≥ 1 partner to distinguish changes in partner counts from the behavior already considered (no vs. any CAS partners). Wilcoxon signed-rank tests were conducted on each group with > 30 observations.

Results

Table 2 shows the sample size and characteristics for HNM-NP respondents. The 2014 sample is roughly half subsequent years' because only a subset of respondents was randomized to receive PrEP questions. The sample is diverse across multiple socio-demographic dimensions. In all years > 80% of respondents who provided sufficient data reported being HNM-NP (Fig. 1). Notably, in the most recent year (2019), condom use remained more common than PrEP, with the proportion of HIV-negative respondents reporting current PrEP use (12%) or any PrEP use in the last 12 months (15%, including the current 12%) lower than that reporting completely consistent condom use for the year (17%) or at least some condom use (at least 45%—the questionnaire design details mean only a lower bound can be determined here). An additional 14% did not have anal sex.

The subsample of 2-year data by respondents represents the basis for most of our analyses; Table S1 examines this subsample's composition to identify potential selectivity. Repeat respondents were disproportionately older, wealthier, more educated, more urban, and more likely to report White race and use of PrEP than the single-year eligible sample from which they were drawn. Nonetheless, the large sample sizes combined across years ensures that important subgroup analyses retain power.

In the HNM-NP sample, the proportion of respondents reporting any CAS was consistently high (62–66% per year), with no significant temporal increase (Fig. 2; Table S2) either overall or stratified by age or race/ethnicity. We reiterate, however, that this test's null hypothesis is for no increase, whereas, in the absence of behavior change among HNM-NP, one should anticipate a decline in CAS among HNM-NP concordant with disproportionate PrEP adoption among those having CAS. This hypothesized differential selection into PrEP use is indeed confirmed in our data: among 2-year respondents not using PrEP in Y1, prevalence of CAS in Y1 was 79% among those who adopted PrEP in

Table 2 Characteristics of respondent subsample who were HIV-negative and not recently on pre-exposure prophylaxis ("HNM-NP"), American Men's Internet Survey (AMIS) 2014–2019 (N = 44,923)

Group	N (%)
All participants	44,923 (100%)
Survey year	
2014	3899 (9%)
2015	8798 (20%)
2016	8286 (18%)
2017	7925 (18%)
2018	8197 (18%)
2019	7818 (17%)
Age	
15–24	16,158 (36%)
≥ 25	28,765 (64%)
Race/ethnicity	
Black (non-Hispanic)	3554 (8%)
Hispanic (any race)	6643 (15%)
White (non-Hispanic)	31,228 (70%)
Another race (non-Hispanic)	2682 (6%)
Unavailable	816 (2%)
Income (US$/year)	
< $20,000	5804 (13%)
$20,000–$39,999	7779 (17%)
$40,000–$74,999	10,328 (23%)
≥ $75,000	13,799 (31%)
Unavailable	7213 (16%)
Educational attainment	
High school or less	8531 (19%)
Some college/2-year/technical degree	14,818 (33%)
Bachelor's degree and beyond	21,029 (47%)
Unavailable	545 (1%)
Census region	
Northeast	8121 (18%)
Midwest	9380 (21%)
South	17,484 (39%)
West	9938 (22%)
NCHS county urbanicity classification	
Large metro—central	16,472 (37%)
Large metro—fringe	9749 (22%)
Medium/small metro	14,118 (31%)
Micropolitan/non-core	4577 (10%)
Unavailable	7 (< 1%)

Note Since our first analysis does not link respondents who appear in the survey in multiple years, these data include these respondents separately for each year that they appear in the data

