

Evidence and implication of interventions across various socioecological levels to address HIV testing uptake among men who have sex with men in the United States: A systematic review

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journals.sagepub.com/home/smoYing Wang¹, Jason Mitchell² and Yu Liu¹ 

Abstract

Objectives: Strengthening HIV testing uptake is critical to curtail the HIV epidemics among men who have sex with men in the United States. Despite the implementation of various interventions to promote HIV testing among men who have sex with men, few aggregated evidence is presented to reflect the “lessons learned” and inform future directions. The objective of this systematic review is to comprehensively summarize published studies that described, tested, and evaluated outcomes (e.g. efficacy, effectiveness, acceptability, feasibility and/or qualitative opinions) associated with an HIV testing intervention and identify gaps as well as opportunities to inform the design and implementation of future interventions to enhance HIV testing uptake among men who have sex with men in the United States.

Methods: We followed the PRISMA guidelines and conducted a systematic review of articles (published by 23 July 2021) by searching multiple databases (PubMed, MEDLINE, Web of Science and PsycINFO).

Results: Among the total number of 3505 articles found through multiple databases, 56 papers were included into the review. Interventional modules that demonstrated acceptability, feasibility and efficacy to improve HIV testing uptake among men who have sex with men include: HIV self-testing, interpersonal-level (e.g. peer-led, couple-based) interventions, personalized interventions and technology-based interventions (e.g. mHealth). Aggregated evidence also reflects the lack of individualized interventions that simultaneously address time-varying needs across multiple socioecological levels (e.g. individual, interpersonal, community, structural and societal).

Conclusion: Development of interventions to improve HIV testing rates and frequency of men who have sex with men has proliferated in recent years. Our review presents important implications in sustaining and improving interventions to address HIV testing uptake among men who have sex with men in the United States.

Keywords

HIV testing, AIDS, intervention, men who have sex with men, systematic review, United States

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Introduction

Men who have sex with men (MSM) bear a disproportionate burden of HIV in the United States, accounting for 69% of the 36,000 new HIV diagnoses and almost 90% of diagnoses among males in 2019.¹ Compared to their White counterparts, Black and Hispanic/Latino MSM continue to be disproportionately affected by HIV.^{1–4} The challenges of HIV prevention in MSM are further compounded by their low self-perceived risk for HIV infection, suboptimal pre-exposure prophylaxis (PrEP) use and HIV testing uptake,

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condomless sex, multiple sex partners and social stigma about HIV and/or their sexual orientation and identity.⁵⁻⁹

HIV testing is the entry point into the HIV care cascade. HIV testing is also a requirement and core component for PrEP (initiation, continuation), and test-and-treat. The expansion of HIV testing and early initiation of these biomedical HIV prevention strategies is critical to curtail the epidemic among HIV-affected populations.¹⁰ In addition, awareness of HIV status was reported to be significantly associated with greater condom use, through which onward transmission of HIV could be prevented.^{11,12} In addition to conventional facility-based HIV testing, different testing modalities including rapid home self-testing (an oral fluid test with rapid provision of testing results), mail-in self-test (dried blood self-collection from a fingerstick for laboratory testing) and couples HIV testing and counseling (CHTC, a couple-based HIV testing service called Testing Together) have been designed and implemented for MSM in the United States to facilitate testing uptake among this subgroup.

Despite the proven HIV prevention benefits and increase in accessibility, HIV testing uptake remains suboptimal among MSM in general. A meta-analysis conducted among Internet-using MSM suggested that only 58% had tested for HIV in the prior year.¹³ The prevalence of HIV testing among same-sex male couples was even lower, where no more than 30% of them had gotten tested for HIV every 6 months.¹⁴ Low HIV testing rates among MSM in the United States could be attributed to a variety of factors at multiple levels, including individual (e.g. lack of knowledge on testing locations, fear of a positive result and worries about confidentiality), interpersonal (e.g. lack of support), institutional/policy (e.g. lack of financial support for HIV testing programs) and social-cultural (e.g. stigma and discrimination) levels.¹⁵⁻¹⁹

The number of behavioral and structural interventions aimed at improving MSM's engagement in HIV testing has increased since 2005. One of the early randomized controlled trials (RCTs) was "Many Men, Many Voices" with Black MSM residing in New York City.²⁰ This intervention aimed to improve their knowledge of and attitudes toward HIV and address structural barriers to testing such as racism and homophobia. Participants were observed to have greater odds of HIV testing compared to the waitlist comparison condition (odds ratio (OR)=1.81, 95% confidence interval (95% CI): 1.08-3.01).²⁰ The limitations of the study included the cost associated with organizing an intervention retreat and diminished retention rate across study periods.

More novel psychobehavioral interventions (e.g. couple-based, social media, behavioral economics, peer-driven) had also been designed and implemented targeting MSM to enhance their HIV testing uptake. While these interventions were successful to promote HIV testing among MSM in a defined period of time, they also have had various levels of limitations in generalizability and sustainability post the intervention period.²⁰⁻²⁶

Despite an increasing body of literature in designing and evaluating interventions to promote HIV testing,²⁷⁻²⁹ few in-depth, systematic summary of the contents, opportunities, strengths and limitations of these interventions is presented for MSM in the United States. The aggregated evidence from existing interventions with a goal to increase HIV testing uptake among MSM may provide prevention scientists with important information regarding which intervention components, modalities and frameworks may work best for various subgroups of MSM; equally important, what interventional aspects may need to be further strengthened to better enhance HIV testing for MSM in the United States. To this end, the objective of this systematic review is to comprehensively summarize published studies that described, tested, and evaluated outcomes (e.g. efficacy, effectiveness, acceptability, willingness, feasibility, barrier/facilitator, and/or qualitative opinions) associated with an HIV testing intervention, and identify gaps as well as opportunities to inform the design and implementation of future interventions to enhance HIV testing uptake among MSM in the United States.

Methods

Literature search strategy

This systematic review was conducted by searching published articles via multiple databases (PubMed, MEDLINE, Web of Science and PsycINFO) published by 23 July 2021, following the PRISMA guidelines (see supplemental material—PRISMA Checklist).³⁰ The final search terms included: ("gay" OR "men who have sex with men" OR "bisexual" OR "homosexual" OR "homosexuality" OR "same-gender-loving" OR "sexual minority") AND ("HIV" OR "human immunodeficiency virus") AND ("testing" OR "test" OR "diagnosis" OR "screening") AND ("intervention" OR "trial" OR "experiment" OR "randomized" OR "pre-post"). We also conducted cross-referencing by reviewing the reference list of the included studies to identify potential papers for consideration.

Inclusion/exclusion criteria

Generally, studies were included in the systematic review if they met the following criteria: (1) published journal articles excluding abstracts or conference proceedings; (2) conducted in the United States; (3) this study and/or the parent trial was based on an experimental or quasi-experimental design (e.g. RCT, one-group pre-post) to test an HIV testing intervention; (4) reported HIV testing-related outcomes (e.g. efficacy, effectiveness, acceptance, intention and willingness) with relevant determinants (e.g. any demographic, behavioral and psychosocial factors); (5) conducted among participants identified as gay, bisexual and other MSM in the original studies; and (6) published in English.

To achieve our goal of comprehensively summarizing the content, scope and factors affecting the implementation of HIV testing interventions for MSM, we also included the following studies for potential evaluation: (1) studies conducted among mixed population groups (e.g. MSM and other sex and gender minorities) if data were reported separately for MSM; (2) studies that used an experimental design to evaluate secondary outcomes (e.g. acceptability, feasibility or cost-effectiveness) with or without reporting efficacy/effectiveness; (3) studies using non-experimental design (e.g. qualitative or cross-sectional study) to assess aforementioned secondary outcomes of an HIV testing intervention if details about the intervention design could be retrieved from their published parent trials by checking the reference lists; (4) we also included protocols that elaborated the design and conceptual frameworks to supplement our summary of the original HIV testing interventions. Any existing reviews, meta-analyses or articles that commented on an existing HIV testing intervention were not included in the current review. We also excluded studies that described the development or adaptation of eligible interventions.

Statistical analysis

All articles identified through database search were stored and managed using a reference management tool (EndNote X9). Titles and abstracts of all identified records were first screened for relevancy and duplicate removal by two independent reviewers (Y.W. and Y.L.). The full-text review and data extraction were then conducted independently by one author (Y.W.) and further cross-checked by the other author (Y.L.) for accuracy. Disagreements were iteratively discussed until agreement was reached. A standardized Excel sheet was used to extract the following information from eligible articles: study location, study/recruitment period, study design, recruitment strategy, participant characteristics, intervention content, theoretical/conceptual framework, barriers to HIV testing addressed by the intervention, control, sample size and retention, HIV testing-related outcome measures and findings (e.g. acceptability, feasibility, cost-effectiveness and efficacy).

