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Factors associated with awareness and usage of safer sex functions in dating apps among MSM, 2019 American Men's Internet Survey (AMIS) study.

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By

Haisu Zhang

B.S., Fudan University, 2019

Thesis Committee Chair: Travis Sanchez, DVM, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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## Abstract

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By Haisu Zhang

Increasing use of dating apps among United States men who have sex with men (MSM) raises serious sexual health issues, but also presents new opportunities for sexual health interventions targeting MSM if we can ensure adequate and equitable uptake. Uptake of these interventions may be substantially influenced by various types of stigma and discrimination experienced by MSM. This study explored the associations between perceived community intolerance of gay/bisexual people, 3 types of sexuality-related stigma and the awareness and usage of safer sex functions in dating apps among MSM. Four safer sex functions in dating apps were examined in dating apps, HIV profile, sexual strategy profile, sexual health testing reminders, and sexual health information and resources. Data from 7700 MSM in the 2019 American Men's Internet Survey were analyzed using multivariable Poisson regression with robust variance, controlling for demographic characteristics. Results are reported as adjusted prevalence ratios (APR) and 95% confidence intervals (CI). Overall, 82.6% of the participants reported being aware and 41.6% reported usage of at least one safer sex function offered by dating apps. Increasing perceived intolerance was associated with reduced awareness of sexual health strategy profile (APR: 0.95, 95% CI: 0.93~0.98) and sexual health information and resources (APR: 0.97, 95% CI: 0.94~0.99), and increasing usage of sexual health information and resources among MSM with known HIV status. Increasing stigma from family and friends and anticipated health-care stigma were associated with reduced awareness of some safer sex functions . Stigma from family and friends was also significantly associated with increased usage of sexual health reminders (APR: 1.14, 95% CI: 1.02~1.28) and sexual health information and resources (APR: 1.16, 95% CI: 1.04, 1.31). Our results showed that safer sex functions in dating apps could be effective supplement ways to access sexual health services for MSM with stigma and discrimination experience. Meanwhile, more efforts should be made to address the reduced awareness of safer sex functions among MSM with stigma and discrimination experience. Hopefully, the safer sex functions could help MSM develop better sexual health behaviors, reduce their risk of getting HIV/STI and improve their HIV/STI testing rate.

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Key words: MSM, dating apps, safer sex, HIV, stigma

# Abstract

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and sexual health information and resources (APR: 0.97, 95% CI: 0.94~0.99), and increasing usage of sexual health information and resources among MSM with known HIV status. Increasing stigma from family and friends and anticipated health-care stigma were associated with reduced awareness of some safer sex functions. Stigma from family and friends was also significantly associated with increased usage of sexual health reminders (APR: 1.14, 95% CI: 1.02~1.28) and sexual health information and resources (APR: 1.16, 95% CI: 1.04, 1.31). Our results showed that safer sex functions in dating apps could be effective supplement ways to access sexual health services for MSM with stigma and discrimination experience. Meanwhile, more efforts should be made to address the reduced awareness of safer sex functions among MSM with stigma and discrimination experience. Hopefully, the safer sex functions could help MSM develop better sexual health behaviors, reduce their risk of getting HIV/STI and improve their HIV/STI testing rate.

# Introduction

Gay, bisexual, and other men who have sex with men (MSM) are the major population affected by HIV in the United States, accounting for 69% new HIV diagnoses in 2018 [1]. The lifetime risk of having HIV infection among males was estimated to be 1 in 100, while the lifetime risk is 1 in 6 among MSM [2]. Adolescent (aged 15-24) and young adult MSM (aged 25-34) were the two leading groups that account for around 60% new HIV diagnoses among MSM. While the number of new HIV diagnoses among MSM in other age groups were decreasing or stable, the

number in young adults increased by 6% from 2014 through 2018 [1]. The disproportionate numbers of new HIV diagnoses among MSM and young age groups raised an alarm that we need urgent action to enhance the HIV prevention and control among those groups. To reduce the heavy HIV burden among young MSM, we need more efficient ways to convey the HIV prevention message and deliver interventions for them.