NCHS National Center for Health Statistics

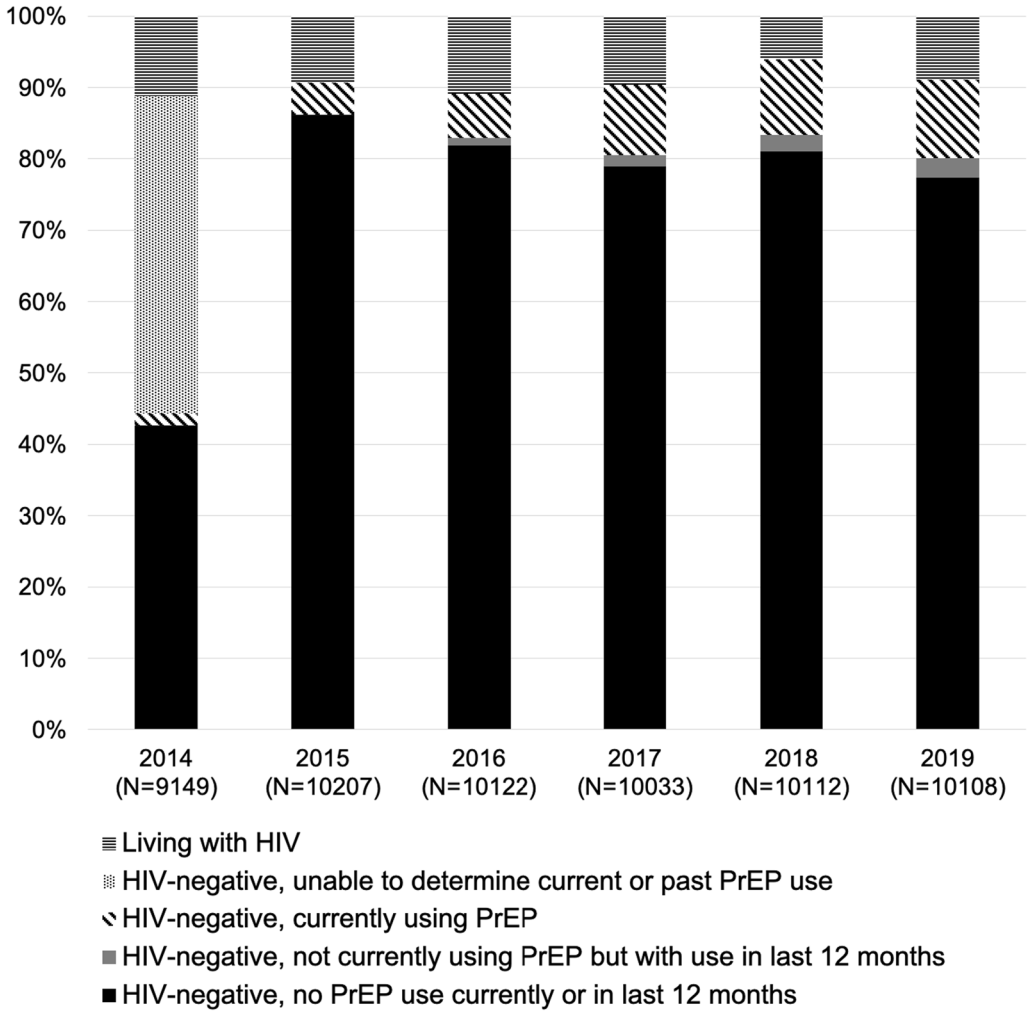

Fig. 1 HIV serostatus and pre-exposure prophylaxis (PrEP) use by year, American Men's Internet Survey, 2014–2019. *Note* Studies focusing on measuring and understanding PrEP uptake, including others using AMIS data, often report proportions of PrEP users out of those with behavioral indications for it [36]. Here we are reporting the overall prevalence of PrEP use within regard to indication given our interest in identifying HNM-NP and assessing behavioral change among them. Any comparisons of PrEP use levels to other reports should be mindful of this distinction

Y2 (N = 220), and 68% among those who did not (N = 2421). Among those with any CAS partners in Y1 (a cutoff chosen to distinguish changes in partner counts from the none/any distinction already considered), the 75th and 90th quantiles for partner number were 10 and 30 for subsequent PrEP adopters (N = 41) and 5 and 10 for non-adopters (N = 244).

Comparing the HNM-NP-2Y sub-sample (N = 2365) between their respective 2 years of data (Table 3) reveals a small (69.9–67.7% = 2.2 percentage-point, or pp) but significant (McNemar odds ratio [MOR] = 1.27, p = 0.008) absolute increase in reports of any CAS year-over-year. This corresponds to a 3.2% (= 69.9%/67.7% - 1) increase on the relative scale. Sub-populations with the largest year-over-year increases include 15–24-year-olds (5.0-pp, 7.2% relative, MOR = 1.60, p = 0.007) and Hispanic respondents (5.1-pp, 7.3% relative, MOR = 1.70, p = 0.038). Smaller but significant effects occurred among those with low-middle incomes ($20–40k, 3.9-pp, 5.8%, MOR = 1.50, p = 0.046), Northeast residents (4.5-pp, 7.3%, MOR = 1.66, p = 0.020), West residents (3.4-pp, 5.1%, MOR = 1.49, p = 0.038), and those with "some" college education (3.8-pp, 5.6%, MOR = 1.45, p = 0.016). The increase among White MSM was also significant (MOR = 1.24, p = 0.027), although with a smaller effect size than in the total population (1.9-pp, 2.8%). Disaggregating race/ethnicity by age reveals a notable 12.8-pp absolute increase (18.7% relative) in any CAS among young Hispanic MSM (MOR = 3.50, p = 0.003). Increases were concentrated in the middle time periods 2015–2016 and 2017–2018 (each a 4.6-pp increase, $MOR_{2015\text{-}2016} = 1.60$ and $MOR_{2017\text{–}2018} = 1.64$, each p = 0.009); other year-pairs all saw small, non-statistically significant changes.

