# Birth Cohort Variations Across Functional Knowledge of HIV Prevention Strategies, Perceived Risk, and HIV-Associated Behaviors Among Gay, Bisexual, and Other Men Who Have Sex With Men in the United States

**Akshay Sharma, MBBS, MPH, PhD**[1,2] (iD)**, Erin M. Kahle, MPH, PhD**[1,2] (iD)**,
Stephen P. Sullivan, MPH**[1,2]**, and Rob Stephenson, MSc, PhD**[1,2]

## Abstract

Gay, bisexual, and other men who have sex with men (GBMSM) in the United States remain heavily impacted by HIV. The purpose of this study was to describe intergenerational differences in functional knowledge of HIV prevention strategies, perceived risk, recent condomless anal sex (CAS), and HIV testing behavior. Eight hundred sexually active GBMSM were recruited via Facebook from August to September 2015, and administered a Web-based survey which included 12 multiple-choice questions to elicit data regarding functional knowledge of different HIV prevention approaches (e.g., condom use, pre-exposure prophylaxis post-exposure prophylaxis, treatment as prevention, circumcision). Cumulative logit and multivariable logistic models were formulated to examine birth cohort variations across four analytic outcomes. Younger generations were significantly more knowledgeable, as were GBMSM with higher education. Non-Hispanic non-White GBMSM and those reporting a bisexual/other sexual orientation had lower functional knowledge. Younger generations were equally concerned about contracting HIV as their older counterparts. Perceived risk was significantly higher among non-Hispanic non-White and Hispanic GBMSM, but lower among those with higher education and those in a relationship. Finally, birth cohort variations with respect to engaging in CAS with ≥2 men in the past 3 months and testing for HIV in the past year were not markedly pronounced. Younger GBMSM might be more knowledgeable about HIV prevention strategies compared to their predecessors, but are equally concerned about contracting HIV. Researchers and practitioners should consider intergenerational and other demographic differences while designing multifaceted HIV prevention programs for GBMSM.

## Keywords

HIV infections, sexually transmitted diseases, sexual and gender minorities, sexual behavior, risk reduction behavior

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Since initial reports in the early 1980s of what would become the HIV epidemic in the United States (Centers for Disease Control and Prevention [CDC], 1981; Haverkos & Curran, 1982), gay, bisexual, and other men who have sex with men (GBMSM) have been disproportionately impacted. HIV incidence among GBMSM steadily increased from approximately 20,000 per year in the early 1990s to approximately 30,000 per year in the mid-2000s (CDC, 2012; Hall et al., 2008). Although

[1]Department of Health Behavior and Biological Sciences, School of Nursing, University of Michigan, Ann Arbor, MI, USA
[2]Center for Sexuality and Health Disparities, University of Michigan, Ann Arbor, MI, USA

**Corresponding Author:**
Akshay Sharma, MBBS, MPH, PhD, Department of Health Behavior and Biological Sciences, School of Nursing, University of Michigan, 400 North Ingalls Street, Ann Arbor, MI 48109, USA.
Email: akshaydr@umich.edu

annual HIV incidence has recently stabilized (Hall et al., 2017), the overall burden of disease in this risk group remains high (CDC, 2017). The field of HIV prevention has been repeatedly transformed over the past 30 years, with different generations of GBMSM being exposed to multiple risk-reduction interventions. Early prevention efforts focused predominantly on behavioral changes such as lowering the number of partners (Noar, 2008), avoiding condomless anal sex (CAS) (Noar, 2008), and decreasing the sharing of needles and syringes (Watters, Estilo, Clark, & Lorvick, 1994). Since 2005, there has been an increased emphasis on biomedical prevention strategies such as pre-exposure prophylaxis (PrEP), post-exposure prophylaxis (PEP), and treatment as prevention (TasP) (Sullivan et al., 2012). Despite GBMSM's keen interest in newer prevention modalities, their uptake has been variable and racial disparities persist (Hoots et al., 2016).

Intervention development has often been guided by theoretical frameworks such as the information-motivation-behavioral skills (IMB) model (Fisher & Fisher, 1992), which conceptualizes risk reduction as a function of one's knowledge of HIV (including its prevention, prognosis, and treatment), motivation to reduce risk, and behavioral skills to adopt specific health-promoting strategies. Public health research has traditionally focused on basic measurements of knowledge including facts and misconceptions surrounding HIV (Kelly, Lawrence, Hood, & Brasfield, 1989), and being aware of the most common routes of transmission (Sonenstein, Pleck, & Ku, 1989). Functional knowledge refers to health literacy beyond just basic awareness of an illness, and high levels have been associated with better health outcomes in people living with HIV (Kalichman & Rompa, 2000; Walker, Hong, Talavera, Verduzco, & Woods, 2017). No studies have assessed the extent to which GBMSM possess the functional knowledge that is necessary to make informed decisions about selecting and utilizing their preferred modes of protection. Given the evolving landscape of HIV prevention, intergenerational differences in functional knowledge of different approaches might exist. For example, older GBMSM might have heard about PrEP, but they might not be aware that inconsistent PrEP use decreases its effectiveness, or that PrEP use does not reduce the risk of other sexually transmitted infections (STIs). Increasing calls to formulate effective HIV prevention packages for GBMSM of all ages necessitates a better understanding of how functional knowledge levels vary across generations (Sullivan et al., 2012).