With the development of information technology and wide use of smartphones, mobile networking has became common among Americans generally. A 2015 report showed that 65% of American adults use social networking sites and young adults are most likely to use the social media comparing to other age groups. 90% of young adults aged 18~29 used social media in 2015, while such percentage was only 7% in 2005 [3]. The rapid growth of internet-based social networking usage brought MSM a new way to make friends and find sexual partners, dating apps designed for MSM. Various studies showed that more than half of MSM reported using MSM-specific dating app or website to find sexual partners. A web-based survey in 2015 showed that the leading MSM-specific dating app or website that participants were using are Grindr, Adam4Adam and Jack'd [4, 5].

While the rapidly increasing use of dating apps enables MSM to find friends and sexual partners conveniently, it also raises serious sexual health issues. Research shows that MSM using dating apps have more sexual partners and are more likely to engage in condomless anal intercourse, which is associated with elevated risk of HIV [6, 7]. A cohort study conducted in Los Angeles County found greater odds of testing positive for gonorrhoea and chlamydia among individuals using dating apps to meet sexual partners, comparing to those met partners through in-person

methods [8].

Dating apps also provide a unique and highly targeted platform for sexual health promotion among MSM. The high proportion of dating app usage among MSM could guarantee the coverage of sexual health promotion delivered through dating apps. Building Health Online Communities (BHOC), an organization where public health professionals work together to support online HIV and STI prevention, has been promoting the integration of safer sex functions in many dating apps [9]. Typical safer sex functions include HIV profile, in which users can display their HIV status and whether they are receiving care and have viral load under control if positive; sexual health strategy profile, in which users can display their sexual health behaviors such as condom use and taking HIV pre-exposure prophylaxis (PrEP); sexual health testing reminders, which remind app users to receive HIV/STI tests regularly or related to higher risk events, such as when their close contacts report HIV/STI infection; and sexual health information and resources, such as prevention strategies to consider and where to get HIV testing or free condoms. Several studies have revealed that MSM were generally interested in sexual health features on dating apps, including app-based notification of potential contact to HIV/STI infected people [10, 11]. They were also comfortable with receiving sexual health services provided by public health department through a dating app [11]. A study conducted in northern Sydney showed that the average monthly rate of HIV test visits of MSM increased by 70.3% in the sexual health clinic after advertising on Grindr, a leading MSM-specific dating app [12].

While several studies have revealed the acceptability of sexual health promotion through

dating apps among MSM and its potential beneficial effect, few studies tried to explore the factors associated with the awareness and actual usage of safer sex functions that are now embedded in several popular dating apps for MSM. In addition to typical factors that can influence usage of sexual health interventions, such as demographics, sexual behaviors and HIV status, stigma and discrimination experiences may also play a substantial role. Previous studies have shown that discrimination and stigma experience of MSM was associated with reduced care-seeking and treatment adherence in traditional settings [13, 14]. MSM living with HIV could have different stigma experience comparing to those with without HIV[15], and the intersectionality of racial stigma, sexual minority stigma and HIV-related stigma could lead to higher depression and anxiety level [16, 17]. The intersectional effect might also present in the association between stigma experience and safer sex function awareness and usage. Therefore, the overall aim of this study is to explore the relationship between stigma and the awareness/usage of safer sex functions, by HIV status, and provide hypotheses for further research to increase usage and impact of safer sex functions in dating apps among MSM.

# Methods

### *Study Population and Procedures*

We used data collected from the 2019 American Men's Internet Survey (AMIS) for this study.

AMIS is a series of cross-sectional internet surveys conducted annually to assess the behaviors of MSM in the United States [18]. Details of survey administration and questionnaire can be found in the AMIS website [19]. MSM are recruited through convenience sampling from website or geospatial social networking applications with advertisement or e-mail from August to December 2019. Eligibility criteria include ≥15 years of age at the time of participation, identify as cis-gender male, live in the US or a dependent area and reported at least one lifetime sex act (oral or anal) with a male partner or gay/bisexual identity (for those 15-17 years). After collecting informed consent, the survey assessed information about demographics, sexual behaviors, substance use behaviors, HIV testing and status, experience with stigma, history of sexually transmitted infections (STIs), awareness and usage of safer sex functions in dating apps, and awareness of HIV prevention campaigns. Participants who reported usage of at least one dating/hookup app designed for MSM were asked additional questions about safer sex functions on those apps. All procedures performed as part of AMIS involving human participants were conducted in accordance with the ethical standards of the Emory University Institutional Review Board. Incentives or compensation for study participation were not provided. For this secondary analysis of deidentified data, additional informed consent was not required.