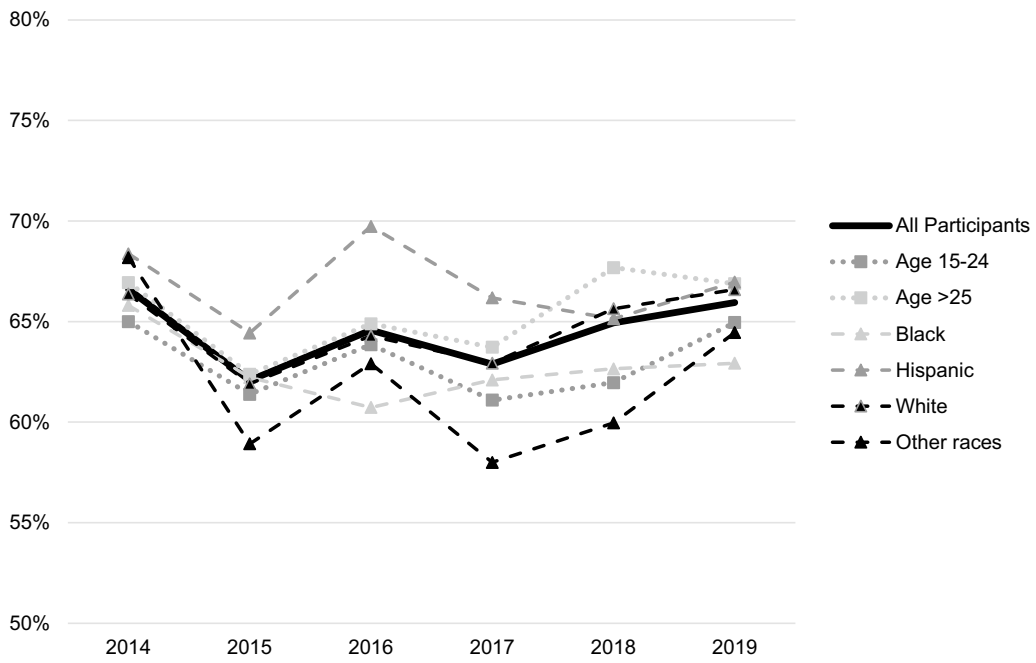

Fig. 2 Percent reporting condomless anal sex in the last 12 months among HIV-negative respondents who have not used pre-exposure prophylaxis (PrEP) in the last 12 months, American Men's Internet Survey, 2014–2019

Table 4 disaggregates these results by reported partner HIV status. Absolute increases are concentrated among partners reported as HIV-negative, with a significant (MOR = 1.37, p = 0.005) 3.6-pp increase, compared to 1.8-pp for partners living with HIV and 0.4-pp for those of unknown status. On a relative scale, these numbers correspond to 6.5%, 32.1%, and 1.9% increases, respectively, indicating that by far the greatest relative increase is with partners known to be living with HIV. Significant absolute increases among sub-groups were also concentrated with HIV-negative partners, and largely replicate significant predictors from overall increases. Significant predictors of increasing CAS with partners living with HIV were a distinct set: having a bachelor's degree (2.9-pp, MOR = 2.33, p = 0.003), and residence in the Northeast (2.1-pp, MOR = 3.33, p = 0.046) or South (3.5-pp, MOR = 1.85, p = 0.049; relative increases not reported for these due to small denominators).

The HNM-NP-2Y-NC sub-sample (N = 764) provides evidence for individual predictors for CAS initiation over time while remaining off PrEP (Table 5). In bivariate analyses, significant predictors include younger age, low household income, lower education, and residence in a fringe county of a large metropolitan area as defined by the National Center for Health Statistics (hereafter "fringe metro" residence). Notably, Hispanic ethnicity was not significant here, in contrast to above. In the multivariable analysis, the largest point estimate for increased odds of initiating CAS was being a young Hispanic respondent (relative to older White respondent), at 2.91 (95% CI 1.42, 6.03; p = 0.004). Other large, significant effects were among younger White respondents (1.81, 9% CI 1.14, 2.87; p = 0.011), those having completed some college (1.45, 95% CI 1.01, 2.07; 0.041), relative to a 4-year college degree), and fringe metro residence (1.70, 95% CI 1.10, 2.62; p = 0.016).

The proportion of men ceasing CAS (12%) was lower than that initiating (32%, HNM-NP-2Y-YC sub-sample, Table S3). The only significant predictor of cessation was high school education or less, with an odds ratio (relative to college degree) of 1.81 (95% CI 1.08, 2.92; p = 0.019). This paucity of significant predictors occurred despite the sample size here being more than twice that for CAS initiation (1601 vs. 764, Table 1).

The final analysis considers the *number* of CAS partners in the last 12 months among those reporting at least one CAS partner (HNM-NP-2Y-YC2 sub-sample, N = 836, Table S4). The overall sample saw the highest two quantiles increase (90th = 4–5, 95th = 7–8), but no significant shift upward in the distribution (p = 0.099). In stratified analyses, significant upward shifts occurred among younger respondents (p = 0.001), Hispanic respondents (p = 0.027), those making $20–40k (p = 0.032), those in the Northeast (p = 0.023), and those with fringe-metro residence (p = 0.001). The inclusion criteria make this sample non-overlapping with that in Table 5, making the similarity in predictors especially notable.