Advances in antiretroviral medications over the past two decades have been hypothesized to contribute to the emergence of "treatment optimism" (Huebner, Rebchook, & Kegeles, 2004; Sullivan, Drake, & Sanchez, 2007), described as "feeling less concerned about acquiring HIV because of medications that can reduce HIV-related mortality and morbidity" (Schwarcz et al., 2007). Lower risk perceptions have in turn been associated with a greater engagement in risky sexual behaviors like CAS (Ostrow et al., 2002; Paz-Bailey et al., 2016), and a reduction in preventive behaviors like HIV testing (CDC, 2016b; White & Stephenson, 2016). Researchers have also raised concerns about "HIV prevention fatigue" among GBMSM, a viewpoint that messages, programs, or services have become monotonous over the years (Stockman et al., 2004). Identifying intergenerational variations can help appropriately tailor content while designing and evaluating novel HIV prevention interventions for this risk group. This study sought to quantify levels of functional knowledge of traditional and contemporary prevention strategies among sexually active GBMSM in the United States, and their overall concern about contracting HIV, that is, perceived risk. Birth cohort and other demographic differences in functional knowledge, perceived HIV risk, as well as associated behaviors including recently engaging in CAS with multiple partners and HIV testing were also evaluated.

## Methods

### Study Design and Survey Measures

The "Prioritizing U" cross-sectional study was conducted from August to September 2015, and the participant recruitment and study procedures have been described in detail elsewhere (Sharma, Sullivan, & Stephenson, 2017). Briefly, GBMSM were recruited via Facebook, asked to provide electronic informed consent, and administered a Web-based survey. Eligibility criteria included reporting a male gender identity, being at least 18 years, residing in the United States, and having sex with at least one man in the past 6 months. Ethical approval was obtained from the University of Michigan's Institutional Review Board (HUM00104699).

Twelve multiple-choice questions were used to gather data regarding functional knowledge of HIV prevention strategies (e.g., condom use, PrEP, PEP, TasP, circumcision), whose specifics are readily available on the CDC's HIV/AIDS Website (CDC, 2018). Perceived HIV risk was collected as an ordinal measure with 0 representing the least amount of overall concern about contracting HIV and 10 representing the greatest amount of concern (Marcus, Gassowski, & Drewes, 2016). The survey also included questions pertaining to recent engagement in potentially high-risk sexual behavior, and HIV testing history.

Participants' reported age at the time of the survey was used to formulate 5 birth cohorts: 1928–1959 (i.e., 56–87 years), 1960–69 (i.e., 46–55 years), 1970–1979

(i.e., 36–45 years), 1980–1989 (i.e., 26–35 years), and 1990–1997 (i.e., 18–25 years). Responses for their number of male anal sex partners in the past 3 months, insertive or receptive positioning, and condom use were used to construct a dichotomous variable reflecting a proxy measure for recent potentially high-risk sexual behavior: had CAS with ≥2 men in the past 3 months versus not. CAS was defined as any insertive or receptive anal sex with a male partner during which a condom was not used the entire time. Data on ever being tested for HIV, and the timing of their most recent test were combined to construct another dichotomous variable reflecting HIV testing history: tested for HIV in the past year versus not. An ordinal index reflecting functional knowledge of HIV prevention strategies was created for each participant by summing their number of correct responses to questions used to elicit this information, in a manner similar to prior HIV research studies (Carey & Schroder, 2002; DiClemente, 1991).

### Descriptive Analyses and Regression Modeling

SAS v. 9.4 (Cary, NC) was used to conduct all statistical analyses. Given this study's primary focus on HIV prevention, the analytic sample was restricted to participants who reported being HIV-negative or of unknown status, provided information on having anal sex with a man in the past 3 months, and responded to all 12 functional knowledge-based questions. $\chi^2$ tests for homogeneity were used to compare excluded individuals with those whose data were analyzed with respect to age, race/ethnicity, educational level, sexual orientation, and relationship status.

Demographic and behavioral characteristics of the sample, overall and stratified by birth cohort, were summarized using descriptive statistics. Kruskall-Wallis tests were conducted to assess overall birth cohort differences in the number of people participants knew who died of HIV/AIDS-related complications, and those living with HIV. Data on the four analytic outcomes of functional knowledge of HIV prevention strategies, perceived HIV risk, recent engagement in potentially high-risk sexual behavior, and HIV testing history were also tabulated, stratified by birth cohort.