***Measures***

The outcomes of interest were awareness and usage of safer sex functions in dating apps designed for MSM, which was assessed from two questions in the survey: “Which of the following features are you aware of dating/hookup smartphone apps offering?” and “Which of the following

dating/hookup smartphone app features have you used in the past 12 months?". Both questions provided 5 choices: "Sexual health testing reminders", "Sexual health strategy profile options", "HIV status profile options", "Sexual health information and resources", and "None of these". Participants who reported no awareness of safer sex functions were excluded in the analysis of usage of safer sex functions. The four safer sex functions were analyzed as separate dependent variables.

Several independent variables were also analyzed. For exposure of interest, perceived intolerance of gay/bisexual population in residence area was assessed by participants' agreement of the statement 'Most people in my area are tolerant of gay and bisexual people.'. Participants can choose from 1-'Strongly agree', 2-'Agree', 3-'Neither agree or disagree', 4-'Disagree', 5-'Strongly disagree'. Recent stigma experience was assessed from a series of 15 questions. Participants can choose from "No", "Yes, in the last 6 months", "Yes, but not in the last 6 months", prefer not to answer or don't know. Based on previous latent class analyses and validation studies of this question set, a 3-class structure was used: "stigma from family and friends", "anticipated healthcare stigma", and "general social stigma" [20]. For each of the 3 stigma items, participants answered "yes, in the past 6 months" to any of the corresponding questions were regarded as having recent experience with that type of stigma. Demographic factors were included as covariates were age in years, race/ethnicity, education level, and annual income. Because substantial number of participants did not report their annual income, we treated the missing annual income as a response category. Population density of participant's county of residence was determined from the National Center for Health Statistics (NCHS) Rural-Urban classification

scheme [21]. HIV status was also included as positive, negative or unknown. Participants who did not know their HIV status, preferred not to disclose HIV status or had missing HIV status were all included in unknown category for HIV status.

***Analyses***

We first excluded incomplete or duplicated responses in our data and restricted our sample to those who had sex with another male in the past 12 months (n = 10130). We then restricted the analysis to those who had used at least one dating app in the past 12 months (n = 7700). Descriptive statistics were calculated for each variable. Frequencies and proportions were calculated for categorical variables while mean and standard deviations (SDs) for continuous variables. Bivariate analyses were conducted to explore the crude associations between demographics, stigma and safer sex functions awareness and usage. Associations are reported as prevalence ratios (PRs) and 95% confidence intervals (CIs) using Poisson regression with robust variance. Multivariate Poisson regression models were run to determine the associations between exposure variables, perceived intolerance and recent stigma experience, and outcome variables, awareness and usage of each safer sex function in dating apps. Different exposure and outcome variables were included separately in different models, and each model only included one of the exposure variables and one of the outcome variables. Demographics and HIV status were the common covariates in those models. Since the HIV status of participants might alter the effect of perceived intolerance and stigma experience, interaction terms for exposure variables and HIV status were also explored in all models at the beginning and dropped if the interaction was not statistically significant. Adjusted

prevalence ratios (APRs) and 95% confidence intervals (CIs) were then calculated. All the analyses were based on complete observations, which meant observations with missing values were dropped in analyses. Descriptive analyses and Poisson regression with robust variance were conducted using SAS University Edition version 9.4.

# Result

### *Study population*

A total of 7,700 MSM were included in our final analysis. The median age of the participants was 31 years, and the majority of participants were White, non-Hispanic, had some college or higher education level and had annual income higher than $40,000 (Table 1). For the dating/hookup apps usage, Grindr and Tinder were most commonly used, followed by Scruff and Jack'd. Most participants knew their HIV status and reported that they were HIV negative. Participants with unknown HIV status had lower education level comparing to those with known HIV status. Most participants who reported positive HIV status were Black, non-Hispanic compared to the majority of negative and unknown status participants being White, non-Hispanic.