Methodological quality assessment

The quality of each study was assessed independently by one author (Y.W.), following the guidance for study assessment.³¹ The other author (Y.L.) further cross-checked the appraisal for accuracy. Conflicts in appraisal were resolved through iterative discussion until agreement was reached. The methodological quality of included studies with a control group was evaluated using National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool of controlled intervention studies.^{31,32} This assessment tool was comprised of 14 questions, which evaluated selection bias (random sequence generation and allocation concealment),

performance bias (blinding of participants and intervention providers), detection bias (blinding of outcome assessors), attrition bias (drop-out), information bias (measurement of outcomes) and other sources of bias. We rated yes, no, cannot determine, not reported or not applicable for each criterion. For example, if authors reported method of randomization, but we were unable to determine whether the randomization was adequate and would respond “cannot determine” to this criterion. If authors did not mention the method of randomization, we scored “not reported” for this criterion. The remaining pretest–posttest studies were similarly assessed using NHLBI quality assessment tool for before–after (pre–post) studies with no control group. Two assessment tools have been described in detail elsewhere.³¹

Results

Search results

A total number of 3505 articles were found through multiple databases. Of 73 full-text papers assessed for eligibility, 56 papers representing 42 interventions were included into the final review. Thirty-seven papers evaluated the acceptability, feasibility, efficacy or cost-effectiveness of interventions aimed at improving MSM’s uptake of HIV testing. Seventeen articles described the protocols for the implementation of interventions. Study selection process was reported in Figure 1.

Study characteristics

Table 1 presented the characteristics of 42 interventions identified from 56 included publications. Reported study locations/settings in the United States included Oregon,³³ New York,^{20–22,44,55,68–70,73} California,^{25,34,36,45,46,50,54,55,60–63,74,75} Michigan,^{35,38,54,65,73} North Carolina,^{24,49,80} Washington,^{39,59} Georgia,^{25,41,53–55,73} Illinois,^{25,47,54} Pennsylvania,⁵³ Texas,^{53,55} Tennessee,⁵⁴ Louisiana,^{23,54} Maryland,⁵⁵ Massachusetts,^{68–70} Nevada,²³ Florida,²³ Minnesota²³ and D.C.^{54,55} Nine studies were conducted nationally.^{26,43,51,52,57,58,64,71,76,78,79} Most studies were implemented after 2000.^{20–26,34–37,39–79,81}

Nine RCTs are still ongoing.^{43,53,54,65,71,74,78,79,81} Thirty-one interventions were evaluated by RCTs.^{20,21,23,26,35,36,38,42–44,49–51,53,54,57,59,64,65,67,68,71–76,78–81} Eleven studies were evaluated by using a quasi-experimental design,^{24,25,33,34,39,41,45,47,55,60,61} 5 of the 11 used a pretest–posttest design.^{24,25,41,47,55}

Regarding recruitment, offline/in-person approaches ranged from outreach (e.g. at local venues, communities, LGBT health care organizations and sexual health clinics), advertisements placed in communities, venues, and print media frequented or used by MSM, to referrals from other participants, friends of participants, and clinicians.^{20,21,25,34,36,38,44,45,47,49,50,57,59,61,65,66,68,72–75,78,81} Peer recruitment within their social networks or venues-based peer outreach were also reported.^{35,60,80} Online recruitment included advertisements placed on gay-oriented

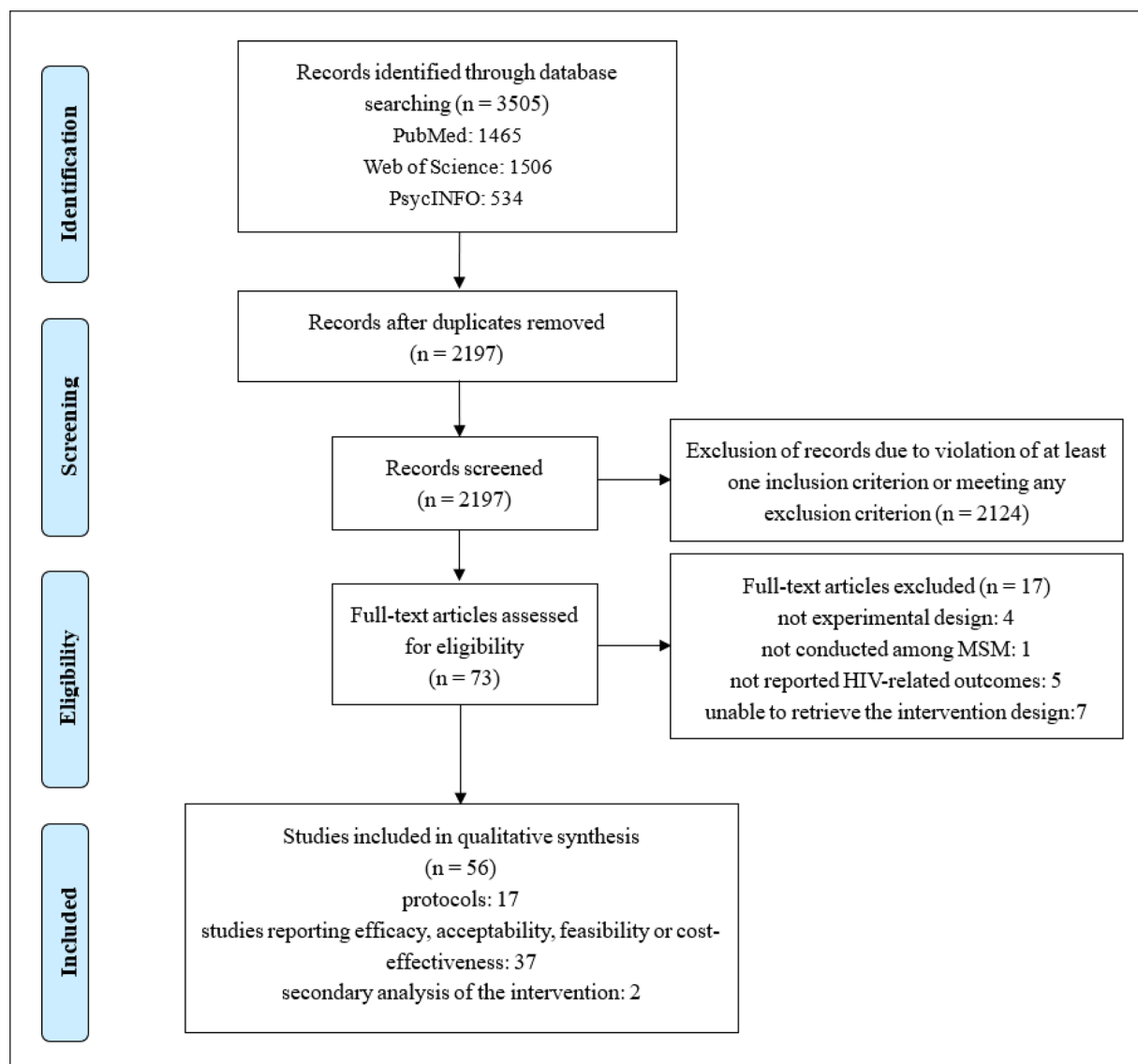


Figure 1. Flowchart of study selection and inclusion procedure.

sexual networking websites, social media sites and social magazines.^{21,23,26,36,38,41,43,44,45,47,49–51,53,54,57,59,64–66,68,71–73,75,76,78,79,81} Participants were MSM only,^{20,23,24,26,35,36,38,39,43,45,47,49–51,53–55,57,59,60,64,66,68,71–73,75,76,78,79,81} or a mixture of MSM with other populations (e.g. heterosexual IV drug users, women or transgender people).^{21,25,33,34,41,42,44,61,65,74,80} Of note, some studies targeted Black,^{20,25,35,44,50,55,60,75,78} Latino^{25,34,49,60,61,78,80} and young MSM.^{25,35,38,43,45,51,53,54,57,64,65,68,71,72,78,79}

Methodological quality assessment

Methodological quality assessment for studies with and without a control group was summarized in Tables 2 and 3, respectively. Of 37 controlled intervention studies, one study received a score of 11 and were considered good

quality, and 24 received a score of 5 to 10 and were considered fair quality. Twelve studies received a score of <5 due to the non-randomized design or lack of evaluation data (i.e. protocols). Five pretest–posttest studies had a mean score of 5.8 (standard deviation = 1.30). All five studies had clear objectives, well-defined interventions that were consistently applied to the participants, and appropriate statistical analyses.

Measurement of outcome

Knowledge of HIV testing⁷² and testing locations³⁴ as outcome measures were reported. Attitudes toward HIV testing were measured by motivation to receive testing on a 5-point Likert-type scale⁴⁷ or willingness to refer other MSM to get

Table 1. Summary of study characteristics.