Because of their ordinal nature, two cumulative logit models were formulated to identify factors independently associated with the index reflecting functional knowledge (Model 1), and perceived HIV risk (Model 2). Two multivariable logistic models were formulated to examine variations in CAS with ≥2 men in the past 3 months (Model 3), and testing for HIV in the past year (Model 4). The number of people participants knew who died of HIV/AIDS-related complications, and those living with HIV, were not included in any regression models, as they do not meet one of the three a priori criteria for a potential confounder. Birth cohort (i.e., the exposure of interest) directly influences both of these variables (and not vice versa), essentially making them intermediates in the pathways to each analytic outcome. All two-way interactions of first-order factors entered into models were evaluated in a stepwise manner, and condition indices and variance decomposition proportions were examined to check for multicollinearity (Belsley, 1991). Results are presented as adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

## Results

During recruitment, 3,734 individuals provided electronic informed consent, of whom 2,241 (60.0%) met the eligibility criteria. Of the 2,161 (96.4%) who began the survey, 286 (13.2%) were missing data on having anal sex with a man in the past 3 months, 203 (9.4%) did not provide information on their HIV testing history, and 147 (6.8%) reported they were living with HIV. Of the remaining 1,525 participants, the analytic sample was restricted to 800 (52.5%) who answered the question on perceived HIV risk, and responded to all 12 functional knowledge-based questions. Excluded individuals were more likely to have lower levels of education (*p*-value < .01), and a bisexual/other sexual orientation (*p*-value = .03), but were similar with respect to other demographic characteristics.

Descriptive characteristics of the 800 GBMSM participants, overall and stratified by birth cohort, are summarized in Table 1. One hundred and sixteen (14.5%) reported CAS with ≥2 men in the past 3 months. Of these, 53 (45.7%) were single (i.e., they did not report having a primary male partner at the time of the survey), 18 (15.5%) were in a monogamous relationship, 36 (31.0%) were in an open relationship with restrictions, and 9 (7.8%) were in an open relationship without restrictions. Two hundred and fifty-one (31.4%) reported being tested for HIV in the past 6 months, 152 (19.0%) in the past 6 months to 1 year, 205 (25.6%) in the past 1–5 years, and 90 (11.3%) >5 years ago. One hundred and two (12.8%) reported never having been tested for HIV.

Questions used to elicit information regarding functional knowledge of different HIV prevention strategies are presented in Table 2. The proportion of correct responses selected by participants ranged from less than one-fifth, for the question on increased risk of STIs associated with serosorting (*n* = 137, 17.1%) (Question 5), to more than nine-tenths for the question on reduced safety of using expired latex condoms (*n* = 747, 93.4%) (Question 2). Majority were aware that inconsistent PrEP use decreases its effectiveness (*n* = 677, 84.6%) (Question 9), PrEP users are recommended to continue using condoms (*n* = 732, 91.5%) (Question 10), and PrEP use does not

**Table 1.** Demographic and Behavioral Characteristics of 800 Gay, Bisexual, and Other Men Who Have Sex With Men, Overall and Stratified by Birth Cohort, United States, August–September 2015.

| | Total | Birth cohort | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | 1928–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1997 |
| | (N = 800) | (N = 214) | (N = 251) | (N = 96) | (N = 104) | (N = 135) |
| Characteristic | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Race/Ethnicity | | | | | | |
| Non-Hispanic White | 642 (80.3) | 196 (91.6) | 211 (84.1) | 71 (74.0) | 72 (69.2) | 92 (68.2) |
| Non-Hispanic non-White[a] | 65 (8.1) | 7 (3.3) | 18 (7.2) | 10 (10.4) | 12 (11.5) | 18 (13.3) |
| Hispanic | 93 (11.6) | 11 (5.1) | 22 (8.8) | 15 (15.6) | 20 (19.2) | 25 (18.5) |
| Educational level | | | | | | |
| Associate's/Technical degree or lower[b] | 315 (39.4) | 75 (35.1) | 97 (38.7) | 33 (34.4) | 25 (24.0) | 85 (63.0) |
| Bachelor's degree | 262 (32.8) | 65 (30.4) | 80 (31.9) | 32 (33.3) | 41 (39.4) | 44 (32.6) |
| Master's/Doctoral degree | 223 (27.9) | 74 (34.6) | 74 (29.5) | 31 (32.3) | 38 (36.5) | 6 (4.4) |
| Sexual orientation | | | | | | |
| Homosexual/Gay | 676 (84.5) | 173 (80.8) | 221 (88.1) | 82 (85.4) | 90 (86.5) | 110 (81.5) |
| Bisexual/Other[c] | 124 (15.5) | 41 (19.2) | 30 (12.0) | 14 (14.6) | 14 (13.5) | 25 (18.5) |
| Relationship status | | | | | | |
| Single | 329 (41.1) | 93 (43.5) | 84 (33.5) | 41 (42.7) | 37 (35.6) | 74 (54.8) |
| Have a primary partner[d] | 471 (58.9) | 121 (56.5) | 167 (66.5) | 55 (57.3) | 67 (64.4) | 61 (45.2) |
| Had CAS in the past 3 months | | | | | | |
| Yes, with ≥2 men | 116 (14.5) | 20 (9.4) | 39 (15.5) | 11 (11.5) | 24 (23.1) | 22 (16.3) |
| Yes, with 1 man | 270 (33.8) | 55 (25.7) | 86 (34.3) | 37 (38.5) | 46 (44.2) | 46 (34.1) |
| No | 414 (51.8) | 139 (65.0) | 126 (50.2) | 48 (50.0) | 34 (32.7) | 67 (49.6) |
| Time of most recent HIV test | | | | | | |
| Tested in the past year | 403 (50.4) | 90 (42.1) | 119 (47.4) | 52 (54.2) | 65 (62.5) | 77 (57.0) |
| Tested more than a year ago | 295 (36.9) | 94 (43.9) | 115 (45.8) | 40 (41.2) | 27 (26.0) | 19 (14.1) |
| Never been tested | 102 (12.8) | 30 (14.0) | 17 (6.8) | 4 (4.2) | 12 (11.5) | 39 (28.9) |
| Self-reported HIV status | | | | | | |
| Negative | 694 (86.8) | 183 (85.5) | 232 (92.4) | 92 (95.8) | 92 (88.5) | 95 (70.4) |
| Unknown[e] | 106 (13.3) | 31 (14.5) | 19 (7.6) | 4 (4.2) | 12 (11.5) | 40 (29.6) |