Table 1. Selected characteristics of 7700 eligible participants of 2019 American Men's Internet Survey

| Characteristic | | All Participants (n = 7700) | HIV status | | |
|---|---|---|---|---|---|
| | | | Positive (n = 762) | Negative (n = 5106) | Unknown (n = 1832) |
| Age, mean (IQR) | | 31 (21-38) | 41.5 (30-53) | 32.3 (22-39) | 24.5 (18-25) |
| Race and ethnicity | | | | | |
| | Black, non-Hispanic | 1287 (16.7) | 377 (49.5) | 748 (14.6) | 162 (8.9) |
| | Hispanic | 1180 (15.3) | 70 (9.2) | 790 (15.5) | 320 (17.5) |
| | White, non-Hispanic | 4432 (57.6) | 253 (33.2) | 3040 (59.5) | 1139 (62.4) |
| | Other or multiple races | 652 (8.5) | 46 (6.0) | 438 (8.6) | 168 (9.2) |
| | Unknown | 149 (1.9) | 16 (2.1) | 97 (1.9) | 36 (2.0) |
| Highest grade completed | | | | | |
| | High school diploma or less | 1579 (20.5) | 84 (11.0) | 728 (14.3) | 767 (41.9) |
| | Some college, Associate's Degree, or Technical Degree | 2749 (35.7) | 290 (38.1) | 1811 (35.5) | 648 (35.4) |
| | >=College | 3338 (43.3) | 388 (50.9) | 2550 (50.0) | 400 (21.8) |
| | Unknown | 34 (0.4) | 0 (0) | 17 (0.3) | 17 (0.93) |
| Residential area | | | | | |
| | Large central metro | 2926 (38.0) | 402 (52.8) | 2032 (39.8) | 492 (26.9) |
| | Large fringe metro | 1700 (22.1) | 177 (23.2) | 1104 (21.6) | 419 (22.9) |
| | Medium metro | 1645 (21.4) | 117 (15.4) | 1073 (21.0) | 455 (24.8) |
| | Small metro | 697 (9.1) | 29 (3.8) | 461 (9.0) | 207 (11.3) |
| | Micropolitan | 494 (6.4) | 23 (3.0) | 300 (5.9) | 171 (9.3) |
| | Non-core | 229 (3.0) | 14 (1.8) | 129 (2.5) | 86 (4.7) |
| | Unknown | 9 (0.1) | 0 (0) | 7 (0.1) | 2 (0.1) |
| Annual income | | | | | |
| | $0 to $19,999 | 1151 (15.0) | 90 (11.8) | 717 (14.0) | 344 (18.8) |
| | $20,000 to $39,999 | 1540 (20.0) | 180 (23.6) | 1032 (20.2) | 328 (17.9) |
| | $40,000 to $74,999 | 2001 (26.0) | 225 (29.5) | 1428 (28.0) | 348 (19.0) |
| | $75,000 or more | 2245 (29.2) | 233 (30.6) | 1564 (30.6) | 448 (24.5) |
| | Unknown | 763 (9.9) | 34 (4.5) | 365 (7.2) | 364 (19.9) |
| App used | | | | | |
| | Grindr | 6677 (86.7) | 587 (77.0) | 4507 (88.3) | 1583 (86.4) |
| | Scruff | 2502 (32.5) | 217 (28.5) | 1894 (37.1) | 391 (21.3) |
| | Tinder | 3995 (51.9) | 195 (25.6) | 2665 (52.2) | 1135 (62.0) |
| | Jack'd | 2353 (30.6) | 555 (72.8) | 1506 (29.5) | 292 (15.94) |
| | Adam 4 Adam/RADAR | 1691 (22.0) | 422 (55.4) | 1068 (20.9) | 201 (11.0) |

### *Awareness and usage of safer sex functions in dating apps*

Overall, 82.6% of the participants reported awareness of at least one safer sex function offered by dating apps, while 41.7% of participants reported using at least one of those functions. Among the four functions, HIV status profile options had the highest awareness and usage among participants.