Table 3 Year-on-year comparisons for reports of any condomless anal sex (CAS) in the last 12 months among HIV-negative men who have sex with men (MSM) who have not used pre-exposure prophylaxis (PrEP) in the last 12 months for whom 2 consecutive years of data were available, American Men's Internet Survey (AMIS) 2014–2019 (N = 2365)

Group	N (col. %)[a]	Percent reporting condomless anal sex in the last 12 months		Percentage point (absolute) increase, Y1 to Y2	1-tailed McNemar test results	
		Year 1	Year 2		Test statistic (odds ratio)	p-value
All participants	2365 (100%)	67.7%	69.9%	2.2%	1.27	**0.008**
Age						
15–24	556 (24%)	69.6%	74.6%	5.0%	1.60	**0.007**
≥ 25	1809 (76%)	67.1%	68.4%	1.3%	1.16	0.105
Race/ethnicity[c] (N = 2342)						
Black (non-Hispanic)	123 (5%)	62.6%	65.9%	3.3%	1.44	0.262
Hispanic (any race)	273 (12%)	70.0%	75.1%	5.1%	1.70	**0.038**
White (non-Hispanic)	1823 (78%)	67.5%	69.4%	1.9%	1.24	**0.027**
Another race (non-Hispanic)	123 (5%)	71.5%	67.5%	−4.0%	0.64	0.895
Income (US$/year)[c] (N = 2108)						
< $20,000	263 (12%)	73.8%	76.4%	2.6%	1.29	0.209
$20,000–$39,999	412 (20%)	67.0%	70.9%	3.9%	1.50	**0.046**
$40,000–$74,999	646 (31%)	68.0%	67.8%	−0.2%	0.98	0.574
≥ $75,000	787 (37%)	66.6%	68.2%	1.6%	1.22	0.145
Educational attainment[c] (N = 2358)						
High school or less	198 (8%)	65.2%	67.7%	2.5%	1.21	0.288
Some college/2-year/technical degree	697 (30%)	67.6%	71.4%	3.8%	1.45	**0.016**
Bachelor's degree and beyond	1463 (62%)	68.3%	69.4%	1.1%	1.16	0.146
Census region						
Northeast	423 (18%)	61.9%	66.4%	4.5%	1.66	**0.020**
Midwest	507 (21%)	71.2%	71.6%	0.4%	1.05	0.458
South	902 (38%)	69.2%	70.5%	1.3%	1.15	0.202
West	533 (23%)	66.4%	69.8%	3.4%	1.49	**0.038**
NCHS county urbanicity classification						
Large metro—central	955 (40%)	65.9%	67.5%	1.6%	1.23	0.116
Large metro—fringe	485 (21%)	69.1%	71.8%	2.7%	1.30	0.116
Medium/small metro	732 (31%)	69.9%	72.0%	2.1%	1.26	0.109
Micropolitan/non-core	193 (8%)	64.8%	68.4%	3.6%	1.38	0.180
Sub-analyses (N = 2342)						
Black (non-Hispanic), ages 15–24	37 (30%)[b]	56.8%	59.5%	2.7%	1.25	0.500
Black (non-Hispanic), ages ≥ 25	86 (70%)[b]	65.1%	68.6%	3.5%	1.60	0.291
Hispanic (any race), ages 15–24	117 (43%)[b]	68.4%	81.2%	12.8%	3.50	**0.003**
Hispanic (any race), age ≥ 25	156 (57%)[b]	71.2%	70.5%	−0.7%	0.93	0.649
White (non-Hispanic), ages 15–24	357 (20%)[b]	71.4%	75.1%	3.7%	1.41	0.086
White (non-Hispanic), age ≥ 25	1466 (80%)[b]	66.5%	68.1%	1.6%	1.20	0.083
Another race (non-Hispanic), ages 15–24	39 (32%)[b]	66.7%	61.5%	−5.2%	0.60	0.856
Another race (non-Hispanic), age ≥ 25	84 (68%)[b]	73.8%	70.2%	−3.6%	0.67	0.849

Bold values indicate statistical significant at $p < 0.05$

NCHS National Center for Health Statistics

[a]Percents may not add to 100% due to rounding

[b]Denominator for proportion is the number of participants in the racial group of the corresponding sub-analysis

[c]1% of data missing for race/ethnicity; 11% missing for income; < 1% missing for education; percentages do not account for missing values

Table 4 Year-on-year comparisons of any condomless anal sex (CAS) in the last 12 months by partner serostatus among HIV-negative men who have sex with men (MSM) who have not used pre-exposure prophylaxis (PrEP) in the last 12 months for whom 2 subsequent years of data were available, American Men's Internet Survey (AMIS) 2014–2019 (N = 2365)