Source ^a	Locations/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and (intervention vs. control)	Outcome measures	Finding (acceptability, feasibility, efficacy or cost-effectiveness)
Felms et al. ¹³	Oregon	August 1986–March 1987	Quasi-experimental	Not reported	A mix of MSM and heterosexual iv drug users and female prostitutes Male: 63.5% White: 96.2% Black MSM Age (mean ± SD): 29.6 ± 9.3	Anonymous HIV testing. In December 1986, Oregon began offering anonymous as well as confidential HIV counseling and testing. Clients who chose anonymous testing were identified by number only. "Many Men, Many Voices" (3MV): Participants were given dates for the weekend intervention retreats they would attend at facilities in upstate New York. The six sessions were (1) the culture of Black MSM; (2) STD/HIV prevention for and prevention options; (4) intentions to test as part of change (3) relationship issues; (6) and social support and problem solving to maintain change. "Hombres Unidos" (Healthy Men): a social marketing campaign Campaign elements included Spanish-language print materials, radio ads and sponsorships, free condom distribution, community-based outreach, and promotional activities at local clubs	Social cognitive theory, behavioral skills acquisition model, transtheoretical model of behavior change and decisional balance model	Intrapersonal: worries about confidentiality Interpersonal: lack of HIV knowledge Social-cultural: lack of social support, racism and homophobia	Confidential HIV testing Clients were asked for their name, birthdate, address and telephone number. This information was stored confidentially Waitlist comparison Conditions: individuals were scheduled to receive the 3MV intervention 6 months following completion of their baseline assessment.	Pretest: 363 Posttest: 1250	Demand for HIV testing	Efficacy: The variability of monthly increased demand for testing by 125% for gay men.
Wilson et al. ²⁰	New York, NY	August 2005–November 2006	RCT	Street outreach; displays at New York City Black gay pride festivals; referrals from friends of participants, community-based gatekeepers and People of Color in, Crise clients; distribution of palm cards in venues frequented by Black MSM; and advertisements in gay newspapers or magazines	African American: 67.6% Caribbean/West Indian: 16.7% Afro-Latino: 11.3% Self-identified gay or bisexual: 81.1% Bisexual: 18.3%					Baseline: 164 vs. 174 Month 3: 120 (73.2%) vs. 125 (71.8%) Month 6: 127 (77.4%) vs. 133 (76.4%)	Participants were asked if they had been tested for HIV, and if tested, if they had received their test results at the 3- and 6-month follow-ups	Efficacy: Month 3: no significant intervention effects on self-reported HIV testing Month 6: OR = 1.81, 95% CI: -3.01, p=0.02
Martinez-Donate et al. ¹⁴	Northern San Diego County, CA	June–December 2006	Quasi-experimental	Seven low-risk venues (6 workshops, a migrant camp, a labor pickup site, two shopping centers, a center for the teaching of English as a second language, and a men's shelter) and five high-risk venues (an adult bookstore and four bars or clubs)	Latino MSM (95.2%) and MSMW (48%) Age for MSMW (mean ± SD): 30.6 ± 9.2		Sociological framework and principles of social marketing	Intrapersonal: lack of HIV knowledge Social-cultural: stigma and social norm	HIV testing behavior before the campaign	Baseline: 626 During campaign: 752 Post-campaign: 385	(1) Previous 6 months HIV testing (2) Knowledge of HIV testing locations	Efficacy for MSMW: (1) Previous 6 months HIV testing: decreased from baseline to campaign (OR = 0.18, 95% CI: 0.04–0.85). (2) Knowledge of HIV testing locations: increased from baseline to post-campaign phase (OR = 2.35, 95% CI: 0.45–12.25)
Outlaw et al. ¹⁹	Detroit, MI	2006–2008	RCT	Peer outreach at community venues providing services and programs for young African American MSM and young people in general.	African American MSM Age (mean ± SD): 19.79 ± 2.2	A peer-based intervention: The session conducted by a peer outreach worker in an outreach venue focused on expressing empathy, exploring ambivalence, and building motivation for change via a motivational interviewing style of communication.	Motivational interviewing principles	Intrapersonal: lack of motivation	Traditional field outreach: focused on provision of education ("HIV 101") in a standard way to all participants	Baseline: 96 vs. 92 Analyzed: 96 vs. 92	The percentages of participants agreeing to (1) traditional HIV counseling and testing (an oral swab if the client is not ready for test results)	Efficacy: (1) HIV counseling and testing: 49% vs. 20% (z ² = 17.94, p < .01) (2) Returned for test results: 98% vs. 72% (z ² = 10.22; p < .01)
Rhodes et al. ²⁴	An online chat room providing social and sexual networking for MSM in northwestern North Carolina	February–July 2009	Pretest-posttest	Recruitment at the chat room.	MSM only Age (mean ± SD): 37.1 ± 10.9 White, European: 71.3% Gay: 58.0% Bisexual: 17.8%	"CyberEating": a chat room-based intervention A well-trained interventionist posted various standardized triggers about HIV testing and his availability to provide information and answer questions about testing within the public chat room. Website-based interventions: (1) Videos The Morning After (a 9-minute dramatic video addressing sexual risk reduction and features 3 gay male friends) and Talking About HIV (a 5-minute documentary video addressing sexual risk reduction through the use of peer support) (2) CDC webpage featuring information about HIV among MSM, with links to prevention information and resources.	Social cognitive theory, empowerment education, health behavior theory, and ask-advise-assist model	Pretest: HIV testing behavior in the previous 12 months	Pretest: 346 Posttest: 315	Self-reported HIV testing during the past 12 months	Efficacy: Self-reported HIV testing increased from 44.5% at pretest to 59.4% at posttest (OR = 1.8, 95% CI: 1.4–2.5).	
Hirstfield et al. ²⁶	Nationwide	April–June 2008	RCT	Banner ad placed on gay-oriented sexual networking websites and email invitation sent to website members	MSM only Age 18–29: 27% Age 30–49: 55% Age 50+: 18% White: 81%	Website-based interventions: (1) Videos The Morning After (a 9-minute dramatic video addressing sexual risk reduction and features 3 gay male friends) and Talking About HIV (a 5-minute documentary video addressing sexual risk reduction through the use of peer support) (2) CDC webpage featuring information about HIV among MSM, with links to prevention information and resources.	Social learning theory, situated cognition, and developmental learning theory Social learning theories informed the instructional design of the intervention along three dimensions: (1) the medium selected (i.e., video); (2) the degree of realism in the content; and (3) the finer-grained structure of the content, such as conflict between the characters to promote critical thinking.	Non-content control: Participants were only provided with links to HIV prevention resources following completion of the behavioral survey.	Video vs. webpage vs. control Baseline: 1874 vs. 609 vs. 609 Analyzed for follow-up: 846 vs. 260 vs. 285	Receiving an HIV test during the 60-day follow-up period No changes were seen in any of the conditions.	Efficacy (Video vs. webpage vs. control): HIV testing at 60-day follow-up: 21% vs. 30% vs. 20% No changes were seen in any of the conditions.	
Acceptability, feasibility and efficacy Young et al. ¹⁶ Secondary analysis Young et al. ¹⁷	Los Angeles, CA	September 2010–January 2011	RCT	Banner and social media site advertisements; community organizations and clinics serving African American and Latino MSM; and participant referrals	MSM only Age (mean ± SD): 31.5 ± 10.4 African American: 27.7% Latino: 59.8% Gay: 75.9% Bisexual: 18.8%	"Harnessing Online Peer Education" (HOPE): a social media- and peer-based intervention Peer leaders instructed to deliver information about HIV prevention and testing to participants via Facebook over 12 weeks (messages, chats, and wall posts). Participants could request a free, home-based HIV testing kit.	Not reported.	Intrapersonal: lack of HIV knowledge Interpersonal: lack of peer support	Peer leaders were instructed to communicate with participants about goal-setting such as diet, exercise, and ways to maintain a low-stress lifestyle.	Baseline: 57 vs. 55 Week 12: 52 (91.2%) vs. 53 (96.4%)	(1) Requesting and (2) returning an HIV kit, and (3) following up for test results	Acceptability: High acceptance and engagement across assessment periods Feasibility: High acceptability for home-based HIV testing Efficacy: (1) Requested an HIV testing kit: 43.9% vs. 20.0% (mean difference = 24%, 95% CI: 8–41%) (2) Returned test: 15.8% vs. 3.6% (3) Followed up for test results: 14.0% vs. 0.0% Secondary analysis: a positive trending relationship (p < 0.1) between increase in network ties and likelihood of testing for HIV and follow-up for test results

(Continued)

Table 1. (Continued)