*Note.* [a]Includes 21 non-Hispanic Black/African American, 13 Asian, 8 Native American/Alaskan Native, 1 Native Hawaiian/Pacific Islander, and 22 other. [b]Includes 89 with an Associate's/Technical degree, 171 with some college education, 48 with a high school diploma or General Educational Development (GED), and 7 with some high school education. [c]Includes 102 bisexual, 7 heterosexual/straight, 11 questioning/unsure, 2 queer, and 2 other. [d]Described to participants as "Someone you feel committed to above all others. You might call this person your boyfriend, partner, significant other, spouse, or husband." Includes 324 in a monogamous relationship, 122 in an open relationship with restrictions, and 25 in an open relationship without restrictions. [e]Includes 102 who never tested, and 4 who tested but did not know their result. CAS = condomless anal sex.

help prevent other STIs (n = 659, 82.4%) (Question 11). Almost three-fifths did not know that PEP must be started within 3 days of a single high-risk HIV exposure event (n = 473, 59.1%) (Question 7), and almost a quarter were unaware that the risk of sexual transmission through people living with HIV who are virally suppressed is negligible (n = 583, 72.9%) (Question 12). Similar proportions reported CAS with ≥2 men in the past 3 months, and testing for HIV in the past year within each stratum of response validity for almost all questions (i.e., whether the answer to a particular question was correct or incorrect).

Data on the number of people participants knew who died of HIV/AIDS-related complications, and those living with HIV, stratified by birth cohort are included in Table 3. Kruskall-Wallis tests for intergenerational differences in these variables were statistically significant (p-value < .01). Younger participants knew progressively fewer people who died of HIV/AIDS-related complications, as well as those living with HIV.

Summary statistics for the four analytic outcomes stratified by birth cohort are presented in Table 4. Median values for the ordinal index reflecting functional knowledge of HIV prevention strategies and perceived HIV risk

**Table 2.** Functional Knowledge of HIV Prevention Strategies Among 800 Gay, Bisexual, and Other Men Who Have Sex With Men, United States, August–September 2015.