Group	N (%)	% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results		% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results		% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results	
		Year 1	Year 2		Test statistic (odds ratio)	p-value	Year 1	Year 2		Test statistic (odds ratio)	p-value	Year 1	Year 2		Test statistic (odds ratio)	p-value
		With partners living with HIV					With HIV-negative partners					With partners of unknown HIV status				
All participants	2365 (100%)	5.6%	7.4%	1.8%	1.32	0.120	55.1%	58.7%	3.6%	**1.37**	**0.005**	21.2%	21.6%	0.4%	0.99	0.547
Age																
15–24	556 (24%)	2.8%	5.1%	2.3%	2.20	0.105	57.5%	66.1%	8.6%	**1.77**	**0.008**	22.7%	22.5%	−0.2%	1.00	0.543
≥25	1809 (76%)	6.5%	8.2%	1.7%	1.18	0.278	54.4%	56.3%	1.9%	1.24	0.078	20.8%	21.3%	0.5%	0.99	0.556
Race/ethnicity[a] (N = 2342)																
Black (non-Hispanic)	123 (5%)	8.8%	11.1%	2.3%	0.75	0.773	52.6%	51.7%	−0.9%	1.40	0.387	20.4%	21.5%	1.1%	1.60	0.291
Hispanic (any race)	273 (12%)	7.1%	8.4%	1.3%	1.50	0.377	56.2%	66.3%	10.1%	**2.78**	**0.005**	30.0%	29.9%	−0.1%	0.77	0.832
White (non-Hispanic)	1823 (78%)	5.0%	6.7%	1.7%	1.30	0.187	54.9%	58.2%	3.3%	**1.29**	**0.038**	20.0%	20.6%	0.6%	1.05	0.394
Another race (non-Hispanic)	123 (5%)	6.1%	11.2%	5.1%	2.00	0.254	58.6%	56.4%	−2.2%	0.90	0.676	20.7%	18.9%	−1.8%	0.70	0.834
Income (US$/year)[a] (N = 2108)																
< $20,000	263 (12%)	3.8%	6.6%	2.8%	1.60	0.291	64.0%	66.2%	2.2%	1.44	0.168	26.0%	27.5%	1.5%	1.32	0.226
$20,000–$39,999	412 (20%)	8.6%	10.5%	1.9%	0.90	0.676	54.0%	62.8%	8.8%	**2.29**	**0.002**	23.8%	23.2%	−0.6%	0.91	0.693
$40,000–$74,999	646 (31%)	5.5%	6.0%	0.5%	0.75	0.808	57.0%	58.2%	1.2%	0.89	0.731	24.3%	22.6%	−1.7%	0.90	0.735
≥ $75,000	787 (37%)	5.5%	7.4%	1.9%	1.73	0.100	52.5%	53.7%	1.2%	1.29	0.142	17.1%	19.3%	2.2%	1.23	0.232
Educational attainment[a] (N = 2358)																
High school or less	198 (8%)	3.5%	7.6%	4.1%	2.50	0.227	55.1%	58.3%	3.2%	1.21	0.360	25.7%	21.5%	−4.2%	0.41	0.989
Some college/2-year/technical degree	697 (30%)	7.9%	6.8%	−1.1%	0.48	0.985	55.8%	62.4%	6.6%	**1.53**	**0.026**	22.3%	23.1%	0.8%	1.07	0.390
Bachelor's degree and beyond	1463 (62%)	4.8%	7.7%	2.9%	**2.33**	**0.003**	55.1%	57.0%	1.9%	1.30	0.063	20.1%	20.9%	0.8%	1.07	0.372

Table 4 (continued)

Group	N (%)	% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results		% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results		% reporting CAS in the last 12 mos		%age point change, Y1 to Y2	1-tailed McNemar test results	
		Year 1	Year 2		Test statistic (odds ratio)	p-value	Year 1	Year 2		Test statistic (odds ratio)	p-value	Year 1	Year 2		Test statistic (odds ratio)	p-value
		With partners living with HIV					With HIV-negative partners					With partners of unknown HIV status				
Census region																
Northeast	423 (18%)	3.7%	5.8%	2.1%	**3.33**	**0.046**	49.1%	54.5%	5.4%	**1.70**	**0.038**	18.3%	21.3%	3.0%	1.41	0.136
Midwest	507 (21%)	8.3%	7.2%	−1.1%	0.38	0.985	58.5%	61.1%	2.6%	1.11	0.397	20.9%	23.0%	2.1%	1.30	0.187
South	902 (38%)	5.1%	8.6%	3.5%	**1.85**	**0.049**	57.5%	59.7%	2.2%	1.22	0.187	22.7%	22.1%	−0.6%	0.98	0.575
West	533 (23%)	5.5%	6.8%	1.3%	1.22	0.412	52.9%	58.1%	5.2%	**1.68**	**0.025**	21.4%	19.5%	−1.9%	0.56	0.990
NCHS county urbanicity classification																
Large metro—central	955 (40%)	6.5%	8.2%	1.7%	1.31	0.256	51.6%	55.0%	3.4%	1.38	0.061	20.4%	17.9%	−2.5%	0.72	0.956
Large metro—fringe	485 (21%)	2.5%	7.2%	4.7%	1.13	0.500	57.7%	60.5%	2.8%	1.10	0.401	20.9%	25.5%	4.6%	1.27	0.218
Medium/small metro	732 (31%)	5.4%	6.8%	1.4%	1.25	0.351	58.1%	61.2%	3.1%	1.45	0.060	23.1%	25.0%	1.9%	1.21	0.189
Micropolitan/non-core	193 (8%)	4.9%	6.7%	1.8%	2.50	0.227	54.6%	62.1%	7.5%	1.82	0.075	18.9%	17.1%	−1.8%	0.86	0.721

Bold values indicate statistical significant at $p < 0.05$

NCHS National Center for Health Statistics

[a]1% of data missing for race/ethnicity; 11% missing for income; < 1% missing for education; percentages do not account for missing values

Table 5 Logistic regression (odds ratio) results for initiation of condomless anal sex among HIV-negative respondents who remained off pre-exposure prophylaxis PrEP for 2 subsequent years and did not report having had condomless anal sex in the first year, American Men's Internet Survey, 2014–2019 (N = 764)