Source ^a	Locations/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Baumeister et al. ¹⁸	Southwest Michigan	Not reported	RCT	In-person recruitment at LGBTQ pride celebrations; distributing palm cards at various bars and clubs that cater to MSM; Facebook ads; and print and online ads in a Michigan-based LGBTQ social magazine	Young MSM Age (mean ± SD): 21 ± 2.3 White: 65.6% Black: 19.5% Latino: 9.4% Gay: 83.8% Bisexual: 14.6%	"Get Connected": a tailored website-based intervention The tailored intervention was developed by customizing content based on MSM's psychosocial data, sociodemographic characteristics, prior testing experiences and motivations, barriers and resources to testing, and important values. Participants received personalized messaging that reflected their lived experiences.	Self-determination theory and integrated behavioral model	Intrapersonal: lack of knowledge on HIV and testing locations; lack of motivation, negative feelings about testing and low income Institutional: no access to transportation social- cultural: lack of social norms and social norms	Non-tailored attention- control condition: Participants only received access to the online provider directory page.	Baseline: 86 vs. 44 Day 30: 104 (80%)	(1) Scheduled a HIV appointment and (2) received HIV testing in the prior 30 days	Acceptability (a 1-7 scale): 6.16 vs. 6.00, Cohen's $d=0.18$ Feasibility: Recruited and retained a diverse sample Efficacy: (1) Made an appointment to get tested for HIV/STIs: 32.4% vs. 27.8% (2) Received HIV/STIs testing: 32.4% vs. 22.2% (Cohen's $d=0.34$)
Efficacy evaluation: Katz et al. ¹⁹ Cost evaluation: Sherman et al. ²⁰	Washington State	January 2010– October 2014	Quasi- experimental	Secondary analysis of STD surveillance/partner services (PS) and HIV/AIDS databases	MSM with STDs (includes Seattle): 68% Urethral chlamydia infection: 35% Urethral gonorrhea: 26%	Integrating HIV testing as an outcome of STD PS Health departments in Washington State modified STD PS programs with the objective of providing PS to all MSM with STDs and ensuring that those without a prior HIV diagnosis tested for HIV infection.	Not reported	Institutional: lack of testing resources	Present: percentage of MSM who received HIV testing	Pre-intervention: 3253 Intervention period: 4880	MSM/STD cases tested for HIV infection at the time of STD diagnosis: tested within 14 days before the STD diagnosis, at the time of STD diagnosis or treatment, or as a result of PS	Efficacy: HIV testing among MSM who received PS increased from 63% to 91% ($p < 0.001$). Cost: Time spent on HIV testing: <5 minutes per interview Total STD PS program cost per HIV test: US \$598–US \$5467
Makour et al. ⁴¹	Atlanta, GA	January– March 2015	Pretest– posttest	Word of mouth, phone call-ins, and Web-based advertisements on dating websites for gay and bisexual men	MSM (95%) and transgender females (5%) Age (mean ± SD): 28.05 Black/non-Hispanic or Latino: 80% Gay/homosexual/same gender-loving: 70% MSM (97.8%) and transgender (2.2%) Age (mean ± SD): 40.9 ± 13.3 White: 72% African American/ Black: 15% Gay: 31% Bisexual: 36%	A video chat- and peer-based intervention: Participants engaged with the peer counselor in pretest HIV counseling, self-administration of the HIV test via video chat, and tailored education plan, substance use, barriers to testing, etc.	Not reported	Intrapersonal: lack of peer support Social-cultural: stigma	Pretest: assessment of barriers to HIV testing	Baseline: 20 Week 6: 18 Month 3: 18	Barriers to HIV testing rated on a Likert-type scale from 1 (strongly disagree) to 6 (strongly agree)	Acceptability: Satisfaction with intervention at the 3 months: 100% Feasibility: HIV testing appointment completion: 87% Efficacy: Integrated educational program on HIV testing at 6 weeks and 3 months
Rhodes et al. ⁴²	Four geographically focused social media sites: Adam4Adam, BlackGayChat, Craiglist, and Gay.com	July 2013– June 2014	RCT	Not reported	MSM (97.8%) and transgender (2.2%) Age (mean ± SD): 40.9 ± 13.3 White: 72% African American/ Black: 15% Gay: 31% Bisexual: 36%	A social media-based intervention: Within social media sites for MSM, the health educator created a public profile and posted triggers on his profile about HIV, the importance of testing; his availability to provide information and answer questions about testing; and local nontraditional HIV testing events.	Empowerment education, social cognitive theory, and natural helping	Intrapersonal: lack of motivation and knowledge of testing locations	Participants received no intervention.	Baseline: 353 vs. 286 Posttest: 339 vs. 314	Past 12-month HIV testing at posttest	Efficacy: Past 12-month HIV testing at posttest: 63.7% vs. 42.0% (OR = 2.9, 95% CI: 1.8–4.7)
Baumeister et al. ¹⁷	Nationwide	Launched in November 2016	RCT	Online ads placed on popular social and sexual networking sites	Young MSM Age (mean ± SD): 21.67 White: 66.7% Black: 10.0% Hispanic/Latino: 30.0%	"myDEX": a tailored web-based intervention Participants receive a 6-session program addressing sociodemographic, personal, and social cognitive barriers to testing desires, etc. This tailored content will match HIV prevention messages and safer sex skills with participants' outcome expectancies when meeting new partners.	Integrated Behavior Model Content will focus on risk reduction, address norms (e.g., stigmatized behaviors), of behaviors in Young MSM's social network, anticipated regret, and perceived behavioral control.	Intrapersonal: lack of HIV knowledge and lack of motivation	Participants receive an attention-control condition (includes HIV/STI life messages available on sex education websites)	Baseline: 120 vs. 60 Day 30: 15 (93.4%) Day 60: 150 (93.4%) Day 90: 147 (81.7%)	Get tested for HIV in the prior 30 days.	The trial is ongoing.
Protocol: Koblin et al. ¹⁴ Efficacy evaluation: Frye et al. ²²	New York, NY	June 2016– February 2017	RCT	Online advertising, face-to-face outreach, and participant referrals	Black MSM (81.4%) and transwoman/female (16.5%) Age (mean ± SD): 23 ± 3.3 Gay/same gender loving: 84.4% Bisexual: 21.7	"All About Me": a tailored computer-based intervention Participants answered questions on key information (e.g., demographics, stigma or fear as a reason not to test, and HIV testing self-efficacy). The answers yielded data for an algorithm that matches them to either "About Me" or "About Us" content and "Sick, To Go": a tailored computer-based intervention using notification and reminder technology The intervention included: (1) recruitment, (2) online enrollment, (3) online activities, and (4) "real-world" activities that occurred at the clinic. Participants earned points through the online activities, which were then redeemed for a chance to win prizes during clinic visits.	Social cognitive theory, theory of planned behavior, stigma theory, social identity theory and social norms theory	Intrapersonal: lack of self-efficacy for HIV testing Intrapersonal: lack of peer support Social-cultural: stigma and lack of social support	Standard HIV testing information: Participants received electronic information about each testing method without personalized recommendations.	Baseline: 118 vs. 118 Month 3, both > 90% Month 6, 83% vs. 87%	Self-reported occurrence of HIV testing during 6 months of follow-up	Efficacy: HIV testing at 3 months: 75.9% vs. 70.9% ($p=0.402$) HIV testing at 6 months: 73.1% vs. 71.6% ($p=0.809$)
Protocol: Meija Piller study: McCoy et al. ⁴⁶	Two sexual health clinics in Oakland and Hollywood, CA	October 2016– June 2017	Quasi- experimental	In-person recruitment at study sites by clinic and research staff; ads on social networking sites (e.g., Grindr, Facebook, Instagram, Craiglist); and flyers placed in the community	Young MSM Age (mean): 23 White: 25.3% Asian: 13.9% Latino: 43.4%	Self-determination theory, empowerment theory, economic and behavioral theory about health behaviors	Intrapersonal: lack of motivation	Historical control: a group of similar young MSM who attended study clinics in the 12 months prior to intervention implementation	Baseline: 166 Month 6: 164	The proportion of participants who received ≥ 2 HIV tests over 6 months of follow-up	Acceptability and feasibility: Positive attitudes toward the program in interviews Efficacy: ≥ 2 HIV tests: 48% vs. 30% (OR = 2.15, 95% CI: 1.03–4.47)	

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Table 1. (Continued)