Table 2. Overall awareness and usage of safer sex functions in dating apps by HIV status, 2019 American Men's Internet Survey.

| Safer sex functions | Participants (n=7700) | HIV status | | |
|---|---|---|---|---|
| | | Positive (n = 762) | Negative (n = 5106) | Unknown (n = 1832) |
| Awareness | 6358 (82.6) | 660 (86.6) | 4322 (84.5) | 1376 (75.4) |
| Sexual health testing reminders | 4123 (53.6) | 411 (54.5) | 2925 (57.8) | 787 (43.9) |
| Sexual health strategy profile options | 2807 (36.5) | 277 (36.7) | 1901 (37.6) | 629 (35.1) |
| HIV status profile options | 5818 (75.6) | 589 (78.1) | 3980 (78.7) | 1249 (69.6) |
| Sexual health information and resources | 3934 (51.1) | 438 (58.1) | 2655 (52.5) | 841 (46.9) |
| Usage | 3601 (41.7) | 361 (47.4) | 2606 (51.0) | 634 (34.7) |
| Sexual health testing reminders | 996 (12.9) | 90 (22.0) | 785 (27.1) | 121 (15.6) |
| Sexual health strategy profile options | 994 (12.9) | 94 (34.1) | 731 (38.9) | 169 (27.1) |
| HIV status profile options | 3065 (39.8) | 294 (50.5) | 2278 (57.7) | 493 (39.9) |
| Sexual health information and resources | 1007 (13.1) | 122 (28.0) | 679 (25.8) | 206 (24.8) |

### *Perceived community intolerance and safer sex function awareness/usage*

Average perceived intolerance score was 2.44 (SD: 1.05) among MSM in the study, and the score did not vary dramatically across MSM with different HIV status. Increasing perceived intolerance was associated with less awareness of sexual health strategy profile options (APR: 0.95, 95% CI: 0.93~0.98) and sexual health information and resources (Table 3; APR: 0.97, 95% CI: 0.94~0.99).

We observed significant interactions between HIV status and perceived intolerance with two of the outcomes. Increasing perceived intolerance was associated with less awareness of HIV status profile options in those with unknown HIV status (APR: 0.96, 95% CI: 0.93~0.99), but no significant association was observed in those with positive or negative HIV status. Increasing perceived intolerance was also associated with more usage of sexual health information and resources functions among participants with positive HIV status (APR: 1.18, 95% CI: 1.03~1.34) and negative HIV status (APR: 1.08, 95% CI: 1.01~1.15), but no significant association was found among those with unknown HIV status.

Table 3. Associations between perceived intolerance and awareness/usage of safer sex functions, 2019 American Men's Internet Survey.

| Outcome category | HIV status | Intolerance Scale, mean (SD) | Adjusted Prevalence Ratio (95% Confidence Interval) | | | |
|---|---|---|---|---|---|---|
| | | | Sexual health testing reminders | Sexual health strategy profile options | HIV status profile options | Sexual health information and resources |
| Awareness | | | | | | |
| | All participants | 2.44 (1.05) | 0.98 (0.96,1.00) | 0.95 (0.93,0.98) | | 0.97 (0.94,0.99) |
| | Positive | 2.38 (1.02) | | | 1.02 (0.98,1.06) | |
| | Negative | 2.41 (1.04) | | | 1.00 (0.99,1.02) | |
| | Unknown | 2.63 (1.11) | | | 0.96 (0.93,0.99) | |
| Usage | | | | | | |
| | All participants | | 1.00 (0.95,1.06) | 0.97 (0.92,1.02) | 0.99 (0.96,1.01) | |
| | Positive | | | | | 1.18 (1.03,1.34) |
| | Negative | | | | | 1.08 (1.01,1.15) |
| | Unknown | | | | | 0.95 (0.84,1.07) |

***Recent stigma experience and safer sex function awareness/usage***

Proportions of participants with stigma from family and friends and with general social stigma in recent 6 months were both around 30%, while that for anticipated health-care stigma was around 15% (Table 4). Participants with unknown HIV status had the highest proportion that reported recent experience with all 3 kinds of stigma, followed by those with negative HIV status, and those with positive HIV status had smallest proportion. After adjusting for covariates, recent experience with stigma from family and friends was associated with reduced awareness of sexual health testing reminders (APR: 0.95, 95% CI: 0.91~1.00) but was associated with increased usage of sexual health reminders (APR: 1.14, 95% CI: 1.02~1.28) and sexual health information and resources (APR: 1.16, 95% CI: 1.04, 1.31). The stigma experience was also associated with decreased usage of sexual health profile strategy options (APR: 0.50, 95% CI: 0.29, 0.85) only in HIV positive participants. Recent experience with anticipated health-care stigma was associated with decreasing awareness of both HIV status profile options (APR: 0.96, 95% CI: 0.92~0.99) and sexual health information and resources (APR: 0.91, 95% CI: 0.85~0.97) but no significant association with usage of safer sex functions was found. Recent experience with general social stigma was not significantly associated with both awareness and usage of safer sex functions.