| Questions assessing functional knowledge of HIV prevention strategies (correct answer) | Validity of selected response | Had CAS with ≥2 men in the past 3 months (N = 116) | Tested for HIV in the past year (N = 403) |
|---|---|---|---|
| | n (%) | n (%)[a] | n (%)[b] |
| 1. By approximately what percentage can the consistent use of male latex condoms reduce the risk of acquiring or transmitting HIV? (80%) | | | |
| Correct | 493 (61.6) | 66 (13.4) | 243 (49.3) |
| Incorrect | 307 (38.4) | 50 (16.3) | 160 (52.1) |
| 2. True or false: Male latex condoms can be safely used beyond their expiration date, or more than 5 years after their manufacturing date. (False) | | | |
| Correct | 747 (93.4) | 107 (14.3) | 381 (51.0) |
| Incorrect | 53 (6.6) | 9 (17.0) | 22 (41.5) |
| 3. What is true about natural membrane condoms, frequently called "natural skin" or "lambskin" condoms? (Permeable to HIV and not recommended for HIV prevention) | | | |
| Correct | 533 (66.6) | 77 (14.5) | 261 (49.0) |
| Incorrect | 267 (33.4) | 39 (14.6) | 142 (53.2) |
| 4. By approximately what percentage has male circumcision been found to reduce the risk of acquiring HIV among predominantly heterosexual men in sub-Saharan Africa? (50%–60%) | | | |
| Correct | 213 (26.6) | 37 (17.4) | 98 (46.0) |
| Incorrect | 587 (73.4) | 79 (13.5) | 305 (52.0) |
| 5. With what has serosorting, or tailoring behavior such as condom use or sexual positioning on the basis of each other's HIV status, been associated? (Increased risk of sexually transmitted infections, e.g., chlamydia, gonorrhea) | | | |
| Correct | 137 (17.1) | 20 (14.6) | 73 (53.3) |
| Incorrect | 663 (82.9) | 96 (14.5) | 330 (49.8) |
| 6. How does being infected with other sexually transmitted infections, for example, chlamydia, gonorrhea, affect one's risk of acquiring HIV? (Increases risk) | | | |
| Correct | 575 (71.9) | 87 (15.1) | 288 (50.1) |
| Incorrect | 225 (28.1) | 29 (12.9) | 115 (51.1) |
| 7. Post-exposure prophylaxis (PEP) refers to the use of antiretroviral medications for 28 days after a single high-risk HIV exposure event to prevent the virus from establishing infection among HIV-negative individuals. Within what timeframe does PEP have to be started in order to be effective? (3 days) | | | |
| Correct | 327 (40.9) | 59 (18.0) | 163 (49.9) |
| Incorrect | 473 (59.1) | 57 (12.1) | 240 (50.7) |
| 8. Pre-exposure prophylaxis (PrEP) refers to the daily use of antiretroviral medications by HIV-negative individuals to prevent HIV from establishing infection once inside the body. By what percentage has PrEP been shown to reduce the risk of acquiring HIV among those who consistently took the drug as prescribed? (92%) | | | |
| Correct | 319 (39.9) | 80 (25.1) | 190 (59.6) |
| Incorrect | 481 (60.1) | 36 (7.5) | 213 (44.3) |
| 9. How does the inconsistent use of pre-exposure prophylaxis (PrEP) influence its effectiveness? (Decreases effectiveness) | | | |
| Correct | 677 (84.6) | 101 (14.9) | 348 (51.4) |
| Incorrect | 123 (15.4) | 15 (12.2) | 55 (44.7) |
| 10. What is the recommendation about using pre-exposure prophylaxis (PrEP) along with condoms? (People using PrEP are recommended to continue using condoms) | | | |
| Correct | 732 (91.5) | 112 (15.3) | 374 (51.1) |
| Incorrect | 68 (8.5) | 4 (5.9) | 29 (42.7) |
| 11. What is true about using pre-exposure prophylaxis (PrEP) and the risk of acquiring other sexually transmitted infections, for example, chlamydia, gonorrhea? (Using PrEP does not help prevent other sexually transmitted infections) | | | |
| Correct | 659 (82.4) | 100 (15.2) | 345 (52.4) |
| Incorrect | 141 (17.6) | 16 (11.4) | 58 (41.1) |
| 12. By approximately what percentage can people living with HIV who adhere to antiretroviral medications to the point of being virally suppressed reduce the risk of sexual transmission? (96%) | | | |
| Correct | 217 (27.1) | 53 (24.4) | 123 (56.7) |
| Incorrect | 583 (72.9) | 63 (10.8) | 280 (48.0) |

*Note.* [a]Percentages indicate the proportion who had CAS with ≥2 men in the past 3 months within each stratum of response validity. [b]Percentages indicate the proportion who tested for HIV in the past year within each stratum of response validity. CAS = condomless anal sex.

**Table 3.** Number of People Participants Knew Who Died of HIV/AIDS-Related Complications, and Those Living With HIV, Stratified by Birth Cohort Among 800 Gay, Bisexual, and Other Men Who Have Sex With Men, United States, August–September 2015.

| | Birth cohort | | | | |
|---|---|---|---|---|---|
| | 1928–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1997 |
| Characteristic | (N = 214) | (N = 251) | (N = 96) | (N = 104) | (N = 135) |
| Continuous variables | Mean, median (interquartile range) | | | | |
| Number of people participants knew who died of HIV/AIDS-related complications | 9, 5 (1–20) | 6, 2 (0–8) | 2, 1 (0–2) | 1, 0 (0–1) | 0, 0 (0–0) |
| Number of people participants knew who were living with HIV | 5, 3 (0–6) | 5, 3 (1–6) | 4, 2 (0–5) | 3, 1 (0–3) | 1, 0 (0–1) |

**Table 4.** Summary Statistics for Analytic Outcomes Stratified by Birth Cohort Among 800 Gay, Bisexual, and Other Men Who Have Sex With Men, United States, August–September 2015.