Source ^a	Location/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Pilot trial: Newcomb et al. ⁴⁷ Secondary analysis: Feinstein et al. ¹⁸	Chicago, IL	January–October 2015	Pretest–posttest	Targeted Facebook ads; venue-based recruitment (e.g., local Pride events); and recruitment from HIV testing and primary care programs at a local LGBT health care organization.	Young male couples Age (mean ± SD): 26.4 ± 4.6 White: 51.8%, Black/African American: 11.4%, Hispanic/Latino: 23.7%, Gay: 87.7%	"ZGETHER": a couple-based intervention. Sessions included: (1) healthy relationships, communication skills training, sexual health information and pleasurable activities; (2) cognitive-behavioral and acceptance-based strategies for coping with minority stress and relationship stress; (3) communication skills training; and (4) healthy sexuality for couple and creating a relationship agreement.	(1) Information Motivation Behavior Skills model Information: couples-specific HIV knowledge (e.g., HIV risk in couples); Motivation: attitudes and peer norms about prevention in relationships; Behavioral Skills: risk reduction skills (e.g., condom use, partner communication, decisions about sex and HIV testing). (2) Vulnerability Stress Adaptation model. Constructs: the individual partner's vulnerabilities (e.g., negative affect, substance use); stressors faced outside the relationship (e.g., stigma, prejudice); and deficits in preparing couple processes (e.g., communication skills).	Intrapersonal: lack of HIV knowledge Interpersonal: lack of peer support Social-cultural: minority stress	Pretest: assessment of motivation to receive couple-based HIV testing Intervention: 110 (96.5%) Posttest: 113 (99.1%)	Pretest: 114 Completed intervention: 110 (96.5%) Posttest: 113 (99.1%)	Dyadic motivation to receive couple-based HIV testing measured based on a 5-point Likert-type scale	Acceptability: Mean acceptability ratings across intervention sessions: 4.3–4.7 Feasibility: Recruited a diverse sample and maintained robust intervention engagement Efficacy: Dyadic motivation to receive couple-based HIV testing: 4.77 vs. 4.70, $p=0.335$ Secondary analysis: Higher acceptability ratings were associated with increase in motivation to receive couple-based HIV testing ($p=0.24$, 95% CI: 0.001–0.49)
Rhodes et al. ⁴⁹	Charlotte and Greensboro, NC	December 2012–February 2015	RCT	Posters, flyers, and brochures distributed at gay bars and clubs, community colleges, Hispanic/Latino-owned businesses; community events (e.g., gay pride and Hispanic/Latino cultural events); mass media (i.e., newspaper and radio) and social media; and participant referrals	Hispanic/Latino MSM Age (mean ± SD): 30 ± 8.9 Gay: 63.8%, Bisexual: 22.7%	"HOLA en Grupos": a traditional intervention Hispanic/Latino gay men were trained to deliver intervention in Spanish. Modules included: (1) the impacts of HIV and STI on Hispanic/Latino MSM, and HIV and STI facts; (2) guidance on how to protect oneself and one's partners from HIV and STI; and (3) how Hispanic/Latino cultural values and the local context can affect sexual health.	Social cognitive theory, empowerment education, and traditional Hispanic/Latino cultural values	Intrapersonal: lack of motivation and knowledge on HIV and testing locations	A general health education comparison intervention with the same number of sessions and duration that focused on prostate, lung, and colorectal cancers, etc.	Baseline: 152 vs. 152 Month 6: 152 (100%) vs. 152 (100%)	Self-reported HIV testing during 6 months of follow-up	Efficacy: Relative to comparison participants, HOLA en Grupos participants reported increased HIV testing during the past 6 months (OR = 13.84, 95% CI: 7.54–25.33)
Shelley et al. ³⁵	Atlanta, GA; Chicago, IL; and San Diego, CA	April 2010–January 2012	Pretest–posttest	Social marketing campaigns, outreach conducted at venues, health care providers, etc.	Young MSM of color (79.3%); female (0.2%) Age (mean ± SD): 18–24 years: 80.3%, Hispanic 41.9%, Non-Hispanic Black/African American: 39.6%	"Aproment": a community-level intervention Content included: (1) core group; (2) formal outreach; (3) M-Course; (4) informal outreach (peers supporting each other to get tested); (5) publicity; and (6) the project space.	Not reported.	Intrapersonal: negative peer motivation Social-cultural: lack of social support and social norms	Pre-intervention assessment of HIV testing behavior	Baseline: 298 Month 3: 256 Month 6: 221	The prevalence of self-reported HIV testing in the last 6 months	Efficacy: Month 3: increased from 33.6% at baseline to 65.0% at 6 months (OR = 1.20, 95% CI: 1.06–1.36) Month 6: increased from 53.6% to 70.2% (prevalence ratio = 1.28, 95% CI: 1.11–1.47)
Washington et al. ⁵⁰	Los Angeles County, CA	April–October 2014	RCT	In-person recruitment at community-based organizations serving Black males at high risk and online recruitment via social media (e.g., Facebook, Twitter, Black Gay Chat).	Black MSM Age (mean ± SD): 23.1 ± 3.4	A social media-based intervention: Participants reviewed 5 60-second intervention videos weekly on Facebook. Each video's scene included young BMSM character actors/peers delivering the content: HIV prevention knowledge, risk behaviors and practices, the benefits of HIV testing, etc.	Integrative model of behavior change The elements in this model are considered to be directly influenced by an intervention as follows: (1) "HIV prevention knowledge" (including behavioral beliefs, (2) behavioral beliefs, (3) self-regulation skill and ability, (4) social supports (social network including online peer influences), and (5) engagement in self-management behavior	Intrapersonal: lack of HIV knowledge and motivation	Participants received standard HIV text information weekly. The content focused on HIV prevention knowledge, sexually transmitted infections, etc.	Baseline: 28 vs. 28 Week 6: 20 vs. 22	Self-report of HIV testing at 6 week follow-up	Feasibility: Self-report of HIV testing at 6 weeks (intervention vs. control): OR = 7.00, 95% CI: 1.72–28.33
Efficacy evaluation: Ybarra et al. ⁵¹ Acceptability and feasibility evaluation: Ybarra et al. ⁵²	Nationwide	June 2014–April 2015	RCT	Online advertisements on Facebook	Young gay, bisexual, and queer aged 14 to 18 years old White: 65%, Hispanic: 20%, Sexual experience: 50%	"Guy2Guy": a text messaging-based intervention The main intervention content was delivered over 5 weeks. Content included HIV information, motivation and behavioral goals. The booster, delivered 6 weeks postintervention, reinforced this content.	Information Motivation Behavior Model Content included HIV information: what it is, how to prevent it, motivation: reasons why to get tested, and behavioral skills: correct condom use	Intrapersonal: lack of HIV knowledge and motivation	An attention-matched "healthy lifestyle" control text: messaging program matched on the number of days in the intervention period. Content focused on general health topics (e.g., self-esteem).	Baseline: 150 vs. 152 Day 90: 137 vs. 146	Self-reported HIV testing behavior at these intervals: ever, at baseline, at the start of intervention, at intervention end, and at the end of the program at 90 day follow-up.	Acceptability: 93% participants liked the program. Feasibility: 94% completed the 3-month follow-up survey. Efficacy: Tested for HIV at 90 days: 95% vs. 81%, 18.1% (OR = 2.28, 95% CI: 1.52–3.58) Tested for HIV at 90 days: 55% vs. 28.2% (OR = 3.42, 95% CI: 1.65–7.09)
Bauermeister et al. ⁵³	Philadelphia, PA; Atlanta, GA; and Houston, TX	Launched in September 2016	RCT	Broad range of social media outlets	Young MSM Age (range): 15–24 years	"Get Connected 2.0": a mobile-optimized web app-based intervention Participants will be granted access to a Web app with content tailored to their specific demographic characteristics, HIV and STI risk behaviors, and sociocultural context.	Self-determination theory, Integrated Behavioral Model and motivational interviewing principles	Intrapersonal: lack of HIV knowledge and motivation	Participants will be directed to the AIDSinfo.org testing site locator.	Participants will be followed for 12 months with follow-up assessments conducted at 1, 3, 6, 9 and 12 months.	The proportion of participants tested for HIV 2 or more times at least 3 months apart in the 12-month follow-up period	The trial is ongoing

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Table 1. (Continued)