Predictor	N (%) from total	N who initiated CAS (row %)	Bivariate OR estimates (95% CI)	p-value	Multivariable OR estimates (95% CI)			p-value
Age (years)								
15–24	169 (22%)	75 (44%)	**2.06 (1.45, 2.93)**	**0.0001**	*NA*[a]			
≥ 25	595 (78%)	166 (28%)	*Referent*					
Race/ethnicity					OR estimates among age 15–24[b]	p-value	OR estimates among age ≥ 25	p-value
Black (non-Hispanic)	46 (6%)	13 (28%)	0.88 (0.44, 1.68)	0.713	0.98 (0.30, 2.83)	0.975	0.95 (0.39, 2.14)	0.911
Hispanic (any race)	82 (11%)	34 (41%)	1.59 (0.98, 2.54)	0.056	**2.91 (1.42, 6.03)**	**0.004**	1.10 (0.54, 2.15)	0.779
White (non-Hispanic)	593 (78%)	183 (31%)	*Referent*		**1.81 (1.14, 2.87)**	**0.011**	*Referent*	
Another race (non-Hispanic)	35 (5%)	9 (26%)	0.78 (0.34, 1.63)	0.522	0.86 (0.19, 2.99)	0.825	0.95 (0.33, 2.40)	0.922
Unavailable	*8 (1%)*	*NA*						
Income (US$/year)								
< $20,000	69 (9%)	31 (45%)	**2.21 (1.27, 3.81)**	**0.005**	*NA*			
$20,000–$39,999	136 (18%)	48 (35%)	1.48 (0.94, 2.30)	0.087				
$40,000–$74,999	207 (27%)	57 (28%)	1.03 (0.68, 1.55)	0.896				
≥ $75,000	263 (34%)	71 (27%)	*Referent*					
Unavailable	*89 (12%)*	*NA*						
Educational attainment								
High school or less	69 (9%)	28 (41%)	**1.87 (1.10, 3.15)**	**0.019**	1.35 (0.76, 2.36)			0.301
Some college/2-year/technical degree	226 (30%)	87 (38%)	**1.72 (1.22, 2.41)**	**0.002**	**1.45 (1.01, 2.07)**			**0.041**
Bachelor's degree and beyond	464 (61%)	124 (27%)	*Referent*					
Unavailable	*5 (1%)*	*NA*						
Census region								
Northeast	161 (21%)	48 (30%)	0.84 (0.55, 1.28)	0.431	0.83 (0.53, 1.29)			0.413
Midwest	146 (19%)	45 (31%)	0.89 (0.57, 1.36)	0.583	0.84 (0.53, 1.32)			0.452
South	278 (36%)	93 (33%)	*Referent*					
West	179 (23%)	55 (31%)	0.88 (0.56, 1.32)	0.543	0.83 (0.54, 1.27)			0.387
NCHS county urbanicity classification								
Large metro—central	326 (43%)	87 (27%)	*Referent*					
Large metro—fringe	150 (20%)	57 (38%)	**1.68 (1.11, 2.54)**	**0.013**	**1.70 (1.10, 2.62)**			**0.016**
Medium/small metro	220 (29%)	72 (33%)	1.34 (0.92, 1.94)	0.128	1.28 (0.87, 1.89)			0.211
Micropolitan/non-core	68 (9%)	25 (37%)	1.60 (0.91, 2.75)	0.096	1.51 (0.84, 2.68)			0.158

Bold values indicate statistical significant at $p < 0.05$

OR odds ratio, *95% CI* 95% confidence interval, *NCHS* National Center for Health Statistics, *CAS* condomless anal sex

[a]The multivariable model includes a fully specified interaction between age and race/ethnicity and does not produce an estimate for the effects of younger age, alone

[b]Referent category is White non-Hispanic respondents 25+ years old. That is, these estimates account for an interaction between race/ethnic group and younger age

Discussion

This paper examines behavior changes among MSM who are HIV-negative and not using PrEP (HNM-NP)—a population that accounts for the majority of US MSM—in the age of PrEP expansion and U = U messaging. Most men in this population have CAS each year, but most also use condoms at least some of the time. Most importantly, the findings

suggest that the apparent flat rates of CAS for this population over time combine two countervailing phenomena, as hypothesized: selective adoption of PrEP among those with the most CAS partners, and increases over time in CAS among a subset of those remaining off PrEP. These increases appear both in the proportion of MSM having any CAS, and CAS partner number among those who do.

The meaning of the observed CAS increases—and the extent to which they are concerning from an HIV prevention standpoint specifically—depends on the partners with whom they occur. Little of the increase was with partners of unknown HIV status, suggesting that increases may not reflect an across-the-board decrease in condom-use culture. A small portion of the CAS increase occurred with partners living with HIV. Although partners' viral suppression status cannot be determined here, one distinct predictor—high education—suggests that this effect may be concentrated among those who are most well-positioned to trust U = U messaging, a public health-endorsed form of indirect protection. The disproportionately large increase in the South in this measure might simply reflect the region's higher HIV prevalence. U = U has a clear role to play in reducing stigma and discrimination towards persons living with HIV, with myriad psychosocial and public health benefits [37, 38]; the findings here warrant further investigation into variation in appreciation of U = U among US MSM, which is rapidly evolving [39].