| | Birth cohort | | | | |
|---|---|---|---|---|---|
| | 1928–1959 | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1997 |
| Characteristic | (N = 214) | (N = 251) | (N = 96) | (N = 104) | (N = 135) |
| Continuous variables | Median (interquartile range) | | | | |
| Functional knowledge of HIV prevention strategies[a] (Scale: 0–12) | 7 (6–8) | 7 (6–9) | 7 (6–8) | 8 (6–9) | 7 (6–8) |
| Overall concern about contracting HIV, that is, perceived risk[b] (Scale: 0–10) | 6 (2–8) | 6 (2–8) | 7 (2.5–8) | 7 (4.5–8) | 7 (5–8) |
| Categorical variables | n (%) | | | | |
| Had CAS with ≥2 men in the past 3 months | 20 (9.4) | 39 (15.5) | 11 (11.5) | 24 (23.1) | 22 (16.3) |
| Tested for HIV in the past year | 90 (42.1) | 119 (47.4) | 52 (54.2) | 65 (62.5) | 77 (57.0) |

*Note.* [a]Ordinal index created by summing the number of correct responses to questions used to elicit information regarding functional knowledge of HIV prevention strategies (Cronbach's $\alpha$ = 0.92). [b]Responses to this question collected as an ordinal measure with 0 representing the least amount of concern and 10 representing the greatest amount of concern. CAS = condomless anal sex.

were similar. Higher proportions of participants born in 1980–1989 and 1990–1997 reported CAS with ≥2 men in the past 3 months and testing for HIV in the past year compared to those born earlier.

Results from regression models used to characterize independent associations with each analytic outcome are included in Table 5. Regarding functional knowledge of HIV prevention strategies, younger birth cohorts were more knowledgeable, as were participants with higher levels of education. Non-Hispanic non-White participants, and those reporting a bisexual/other sexual orientation were less knowledgeable (Model 1). Regarding perceived HIV risk, younger birth cohorts were equally concerned about contracting HIV as older birth cohorts, after adjusting for functional knowledge. Perceived HIV risk was higher among non-Hispanic non-White and Hispanic participants, but lower among those with higher educational levels and those who were primarily

partnered (Model 2). The adjusted odds of CAS with ≥2 men in the past 3 months were higher among participants born in 1980–1989 compared to those born in 1928–1959, and increased with greater levels of functional knowledge. The adjusted odds did not vary across any other characteristics including race/ethnicity (Model 3). Finally, no birth cohort differences were observed regarding HIV testing in the past year. The adjusted odds of testing were higher among Hispanic participants, and increased by 10% for each unit increase in perceived HIV risk. Also, the adjusted odds were more than thrice as high among participants who reported CAS with ≥2 men in the past 3 months (Model 4).

## Discussion

Intergenerational variations in functional knowledge of HIV prevention strategies were identified in a Web-based

**Table 5.** Factors Independently Associated With Analytic Outcomes Among 800 Gay, Bisexual, and Other Men Who Have Sex With Men, United States, August–September 2015.

| Characteristic | Model 1<br>Functional knowledge of HIV prevention strategies[a]<br>aOR (95% CI) | Model 2<br>Overall concern about contracting HIV, that is, perceived risk[b]<br>aOR (95% CI) | Model 3<br>Had CAS[c] with ≥2 men in the past 3 months<br>aOR (95% CI) | Model 4<br>Tested for HIV in the past year<br>aOR (95% CI) |
|---|---|---|---|---|
| Birth cohort (age in years) | | | | |
| 1928–1959 (56–87) | Ref. | Ref. | Ref. | Ref. |
| 1960–1969 (46–55) | 1.4 [1.0, 2.0] | 1.0 [0.7, 1.4] | 1.7 [0.9, 3.0] | 1.1 [0.7, 1.6] |
| 1970–1979 (36–45) | **1.6 [1.1, 2.5]** | 1.0 [0.6, 1.5] | 1.1 [0.5, 2.5] | 1.4 [0.8, 2.3] |
| 1980–1989 (26–35) | **1.7 [1.1, 2.5]** | 1.4 [0.9, 2.1] | **2.8 [1.4, 5.5]** | 1.6 [1.0, 2.7] |
| 1990–1997 (18–25) | **1.6 [1.1, 2.4]** | 1.1 [0.8, 1.7] | 1.6 [0.8, 3.3] | 1.3 [0.8, 2.2] |
| Race/Ethnicity | | | | |
| Non-Hispanic White | Ref. | Ref. | Ref. | Ref. |
| Non-Hispanic non-White[c] | **0.6 [0.3, 0.9]** | **1.8 [1.2, 2.9]** | 0.9 [0.4, 2.0] | 1.6 [0.9, 2.8] |
| Hispanic | 0.7 [0.5, 1.0] | **2.8 [1.8, 4.1]** | 0.7 [0.4, 1.4] | **2.7 [1.6, 4.5]** |
| Educational level | | | | |
| Associate's/Technical degree or lower[d] | Ref. | Ref. | Ref. | Ref. |
| Bachelor's degree | **2.0 [1.5, 2.7]** | **0.7 [0.5, 0.9]** | 0.8 [0.5, 1.3] | 1.0 [0.7, 1.4] |
| Master's/Doctoral degree | **2.6 [1.9, 3.6]** | **0.7 [0.5, 0.9]** | 0.7 [0.4, 1.3] | 1.1 [0.8, 1.7] |
| Sexual orientation | | | | |
| Homosexual/Gay | Ref. | Ref. | Ref. | Ref. |
| Bisexual/Other[e] | **0.6 [0.4, 0.9]** | 1.0 [0.7, 1.4] | 1.0 [0.5, 1.7] | 0.8 [0.5, 1.2] |
| Relationship status | | | | |
| Single | Ref. | Ref. | Ref. | Ref. |
| Have a primary partner[f] | 1.0 [0.8, 1.3] | **0.5 [0.4, 0.6]** | 0.8 [0.5, 1.2] | 1.0 [0.7, 1.3] |
| Functional knowledge of HIV prevention strategies[a] | – | 1.0 [1.0, 1.1] | **1.3 [1.1, 1.4]** | 1.1 [1.0, 1.1] |
| Overall concern about contracting HIV, that is, perceived risk[b] | – | – | 1.1 [1.0, 1.1] | **1.1 [1.1, 1.2]** |
| Had CAS with ≥2 men in the past 3 months | – | – | – | **3.3 [2.1, 5.2]** |