Source ^a	Location/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Bauermeister et al. ¹⁴	Chicago, IL to Detroit, MI; Washington, DC to Atlanta, GA; San Francisco, CA to San Diego, CA; Memphis, TN to New Orleans, LA	Launched in March 2018	RCT	Targeted banner ads placed on commonly used social media sites and community events (e.g., LGBTQ+ pride events)	Young MSM aged 13 to 18 years old Racially/ethnically diverse	"REACH": a tailored web app and peer-based intervention components included: (1) life skills educational modules tailored to participants' unique needs and characteristics; (2) setting goals and characterizing oneself; (3) assessing relevant social networks; (4) connecting with resources; (5) connecting with resources across the life skills areas; and (6) peer mentors "Testing Makes Us Stronger" (TMUS): a campaign components included: (1) national and local online and magazine ads and transit and billboard ad; (2) a digital media strategy with a dedicated website, and social media outreach; and (3) partnerships and supported local community events (e.g., conferences, meetings, house/club parties)	Not reported.	Intrapersonal: lack of HIV knowledge and motivation Social-cultural: lack of social support	Attention-control arm: Participants will only receive access to the "Locator" component of the intervention (national and local resources (e.g., gay rights agencies, HIV testing locations))	Participants will be followed for 12 months with follow-up assessments conducted at 3, 6, 9 and 12 months.	HIV testing behavior assessed at each 3-month interval	The trial is ongoing.
Boudewyns et al. ¹⁵	Atlanta, GA; Baltimore, MD; Houston, TX; New York, NY; San Francisco, CA; and Washington, DC.	January 2011–December 2014	Pretest-posttest	Secondary analysis of monthly city-level HIV testing event data	Black MSM 18–44 years of age	"MyPEEPs": a mobile app-based intervention acrosses comprised of didactic content, role-play, and multiple-choice quizzes. The intervention is delivered in the period between baseline and the 3-month follow-up visit.	Normative social behavior theory	Social-cultural: lack of social support	Pretest HIV testing events among the priority audience in six TMUS implementation sites	Not reported	HIV testing event an HIV test technology or an HIV test result was reported.	Efficacy: After the introduction of TMUS, the number of HIV testing events among Black MSM in the six implementation sites increased at a rate of 6.22 tests per month (95% CI: 2.3–10.12)
Usability evaluation: Cho et al. ¹⁶ Protocol: Kuhns et al. ¹⁷ Efficacy evaluation: Sohail et al. ¹⁸	Nationwide	Not reported	RCT	Local recruitment (Birmingham, AL; Chicago, IL; New York, City, NY; Seattle, WA); youth- and community-based recruitment events and posted flyers and nationwide recruitment: ads on platforms frequented by adolescents	Racially and ethnically diverse young MSM only Age (range): 13–18	Social/Personal Framework, which builds on Social learning theory and includes: (1) app-based content; (2) role-play; and (3) peer support. The intervention is delivered in the period between baseline and the 3-month follow-up visit.	Intrapersonal: lack of HIV knowledge and motivation Social-cultural: lack of social support	Intrapersonal: lack of HIV knowledge and motivation Social-cultural: lack of social support	Delayed intervention: Participants were provided MyPEEPs app at the 9-month visit. Peer mentors for app access and incentives for completion are the same as for the intervention condition. Access is provided through the 12-month study visit.	Participants will be followed for 2 months with follow-up assessments conducted at 3, 6, 9 and 12 months (delayed intervention arm only).	HIV testing at 3-, 6- and 9-month follow-up	Usability: Scores rated by experts: 0–2.6 (0 = no problem to 4 = usability catastrophe) Feasibility: Rated by the end users: 1.63 ± 0.65 Preliminary efficacy: More HIV testing in the past 3 months were reported by the intervention group compared to control (p=0.0156).
Katz et al. ¹⁹	Seattle, WA	September 2010–December 2014	RCT	Recruitment at PHSKC STD Clinic and other Seattle sites serving MSM and clinician referral; ads on Facebook, Google, and local MSM websites; and local LGBTQ listeners	High-risk MSM Age (range): 27–47 White: 73.5% Black: 9% Hispanic/Latino: 14.8%	"I Test": Participants received in-depth training in the performance of OraQuick (rapid test on oral fluids) and a single test to take home. Additional kits were available on request and could be mailed or picked up at the clinic.	Not reported.	Intrapersonal: lack of self-efficacy for HIV testing Social-cultural: stigma	Testing as usual	Baseline: 116 vs. 114 Month 9: 80 (69%) vs. 81 (71%) Month 15: 194	Self-reported number of HIV tests during follow-up	Acceptability: Willing to test HIV more often: 85% Efficacy: mean number of HIV tests: 5.3, 95% CI: 4.7–6.0 vs. 3.6, 95% CI: 3.2–4.0
Lightfoot et al. ²⁰	Alameda County, CA	January 2016–March 2017	Quasi-experimental	The peer recruiters were identified from HIV-related support groups, local gay bars, online social networking and dating apps, community-based organizations, and word of mouth. Peer recruiters distributed the test kits to their friends eligible for the study.	African American (49.6%) and Latino (27.3%) MSM Age 18–34: 74.77% Gay/bisexual: 81.47% Bisexual: 27.52%	A peer-based intervention: Peer recruiters underwent training on HIV. Each peer recruiter was provided with 5 HIV test kits and asked to distribute the test kits to friends who they believed were African American or Latino MSM. Peer recruiters were encouraged to encourage their friends to complete a survey after using the kit.	Not reported.	Intrapersonal: lack of peer support	The community-based HIV testing programs funded by Alameda County Public Health Department in 2015	Test kits given to peers: 183 Test kits distributed to social and sexual network members: 85 Survey completed: 114 (69%)	Previous and current HIV test results, frequency of testing, sexual risk behaviors and demographics were compared with data from County programs.	Efficacy: Compared with MSM in the control group, individuals reached through the peer recruiters were more likely to have never tested for HIV (3.5% vs. 0.4%, p < 0.001)
Protocol: Linnemayr et al. ²¹ Efficacy evaluation: MacCarthy et al. ²² Acceptability and feasibility evaluation: MacCarthy et al. ²³	Bienestar, a primarily Latino focused HIV service provider located across Los Angeles County	May 2017–April 2018	Quasi-experimental	Bienestar staff recruited participants coming to Bienestar for HIV testing.	Latino sexual minority men (62.0%; 67.4%) and transgender women ("info only" vs. "info plus") Age (mean): 34.8 vs. 35.2 White: 52.7% vs. 60.7% Bisexual: 58.2% vs. 60.7% Gay, lesbian, queer: 14.3% vs. 13.1%	"MOTIVES": a text message-based intervention (1) The "information only" (IO) group received text messages with HIV prevention information. (2) The "information plus" (IP) group additionally could win incentives by answering weekly quiz questions correctly and testing for HIV once every 3 months.	Behavioral economics	Intrapersonal: lack of HIV knowledge and motivation	Controls were identified via electronic medical records who came to Bienestar for HIV testing during the intervention period who had the same eligibility criteria as study participants but were not offered the intervention.	IO vs. IP Baseline: 99 vs. 119 Discontinued intervention during follow-up: 2 vs. 10	Tested for HIV in 3-month interval	Acceptability: Most participants understood moving beyond a narrow focus on HIV. Feasibility: Most participants reported the text message platform worked well. Efficacy (IO vs. IP vs. control): Frequency of HIV testing within a given 3-month period: 22.0% vs. 24% vs. 28.9% (95% CI: 19–2.5); IP relative risk ratios = 2.41, 95% CI: 1.89–2.98
Marchant et al. ²⁴	Nationwide	April 2015–April 2016	RCT	Multiple social media platforms	Young MSM Age (median): 22 (IQR: 21–24) Black: 30% Hispanic: 35% White: 35%	An internet-based intervention: Participants were provided with instructions, an internet-based gift card to purchase the assigned test kit, and weblinks to companies from which to purchase their assigned test via the internet. Participants ordered the tests themselves and chose where and when their assigned tests would be delivered.	Not reported.	Institutional: no access to transportation and testing locations	(1) Mail-in blood sample (2) Community organization/medical facility testing	Oral fluid vs. mail-in blood sample vs. community enrollment: 142 vs. 142 vs. 141 Completed final study assessment: 100 vs. 80 vs. 82	(1) Completion of HIV testing within a 3-month period, (2) willingness to refer and (3) referrals of other MSM to use the same test they had been assigned in the trial	(1) Completion of blood sample vs. medical facility/community: (1) Completion of assigned test: 66% vs. 46% vs. 56% (2) willingness to refer: 36% vs. 20% vs. 26% (3) legitimate referrals: 58% vs. 43% vs. 43%

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Table 1. (Continued)