Table 4. Association between recent stigma experience and awareness/usage of safer sex functions, 2019 American Men's Internet Survey.

| Outcome category | Stigma Group | HIV status | Recent experience of stigma, n (%) | Adjusted Prevalence Ratio (95% Confidence Interval) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Sexual health testing reminders | Sexual health strategy profile options | HIV status profile options | Sexual health information and resources |
| Awareness | | | | | | | |
| | Stigma from family and friends | All participants | 2406 (31.6) | 0.95 (0.91,1.00) | 0.99 (0.93,1.06) | 0.98 (0.95,1.00) | 0.96 (0.92,1.01) |
| | Anticipated health-care stigma | All participants | 1185 (15.4) | 0.99 (0.93,1.05) | 0.99 (0.91,1.08) | 0.96 (0.92,0.99) | 0.91 (0.85,0.97) |
| | General social stigma | All participants | 2598 (33.8) | 0.96 (0.91,1.00) | 0.98 (0.92,1.05) | 0.99 (0.97,1.02) | 0.97 (0.92,1.01) |
| Usage | | | | | | | |
| | Stigma from family and friends | All participants | | 1.14 (1.02,1.28) | | 0.99 (0.94,1.04) | 1.16 (1.04,1.31) |
| | | Positive | | | 0.50 (0.29,0.85) | | |
| | | Negative | | | 1.04 (0.92,1.17) | | |
| | | Unknown | | | 0.94 (0.72,1.24) | | |
| | Anticipated health-care stigma | All participants | | 1.06 (0.91,1.23) | 0.90 (0.78,1.05) | 1.02 (0.95,1.10) | 1.09 (0.94,1.27) |
| | General social stigma | All participants | | 1.05 (0.93,1.18) | 1.03 (0.93,1.15) | 0.99 (0.94,1.04) | 1.12 (0.99,1.25) |

## Discussion

In the present study, we explored the awareness and usage of safer sex functions among MSM and found that although majority (81%) of the participants reported awareness of safer sex functions, less than half of the participants reported usage of at least one of such functions. We also revealed that perceived intolerance of gay/bisexual people and recent stigma experience were associated with the awareness and usage of safer sex functions integrated in dating apps among MSM, and in some situations, such associations were modified by MSM's HIV status.

The usage of sexual health testing reminders, sexual health strategy profile options and sexual health information and resources were all reported in only around 13% of the participants, respectively. While previous studies showed that sexual health promotion was possibly feasible through online dating or social apps, and respondents showed willingness to participate such prevention program [22, 23], our results showed that additional efforts were needed to increase the usage of safer sex functions for dating app users. Among the four safer sex functions, HIV status profile options had highest awareness and usage in the participants. This finding was in agreement of the results from previous research that HIV serosorting, or the selection of a sex partner based on matching HIV status, was a common practice among MSM in order to reduce the risk of HIV transmission [24, 25]. While serosorting could reduce the risk of HIV infection compared to no condom use, it was less effective than consistent condom use [26], and

needs to be combined with other preventive measures in order to sufficiently reduce HIV transmission. Thus, the remaining three sexual health functions, which were related to other sexual health resources, need to be emphasized to cultivate comprehensive sexual health behaviors among MSM. Overall, there is still great potential of improving the awareness and especially the usage of safer sex functions in dating apps among MSM, given that MSM were willing to search sexual health information online [27].