On an absolute scale, most of the observed CAS increase occurred with partners who the respondent reported as HIV-negative; on the relative scale, the largest increase was with partners reported as living with HIV. Without knowing partners' biomedical status, one cannot fully distinguish here between indirect protection or more general condom reductions; however, the evidence across partner HIV status seen above tilts towards the former, as does a recent report on hypothetical condom use likelihood by partner biomedical status [40]. If the increase in CAS with partners believed to be HIV-negative were entirely with partners perfectly adherent to PrEP, there would be little concern from an HIV transmission perspective. However, we consider this unlikely for two reasons. First, PrEP use remains the minority status among MSM generally, with no more than 15% of HIV-negative respondents here reporting PrEP use in any year. Second, the predictors for increasing CAS with HIV-negative partners (younger age, Hispanic ethnicity, fringe metro residence, and lower education and income) likely represent a pattern of MSM who are less well-positioned than others to navigate reliance on indirect protection through partner PrEP, reflecting well-known structural barriers to accessing care within such communities [41]. The significance of newly reporting CAS with HIV-negative partners depends on whether such respondents were not previously having CAS, or were having CAS with partners living with HIV or of unknown status. A post-hoc analysis determined that 92% of respondents who reported CAS initiation with HIV-negative partners reported no CAS in the previous year.

The strongest, most consistent predictor of initiating CAS or increasing CAS partner number while remaining off PrEP was young (18–24) age. This supports our initial hypothesis that condom use practices are changing most rapidly among the youngest cohort newly forming their sexual health strategies. Consequently, special attention should be paid to determine if young MSM not on PrEP represent a rising proportion of all MSM diagnosed with HIV in the US in coming years.

Hispanic respondents accounted for the highest increases in any CAS among racial/ethnic groups, and the only significant increase in CAS partner number. This is particularly concerning, since Hispanic MSM were already disproportionately burdened by HIV before PrEP expansion, and PrEP use lags in this community relative to non-Hispanic White MSM [42]. Our multivariable model confirmed that this was not simply driven by age confounding given the younger age profile of Hispanic persons in the US; nevertheless, these effects were concentrated among young Hispanic respondents. Disproportionate behavior change in this population provides additional explanation for the slower decline in new HIV diagnoses among Hispanic MSM relative to other racial/ethnic groups, even after accounting for changes in their share of the US population [1]. It is also consistent with work showing variation in how MSM interpret testing negative for HIV, with one study finding that Hispanic/Latino MSM exhibited a relatively low sense of reinforced safety and high sense of luck or invulnerability compared to non-Hispanic respondents—a pattern associated with subsequent increases in CAS [43]. Still, more research is needed to determine if this pattern has continued into the present day and, to the extent that these young Hispanic MSM (or, indeed, any MSM) are basing their decisions on indirect protection, what is the basis and accuracy of their understanding of each partners' biomedical prevention status.

Our full set of significant predictors for CAS increases while off PrEP include not just age and ethnicity but also fringe metro residence and lower education and income. If these were predictors of PrEP uptake, we might attribute them to well-known barriers to PrEP access [44–46]. Their role in predicting increases of CAS conditional on being off PrEP is perhaps less expected, but could still reflect lower access to MSM-oriented HIV prevention messaging and services. That said, we note that Black MSM, who are also disproportionately impacted by HIV and experience reduced service access [47–49], did not report significant CAS increases while not on PrEP. Although this is itself encouraging news, it is worth noting that the persistent segregation of sexual networks and disparities in viral suppression and PrEP uptake together still imply that the same behavior is

more likely to generate higher HIV acquisition risk for Black MSM than for other groups [50–52].

Collectively our findings support the familiar and persistent need to identify feasible, acceptable, scalable, and culturally-sensitive ways to deliver HIV prevention services to sub-populations of MSM who experience higher risk for HIV and lower PrEP uptake. In particular, this work demonstrates that this need still applies to the traditional mainstay of both HIV and STI prevention—condoms—alongside newer biomedical prevention forms. Some men may choose not to use condoms consistently or ever, despite CDC recommendations for a comprehensive sexual health strategy encompassing both HIV and STI prevention. These men remain prime candidates for PrEP, including regular STI testing. However, even with increases in CAS, our data show that a sizeable fraction of HIV-negative MSM report at least some condom usage (at least 45% in the latest survey year, 2019, representing 52% of those having any anal sex), suggesting that condoms retain some level of feasibility and acceptability for many MSM. Nevertheless, the concentrated increase in CAS among MSM who are young, Hispanic, and/or outside urban cores points to particular sub-populations where re-invigorated public health promotion and access for condoms may serve the greatest HIV prevention need, alongside PrEP promotion and access. All such efforts must contend with the challenge that, unlike PrEP or viral suppression, condom decisions are explicitly dyadic, making them especially prone to cascading social network feedback, which creates both specific challenges and opportunities [26].

One context with clear opportunity for these efforts is the continued expansion of comprehensive LGBTQ+-inclusive sexual education. Roughly half of US high schools lack this resource [53], a number which is almost certainly higher outside major urban cores, where the largest increases in CAS among young MSM were observed. This may be complemented by further promotion of online, interactive, and engaging sexual health education materials catering specifically to YMSM, which have been shown to reduce CAS in this population [54, 55], as has sexual health education that explicitly incorporates discussions of pleasure [56]. Another area for opportunity is the further development and promotion of comprehensive, coordinated, patient-specific approaches to sexual health that address all prevention modalities, such as New York City's PlaySure network [57].