Source ^a	Location/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Stephenson et al. ¹⁴	Detroit, Flint, and Ann Arbor, MI	Launched in April 2017	RCT	Web-based ads on social media websites (eg, Facebook, Grindr); in-person recruitment at local venues and community outreach events in the region	Young MSM and transgender people aged 15-25 years old	"Swerve": a tailored intervention component included (1) employing algorithms to explore sexual risk-taking with cultural and developmental tailoring for participants; and (2) risk reduction counseling for HIV-negative participants or linkage and retention to HIV care among newly HIV-diagnosed individuals	Social cognitive theories, transtheoretical model change theory, and decision theory; social cognitive factors that impact behavior change Motivational interviewing; resolving ambivalence about problem behaviors, increasing self-efficacy for motivation moving toward action	Intrapersonal: lack of HIV knowledge and motivation Interpersonal: lack of social support	Standard HIV counseling, testing, and referral	Participants will be followed for 6 months, with follow-up assessments conducted every 3 months.	The proportion of participants who obtain repeat HIV tests at least 3 months apart within 15 months	The trial is ongoing.
Pilot trial: Wray et al. ¹⁵ Protocol: Wray et al. ¹⁶	Northeastern United States	Launched in January 2019	RCT	Gay-oriented smartphone dating apps (eg, Grindr and Scout24); recruitment at local Facebook and Grindr group person outreach (eg, flyers)	High-risk MSM only	(1) "e-TEST": a mobile app-based intervention that provides tailored HIV self-testing kits equipped with devices that detect when the kit, a counselor will call participants to conduct post-test counseling and refer them to other needed services. (2) standard HIV self-testing kits with no follow-up	Not reported	Institutional: no access to testing locations and stigma Social-cultural: stigma	Text messages will be sent to participants once every 2 weeks, when they are not tested for HIV at a local clinic and provide them with information about free clinic-based testing in the area.	Participants will be followed for 6 months, with follow-up assessments conducted at baseline, 1 month, 4 months, 7 months, 10 months, and 12 months	The proportion of participants in each group who (1) tested for HIV at least once over the 12 month study; (2) tested within each 3 month interval; and (3) were tested at least once during the intervals of at least once every 6 months over the year-long study	Preliminary efficacy (e-TEST vs. standard vs. control): HIV testing at 100% vs. 72% ($p < 0.007$). Repeat testing: 81.0% vs. 77.2% vs. 40.9% ($p < 0.001$)
Protocol: Biello et al. ¹⁷ Pilot trial: Biello et al. ¹⁸ Acceptability and feasibility evaluation: Biello et al. ¹⁹	Boston, MA, and Bronx, NY	Launched in October 2018	RCT	Recruitment at organizations and venues where MSM attend; flyers, posters, and advertisements on popular Web-based social media outlets (eg, Facebook, Grindr, etc)	MSM aged 15 to 24 years	"MyChoices": a mobile app-based intervention that includes tailored information on negotiation of HIV risk, self-efficacy for HIV prevention and an individually tailored HIV testing plan	Social cognitive theory Constructs: self-regulation, decision-making, development of testing plans; and self-efficacy belief that one can attain the goal to test regularly; goal setting and environmental influences	Intrapersonal: lack of HIV knowledge, self-efficacy for HIV testing and motivation Interpersonal: lack of social support	Standard of care: Participants will receive information on prevention conditions for HIV testing and referrals to local HIV testing sites and prevention services.	Participants will be followed for 6 months, with follow-up assessments collected at baseline, 3, and 6 months	Proportion of HIV testing at least once over the 6 months: 70% vs. 50% vs. 40% Frequency of use of HIV testing plan and reminders, frequency of testing due to geofencing technology	Acceptability: Mean System Usability Scale (0-100) score: 70 vs. 60 Feasibility: Frequency of using the app: 8 times on average over the 2 months
Gamarel et al. ²⁰	Nationwide	Launched in June 2017	RCT	Online ads placed on key social media websites (eg, Facebook) and social media sites aimed specifically at MSM (eg, Grindr)	MSM aged 15-19 years and their partners	"We Prevent": a couple- and video chat-based intervention Two telehealth-delivered sessions are: (1) techniques to explore and build communication skills in a relationship; and (2) couples HIV testing and counseling and prevention planning. Both sessions are attended by both members of the dyad.	Relationship-Oriented Information Motivation-Behavioral Skills Information: YMSM-specific knowledge (eg, risk within dyads and with outside partners); Motivation: attitudes about HIV prevention, relationships, and Behavioral Skills: risk-reduction skills relevant to YMSM and their partners YMSM and their partners (eg, discussion about safer sex, HIV testing, and negotiating safety in one's sexual agreement)	Intrapersonal: lack of HIV knowledge Interpersonal: lack of peer support	Participants will engage in only one telehealth session: the existing couples-HIV testing and counseling intervention delivered via video counseling.	Participants will be followed for 9 months, with follow-up assessments conducted every 3 months.	The proportion of participants tested for HIV 2 or more times, at least 3 months apart, in the 9-month follow-up period	The trial is ongoing.

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Table 1. (Continued)

Source ^a	Location(s)/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Protocol: Liu et al. ⁷ Acceptability evaluation: Biello et al. ¹⁶	Not reported	Launched in October 2018	RCT	Web-based and social media strategies (Crainlist, social networking ads, etc.); distributing posters, flyers, and pain cards; direct outreach at local venues (bars, clubs, etc.); MSM; clinic-based recruitment including reviewing medical charts or referrals	MSM aged 15–24 years	"LYNX": a mobile app-based intervention that included an electronic diary to track sexual behaviors, a personalized risk score to promote accurate risk perception, text-based reminders, and access to HIV/STI testing services; geospatial-based HIV/STI testing care sites.	Information Motivation Behavior Skills model Information: Personalized HIV risk assessment; sexual history diary Motivation: Personalized testing reminders; HIV/STI-testing diary and score; and behavioral skills: Home-based HIV/STI-testing options and instructions; geospatial-based testing site and linkage to HIV care	Intrapersonal: lack of knowledge on HIV and testing locations Institutional: no access to local HIV testing sites and prevention services. Social-cultural: stigma	Standard of care consisting of provision of information regarding recommendations for HIV testing and referrals to local HIV testing sites and prevention services.	Participants will be followed for 24 weeks with follow-up assessments conducted at 12 and 24 weeks.	(1) HIV testing frequency: number of HIV tests during study; and (2) HIV testing knowledge: attitudes measured by National HIV Behavioral Surveillance men who have sex with men-4 scale	Acceptability: Very convenient to use test kit in future: 80% Extremely confident in correct use of test: 80%
Sullivan et al. ¹⁷	Detroit, MI; New York City, NY; and Atlanta, GA	January–December 2018	RCT	Targeted banner ads (e.g., Facebook); traditional advertising (e.g., radio); recruitment at venues; referrals from community service providers; and in-person outreach	MSM aged 19 years and older	"M-Cubed": a mobile app-based intervention that provided risk-outcome feedback, written and video messages for participants. The messages included condom use, HIV/STI testing, PrEP, etc.	Social cognitive theory Theory constructs (e.g., self-efficacy, norms, barriers, and self-efficacy)	Intrapersonal: lack of HIV knowledge	Waitlist control: participants were given the intervention app. At the 9-month post-enrollment.	A total of 1229 MSM were enrolled. Participants were followed for 9 months with follow-up assessments conducted at 3, 6 and 9 months.	HIV screening behaviors in the past 3 months	The result has not been reported.
Edwards et al. ¹⁸	Los Angeles County Men's Central Jail and residential recovery facilities in the county	Launched in November 2019	RCT	Referral by staff at residential facilities and in-person enrollment in jail	MSM and transgender women leaving jail	A mobile app- and peer-based intervention: Participants will receive customized wellness goals in addition to Geofix (a GPS-based mobile app), cash incentives, and the support of a trained peer mentor for 6 months.	Social Cognitive Theory Environmental factors include the experience of social support, social stigma, availability of care services, competing basic needs for care, and relationship with partners Personal factors include knowledge about HIV prevention and the skills to perform and maintain related behaviors; and behavioral factors include self-efficacy, outcome expectations, goal setting, and problem solving.	Intrapersonal: lack of HIV knowledge and motivation Interpersonal: lack of peer support	Participants receive usual care.	Participants will be followed for 9 months with follow-up assessments conducted at 3, 6 and 9 months.	HIV screening every 3 months	The trial is ongoing.
Harawa et al. ¹⁹	Los Angeles, CA	October 2015–April 2017	RCT	Direct outreach at public venues, community-based organizations, parks, and events; provider referrals; fliers placed at public venues; and outreach via Craigslist.com, Instagram, and a study website	Black MSM Age (mean ± SD): 44.3 ± 11.2	"The Passport to Wellness": a peer-based intervention components included: (1) a customized wellness plan (or Passport) that included social support services and incentives for accessing those services; (2) incentives for providing documentation of completed Passport activities; (3) a trained peer who provided support, encouragement, and navigation; and (4) social/education group outings.	Principles of patient navigation and contingency management; social impact; social comparison; and cognitive-behavioral theories	Intrapersonal: lack of motivation Interpersonal: lack of peer support	Non-peer mentor intervention arm	Baseline: 55 vs. 50 Month 1: 22 (51.1%) vs. 18 (51.4%) Month 2: 21 (51.1%) vs. 18 (51.4%) Month 6: 34 (75.6%) vs. 27 (77.1%)	HIV screening within the prior 6 months	Efficacy: Tested for HIV at 6 months: 91% vs. 81%
Horvath et al. ²³	Las Vegas, NV; Miami, FL; Minneapolis, MN; and New Orleans, LA	March 2017–May 2018	RCT	Targeted ads on dating and social networking platforms (Grindr, Scruff, Facebook)	MSM only Age (mean ± SD): 28.8 ± 5.9 White, non-Hispanic: 48.7% White, Hispanic: 23.0% Homosexual/gay: 65.0%	Status Update Project (SUP): a mobile app-based intervention Participants had access to the following app components for 8 months: My Health Tab with HIV Test Date and Frequency Recommendation, Test Reminder, Prevention 411, Resources, Local Events and My You.	Not reported.	Intrapersonal: lack of motivation and knowledge on HIV and testing locations	No-treatment control: Participants did not receive any intervention and were only asked to complete the baseline and follow-up assessments.	Baseline: 57 vs. 56 Month 4: 47 (82%) vs. 52 (93%) Month 8: 45 (79%) vs. 49 (88%)	Two or more HIV tests at 4 and 8 months	Acceptability: System Usability Scale score for the intervention at 4 months: 68.5 (considered average) Feasibility: Repeat testers at 4 months: 94% (95% CI: 0.9–0.98) Repeat testers at 8 months: 95% (95% CI: 0.9–0.98) Relative Risk = 1.2, 95% CI: 0.8–2.0

(Continued)

Table 1. (Continued)