Perceived community intolerance of gay and sexual people was associated with decreasing awareness of sexual health strategy profile options and sexual health information and resources. This could result from the fear of discrimination, which was a one of the major barriers in seeking sexual health services among MSM [28]. Our finding indicated that building MSM-friendly social environment might help the promotion of safer sex functions through dating apps. Increasing perceived intolerance was also associated with less awareness of HIV status profile options function only among participants with unknown HIV status. We hypothesize that those with unknown HIV status might not be interested in safer sex functions related to disclosure of HIV status, and the intolerant social environment would further prevent them from using such functions. We also observed the association between perceived intolerance and increasing usage of sexual health information and resources function only in participants with known HIV status, and the relationship was stronger among HIV positive participants. HIV positive MSM could receive more discrimination and choose

to keep their situation in secret [29]. While they were exposed to gay-intolerant environment, they were more likely to avoid in-person ways which could lead to discrimination experience and leaking their HIV status and use online resources such as the safer sex functions in dating apps to obtain sexual health information.

Recent stigma from family and friends was associated with less awareness of sexual health testing reminders but more usage of that function and sexual health information and resources. Such association was consistent with our findings in perceived intolerance and might share similar explanation that MSM favored online safer sex functions to avoid in-person resources that might lead to further stigma or discrimination experiences from family or friends. Recent stigma from family and friends was also significantly associated with reduced usage of sexual health strategy profile function only among those reported positive HIV status. HIV positive MSM could experience intersectional stigmas with regard to their sexual minority identity and HIV status, which was found to be associated with higher depression and anxiety level [30], and might explain the reduced usage of sexual health strategy profile function in our finding. Recent anticipated health-care stigma was associated with less awareness of HIV status profile options and sexual health information and resources. Such association was in agreement of findings in previous studies that having health-care related stigma reduced engagement with health-care services [13]. However, the anticipated health-care stigma was not significantly associated with usage of safer sex functions, which suggested that safer sex functions in dating apps could be a

supplement way to access sexual health services for MSM with anticipated health-care stigma who become reluctant to seek care in person [14]. No significant association was observed between general social stigma and awareness and usage of all safer sex functions, which might result from the heterogeneity of stigma items in this category. The utility of the general social stigma that came from different aspect of life might not be specific enough to evaluate its impact on awareness and usage of safer sex functions.

Overall, there was similarity in our findings that both perceived intolerance and recent stigma experience were associated with reduced awareness but increasing usage in some of the safer sex functions. We thought that they might have common underlying structure that both perception of intolerance and stigma experiences prevent MSM from seeking new ways to access sexual health services. However, if MSM were aware of safer sex functions in dating apps, they might favor the online safer sex functions since such functions provided virtual platform with less chance to get stigmatized. Meanwhile, MSM's community perception of intolerance could be informed by their recent stigma experience. MSM with recent stigma experience were likely to have the perception that their communities were intolerant of gay/bisexual population, and we also observed that crude positive association between perceived intolerance and recent stigma experience in our survey data (data not shown). On the other hand, while perceived intolerance was the general perception of participant's surrounding social environment, the stigma experience was assessed more accurately with 15 questions asking participant's real-life experience and was not limited to their residence area.

Such difference might explain the different results we observed between them. The stigma experience from different sources also had very different association with awareness and usage of safer sex functions. The heterogeneity of stigma experience could be important in understanding its effect on acceptance of this type of sexual health intervention among MSM.

Our study has several limitations. First, results may not be generalizable to US MSM. AMIS participants were recruited through internet with convenience sampling. Black, non-Hispanic MSM and those with lower education were also under-represented compared to the US population and those at excessive risk of HIV infection. For example, 16.7% of our analytic sample are Black/African American, while Black/African American MSM accounted for nearly 40% of the newly diagnosed HIV cases in 2018 [1]. Second, data in this study were collected through self-report and subject to information bias. For example, participants with positive HIV status might choose 'I prefer not to answer' in the HIV status question and be classified into group with unknown HIV status. Finally, there were no explanations or illustrations in the questionnaire about the app features, so that participants might not understand the terminology in the questions and gave answers different from real situations.

## Conclusion

More effort should be made to increase the awareness and encourage the usage of

safer sex functions integrated in dating apps among MSM. Continuing to build app environments that directly address discrimination and stigmatization could help increase the awareness of safer sex functions in dating apps. For MSM living in gay-intolerance environment or experiencing discrimination and stigma, safer sex functions in dating apps are favored and could serve as an additional way to access sexual health information and services. With the increasing awareness and usage of safer sex functions in dating apps, MSM could develop better sexual health behaviors, have reduced risk in getting HIV/STI and improved HIV/STI testing.

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