*Note.* [a]Ordinal index created by summing the number of correct responses to questions used to elicit information regarding functional knowledge of HIV prevention strategies (Cronbach's $\alpha$ = 0.92). [b]Responses to this question collected as an ordinal measure with 0 representing the least amount of concern and 10 representing the greatest amount of concern. [c]Includes 21 non-Hispanic Black/African American, 13 Asian, 8 Native American/Alaskan Native, 1 Native Hawaiian/Pacific Islander, and 22 others. [d]Includes 89 with an Associate's/Technical degree, 171 with some college education, 48 with a high school diploma or General Educational Development (GED), and 7 with some high school education. [e]Includes 102 bisexual, 7 heterosexual/straight, 11 questioning/unsure, 2 queer, and 2 others. [f]Described to participants as "Someone you feel committed to above all others. You might call this person your boyfriend, partner, significant other, spouse, or husband." Includes 324 in a monogamous relationship, 122 in an open relationship with restrictions, and 25 in an open relationship without restrictions. CAS = condomless anal sex; aOR = adjusted odds ratio; CI = confidence interval.
Bolded terms indicate *P*-value < 0.05.

sample of GBMSM residing in the United States. Younger birth cohorts had higher knowledge levels (adjusted odds for the three youngest cohorts were 60%–70% higher compared to the oldest cohort), but no differences were observed with respect to perceived HIV risk. These results suggest that although younger GBMSM might be relatively more knowledgeable, possibly due to greater media exposure or access to latest information about HIV

prevention and treatment options, they are just as concerned about contracting HIV as their older counterparts who experienced the full brutality of the epidemic. This is encouraging in the contexts of "HIV prevention fatigue" and "treatment optimism" documented among young GBMSM (Huebner et al., 2004; Stockman et al., 2004), as well as in light of growing apprehensions about their complacency surrounding HIV (CDC, 2016a; MacKellar

et al., 2011). This also highlights the need to improve HIV prevention messaging for older, sexually active GBMSM.

Regarding functional knowledge of HIV prevention strategies, majority of the participants ($n = 499$, 62.4%) scored ≥7 of 12 questions correct (median: 7; interquartile range: 6–8; range: 1–12). Racial and ethnic minority participants had lower knowledge levels, suggesting that current prevention messages might not be reaching individuals at highest risk. Given the steady increases in HIV diagnoses among non-Hispanic Black/African American GBMSM over the past decade (CDC, 2016d), targeted efforts are needed to inform them within the framework of social factors influencing their risk (Peterson & Jones, 2009). Simplifying media messages about traditional and contemporary HIV prevention approaches, with a greater emphasis on visual representation and interactivity (Megan, Jennifer, Ayala, & Ellen, 2012), might help improve levels of functional knowledge among participants with lower educational attainment. Participants reporting a bisexual/other sexual orientation were less knowledgeable about HIV prevention strategies, possibly reflecting the lack of programmatic attention directed towards this subgroup (Doll & Beeker, 1996). Another reason could be relatively lower levels of discussion around HIV among men who do not identify as homosexual/gay (Goldbaum et al., 1998).

Regarding overall concern about contracting HIV, majority of the participants ($n = 482$, 60.3%) indicated their perceived risk to be ≥-6 on a scale of 0 to 10 (median: 7; interquartile range: 3–8; range: 0–10). Non-Hispanic non-White and Hispanic participants were substantially more concerned, similar to published research with these demographic subgroups (MacKellar et al., 2007). Risk appraisal is a complex analytical and emotional assessment process (Slovic, Finucane, Peters, & MacGregor, 2004), which includes a personal evaluation of the prevalence of HIV within one's community (White & Stephenson, 2016). This result should be interpreted with caution due to the relative underrepresentation of racial and ethnic minority GBMSM, an unfortunate reality plaguing Web-based studies (Sullivan et al., 2011). Consistent with previous research (Klein & Tilley, 2012; MacKellar et al., 2007), participants who had completed college or earned higher degrees were less concerned about contracting HIV. Those who were primarily partnered had lower HIV risk perceptions, which is analogous to a recent national study in which GBMSM in main partnerships were more likely to perceive zero risk of HIV infection, and felt very confident of remaining HIV-negative (Stephenson, White, Darbes, Hoff, & Sullivan, 2015). Given that global measures of perceived HIV susceptibility might be better predictors of actual risk than simple behavioral indicators (MacKellar et al., 2005,

2007), providers offering HIV prevention services to GBMSM should consider evaluating their clients' risk perceptions to enhance the personalized decision-making process.