Respondents who supplied multiple years of data and who are thus central to our analysis disproportionately reported White race, older age, and urban residence than the single-year samples from which they were drawn. However, the largest CAS increases were among younger and Hispanic MSM and those in the metro fringe. Thus, one would expect the sampling bias in AMIS to *underestimate* the population-level effect in the overall sample, portending a larger public health concern. Similarly, Black MSM are under-represented in AMIS, reducing our ability to discern trends in this highly impacted population, although the absolute number of surveys from Black respondents was still large. Racial and ethnic identity in the US is complex, and it is difficult to know a priori which elements will be most salient for a given phenomenon. The 4-category version of race/ethnicity used here is commonly employed in demographic research for power considerations; considering the profound, multi-level racial and ethnic disparities in the HIV incidence and care continuum in the United States, it is conceivable that using more granular categories in future work will provide more nuanced insight into potential future trends in the epidemic. AMIS did not ask about country of birth for much of this time period, limiting our ability to disaggregate effects between native-born and immigrant MSM overall, or within the young Hispanic population who saw the largest behavioral changes in particular. We did not employ Type I error corrections, instead focusing our interpretation on predictors that appeared across multiple analyses, including those relying on non-overlapping sub-samples. The available data cannot determine the extent to which PrEP expansion is the cause of observed behavior change or simply coincident with it; however, the epidemiological impact of that change does not actually depend on this.

A small portion of our sample (1.9%) provided 3 years of data, which were treated as two observations of 2-year comparisons despite non-independence, given the small sample size and since our nested analyses are already complex. To test the impact of this decision, we repeated our analysis using only the first 2-year pair for each of these respondents. Our central findings remain qualitatively similar. The most notable difference is that the main effect for Hispanic respondents in Table 3 retains the same effect size (5.1-pp) but falls out of significance given the smaller sample ($p = 0.072$). However, the effect for young Hispanic respondents remains highly significant ($p = 0.007$) with a similar effect size (12.9-pp), and this combination of identities also retains similar explanatory power in the logistic regression results (Table 5; multivariable OR estimate 2.91, CI 1.42–6.03, $p = 0.004$). The significant increase for Hispanic respondents in CAI with partners perceived to be HIV-negative also remains (Table 4; 8.5-pp increase; $p = 0.010$). We note that this approach is also imperfect as it discards useful information (the third year of reports from some respondents) and thus loses power. We anticipate that more refined analyses retaining all data and accounting for dependence would produce results in line with those already presented.

Our study's largest limitation is the lack of data on partner PrEP or viral suppression status. We chose to analyze AMIS data regardless, since the study covers the roll-out period for both PrEP and U = U messaging, which were hypothesized

to be a critical period to observe behavior change among MSM not on PrEP, and contains longitudinal observations of a sufficiently large number of respondents, a key element for the analysis. Moreover, no study identified fulfilled all desiderata, which may help explain the relative dearth of research on this topic; however, we considered the question crucial enough to warrant whatever forms of investigation were possible with existing data. Efforts to ameliorate this limitation included disaggregating by partner status, and then identifying the distinct predictors, including education level, of CAS initiation by partner status. Although this approach is unable to demonstrate precisely what proportion of the increase is with partners not known to be on PrEP—or believed to be on PrEP but not fully adherent—it still highlights a strong need for increased attention to the question of behavior change among MSM who themselves are not on PrEP. While HIV diagnoses have declined considerably in the US in recent years, there are still more than 20,000 new cases among MSM each year [1]; and MSM who are not using PrEP presumably make up a large proportion of those newly infected. Understanding the contexts behind these transmission events is crucial for extending progress. Both quantitative and qualitative studies will be useful to understand the nuanced meanings and motivations of partner selection and condom use decision-making for MSM who remain off PrEP, especially young MSM who have only ever navigated sexual health in the PrEP and U = U era.

To our knowledge, this study is the first since the onset of PrEP and U = U to document CAS increases specifically among MSM who are HIV-negative and off PrEP in the United States. Considerable attention has rightly been paid to the many barriers to PrEP uptake, adherence, and retention. In the US, these include internalized stigma, distrust or discomfort with medical systems, avoiding PrEP-use disclosure to health plan providers, and lack of insurance or other resources to access PrEP, all of which fall disproportionately to MSM who are younger or of color [44, 58, 59]. While long-acting injectable PrEP may relieve pill burden [60], its current form brings additional challenges, including increased medication cost and more frequent provider visits [61]. For these and other reasons, a decade after PrEP's approval most MSM are not on PrEP at any moment, and young MSM in particular are likely to continue experiencing sizeable HIV exposure risk before they initiate PrEP, if they ever do. While it is crucial that we continue working to remove PrEP barriers for all, it remains just as crucial to find ways to support MSM, and especially young MSM, who are not on PrEP in adopting or maintaining strategies that they find feasible and sustainable for balancing HIV prevention with intimacy and pleasure.

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Declarations

Competing Interests The authors have no competing interests to declare that are relevant to the content of this article. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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