Birth cohort variations with respect to recent engagement in potentially high-risk sexual behavior were not markedly pronounced. Increasing functional knowledge of HIV prevention strategies was associated with recently engaging in CAS with multiple partners. The IMB model recognizes that information and motivation could be independent of each other, as observed when well-informed individuals are not motivated to change behaviors that increase their HIV risk (Fisher & Fisher, 2000). CAS occurs in the context of disparate psychological and sociological factors (Adam, Husbands, Murray, & Maxwell, 2005), which poses challenges to developing effective risk-reduction programs. Racial and ethnic minority participants were not more likely to report potentially high-risk sexual behavior, a result consistent with current literature (Millett et al., 2012). Overall, approximately half the participants reported CAS in the past 3 months, almost a third of whom reported CAS with ≥2 men. This is a disconcerting observation because CAS increases the risk of STIs such as chlamydia, gonorrhea, and syphilis (CDC, 2016c), regardless of one's use of medications to prevent HIV (Grant et al., 2010). Of the 202 HIV-negative participants who responded to the question on current PrEP use, only 12 (6%) reported being on PrEP, a proportion similar to national estimates (CDC, 2016b).

No intergenerational differences were observed with respect to HIV testing in this study. Hispanic participants were almost thrice as likely to have been tested in the past year compared to non-Hispanic White participants. This is reassuring, given the estimated 20% increase in HIV infections in this demographic stratum from 2008 to 2014 (CDC, 2017). Testing is the first step in making serostatus-dependent client-specific recommendations regarding the adoption of most biomedical prevention approaches (Sullivan et al., 2012), and should be prioritized for all sexually active GBMSM regardless of age or race/ethnicity. Increasing risk perceptions among the participants were positively associated with HIV testing, similar to prior observations (Grover & Miller, 2014; Tillman & Mark, 2015; White & Stephenson, 2016). The observation that participants who recently engaged in CAS with ≥2 men were more likely to have been tested for HIV might be reflective of an event-driven testing pattern (Lorenc et al., 2011; Maguen, Armistead, & Kalichman, 2000). Alternatively, this relationship could indicate behavioral disinhibition among GBMSM who have tested negative for HIV, which is a cause for concern given the rising STI rates in this subgroup (CDC, 2016c). Overall, approximately half the participants reported having been tested in

the past year, a proportion considerably lower than the most recent national estimate of 71% (CDC, 2016b). These results highlight the need to continue researching motivational constructs that might positively influence the uptake of health-promoting strategies among GBMSM.

Strengths of this study include recruiting a large sample of sexually active GBMSM from across the United States in a time and resource efficient manner. Survey completion was not incentivized, and because it could only be accessed by clicking on banner advertisements displayed on Facebook, duplicate attempts are unlikely. Individuals tend to be more open and honest while reporting sensitive information through Web-based surveys, thereby reducing the possibility of social desirability bias (Heerwegh, 2009).

Limitations of this study include the use of a convenience sample, which was predominantly non-Hispanic White and college-educated. Participants voluntarily self-selected into the study, and several did not respond to all 12 functional knowledge-based questions. Caution must be exercised in generalizing study results to GBMSM who are active on Facebook or other social media, and those in the general U.S. population. The cross-sectional nature of these data precludes commenting on the temporality of observed associations. Finally, although an attempt was made to formulate an exhaustive list of questions for assessing functional knowledge of HIV prevention strategies, the authors acknowledge that this question set might not be complete.

## Conclusion

Results of this study have important implications for furthering HIV prevention efforts among sexually active GBMSM in the United States. New information on their levels of functional knowledge needed to successfully adopt preferred modes of protection has been presented, and demographic subgroups that could potentially benefit from comprehensive messaging have been identified. Younger generations might be more knowledgeable about HIV prevention strategies compared to their predecessors, but are equally concerned about contracting HIV. Researchers and practitioners should consider these important issues while designing combination prevention interventions for GBMSM. Additional research is needed to evaluate whether their awareness translates into actual use, and to better understand how their risk perceptions influence behaviors such as CAS with multiple partners and regularly testing for HIV.

### Declaration of Conflicting Interests

### Funding

### ORCID iDs

Akshay Sharma [iD] https://orcid.org/0000-0001-7864-5464
Erin M. Kahle [iD] https://orcid.org/0000-0001-6060-9852

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