Source ^a	Locations/setting	Recruitment/ study period	Study design	Recruitment strategy	Population characteristics	Intervention (components)	Theoretical/conceptual framework	Multilevel barriers addressed by the intervention	Control	Sample size and retention (intervention vs. control)	Outcome measures	Findings (acceptability, feasibility, efficacy or cost-effectiveness)
Efficacy evaluation: MacGowan et al. ¹⁶ Cost evaluation: Shrestha et al. ¹⁷	Nationwide	March–August 2015	RCT	Advertisements placed on social network, music, and dating websites frequented by MSM	MSM only Age < 30; 57.3% Non-Hispanic white: 57.8%	"STAMP": a website-based intervention app and peer-based intervention after completing the baseline survey with the option to replenish self-tests after completing quarterly surveys. Online videos were provided on how to use all HIV-testing materials	Not reported.	Intrapersonal: lack of self-efficacy for HIV testing Institutional: no access to transportation and testing locations Social-cultural: stigma prevention information in their area.	Participants were provided HIV prevention information about the importance of testing, a link to AIDSVA.org, and resources to locate HIV testing services and prevention information in their area.	Baseline: 1325 vs. 1340 Month 3: 824 vs. 766 Month 6: 725 vs. 756 Month 9: 748 vs. 838 Month 12: 752 vs. 832	Frequency of HIV testing: mean number of times tested (testing ≥ 3 times during the trial) Cost: Total implementation cost: \$449,510 Cost per self-test completed \$61 once \$145 The trial is ongoing.	
Muesig et al. ¹⁸	Nationwide	Launched in July 2020	RCT	Ads based on sociodemographic characteristics on social media sites (e.g., Facebook, Tumblr, Instagram, Grindr, and dating websites like Grindr, Scarff), clinic referrals, and participant repositories	Black and Latinx MSM aged 15 to 29 years	"HealthPwment 2.0" (HMP 2.0): an app- and peer-based intervention (1) Researcher-created network in which participants have access to all features of HMP 2.0, including test kit ordering, care navigator, profile, activities, forums, etc. (2) Peer-Referenced Network Intervention: Participants have access to all features of HMP 2.0 and a customized invitation for peers to join the study. "SMART": a web-based stepped-care intervention SMART Sex Ed (SSE, tier 1): an information- only intervention to which all participants will be granted access; SMART Squad (tier 2): a more intensive selective intervention offered to those who report HIV risk behaviors and/or lower adherence to SSE SMART Sessions (tier 3): a higher cost, indicated intervention designed for those who continue to report HIV risk intentions or behavior following the two previous interventions.	Integrated Behavior Model Conceptual Framework for HIV-Related Stigma, Engagement in Care, and Health O increases the salience of stigma-related beliefs, norms, and attitudes through new intervention content and activities.	Intrapersonal: lack of HIV knowledge and motivation	Information-only control: Participants have access to informational content only, including and care navigator	Participants will be followed for 12 months with follow-up assessments conducted at 3, 6, 9, and 12 months.	(1) Participation in routine HIV testing: 2 or more HIV tests in at least three months (testing ≥ 3 times during the trial) (2) The proportions of participants who complete at least one HIV test in the 12-month period	The trial is ongoing.
Muzanski et al. ¹⁹	Nationwide	Launched in April 2018	RCT	Ads on social media (eg, Instagram, Facebook), active web-based engagement using geospatial dating apps; and other social media outlets (eg, Reddit, Tumblr)	MSM aged 13 to 18 years	"HOLA": a peer-based intervention Well-trained Navigators promoted HIV testing among their social network members by carrying out informal and formal helping, using the skills and materials gained through the training.	Medicine's prevention model and information- motivation-behavioral skills model	Intrapersonal: lack of HIV knowledge and motivation	SSE 2.0: an expanded version of the SSE (with 6 modules and 2 boosters)	Participants were followed for 12 months with follow-up assessments conducted at 3, 6, 9, and 12 months	Self-reported history of testing for HIV in the previous 3 months	The trial is ongoing.
Rhodes et al. ²⁰	North Carolina	Not reported.	RCT	21 Latinx MSM and transgender women (TW) who serve as Navigators were recruited through word-of-mouth. Navigator recruited eight non- overlapping members of their social networks.	Latinx MSM (89.2%) and TW (10.8%) Age (mean ± SD): 29.6 ± 6.7 Gay: 79.5%	"HOLA": a peer-based intervention Well-trained Navigators promoted HIV testing among their social network members by carrying out informal and formal helping, using the skills and materials gained through the training.	Social cognitive theory, empowerment education and social support	Intrapersonal: lack of motivation and knowledge on HIV and testing locations Intrapersonal: lack of peer support	Waitlist control	Baseline: 86 (11 networks) vs. 80 (10 networks) Month 12: 82 (95%) vs. 75 (94%)	Self-reports of HIV testing in the past 12 months	Efficacy: HIV testing at 12 months: 90.2% vs. 60.0% (OR = 8.3, 95% CI: 3.0–23.0)
Frye et al. ²¹	New York, NY	July 2016– January 2019	RCT	Friend pairs (primary eligible participant (PEP) and the friend of the PEP) were recruited via online advertisements, direct outreach and referrals by study participants.	MSM (74.2%) and transgender women (16.7%) Age (mean ± SD): 18–29 African American: 49.7% Afro-Latino: 29.3% Gay/same gender loving/ queer: 56.9% Bisexual: 28.2%	"TRUST": a peer-based intervention Friend pairs engaged in HIV testing and received results together. Then they provided HIV testing information on including HIV self-testing instruction, skills building, peer support, and planning for consistent self-testing.	Sociocological, empowerment, self- efficacy, social support, interviewing theories	Intrapersonal: lack of motivation and knowledge on HIV and testing locations Social-cultural: lack of social support	Time and attention control: Friend pairs were HIV tested separately, but were provided information together, and then were provided information about a range of self-screening approaches for common, adverse health conditions.	n: friend pairs Baseline: n = 89 vs. n = 77 (98%) Month 3: n = 70 (79%) vs. n = 77 (98%) Month 6: n = 71 (80%) vs. n = 81 (82%) Month 9: n = 56 (63%) vs. n = 73 (74%) Month 12: n = 78 (88%) vs. n = 78 (79%)	Self-testing for HIV within the past three months, after 12 months of follow-up.	Efficacy: "TRUST" vs. control at 3 months: OR = 1.94, 95% CI: 0.83–4.58 "TRUST" vs. control at 6 months: OR = 2.29, 95% CI: 1.15–4.58
Reback et al. ²²	A west coast metropolitan	Launched in January 2019	RCT	Banner ads or digital flyers placed on gay websites, apps, and social media sites that target MSM; street- and venue-based outreach; poster ads; and participants referral	Methamphetamine- using MSM	"Getting Off": a mobile app-based intervention Core elements include treatment and recovery structure, meaning of meth use, triggers, social networks, emotions and feelings, sex and HIV, social identity, and peer support. The app includes an assessment; participants will have immediate access to the Getting Off app.	Stages of change model and cognitive-behavioral therapy model	Intrapersonal: lack of motivation and knowledge on HIV and testing locations Intrapersonal: lack of peer support	Delayed delivery a.m: Participants will have access to the Getting Off app after 9 months with follow-up assessments conducted at 1, 2 months (delayed delivery at 3 months), 3, 6 and 9 months.	Participants will be followed for 9 months with follow-up assessments conducted at 1, 2 months (delayed delivery at 3 months), 3, 6 and 9 months.	HIV testing: yes/no	The trial is ongoing.

MSM: men who have sex with men; HIV: human immunodeficiency virus; RCT: randomized controlled trials; MV: many voices; OR: odds ratio; CI: confidence interval; CDC: Centers for Disease Control and Prevention; HOPE: harnessing online peer education; STD: sexually transmitted diseases; PS: partner services; AIDS: acquired immunodeficiency syndrome; TMUS: testing makes us stronger; IO: information only; IP: information plus; SUP: status update project; HMP: HealthPwment; SSE: SMART sex ed; TW: transgender women; PEP: primary eligible participant.

Table 2. Quality assessment of controlled intervention studies.

Study	1. Was the study described as a randomized trial, a randomized clinical trial, or assignment? (RCT?)	2. Was the method of randomization adequate (i.e., use of a randomly generated sequence)?	3. Was the treatment allocation concealed (so that assignments could not be predicted)?	4. Were study participants and providers blinded to treatment group assignment?	5. Were the people assessing the outcomes blinded to the treatment group assignments? (e.g., the number allocated to treatment?)	6. Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)?	7. Was the overall drop-out rate from the study at endpoint 20% or lower of groups at endpoint 15 percentage points or lower?	8. Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower?	9. Was there high adherence to the intervention protocols for each treatment group?	10. Were other interventions avoided or similar in the groups (e.g., similar background treatments)?	11. Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	12. Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?	13. Were outcomes reported or analyzed in subgroups prespecified (i.e., identified before analyses were conducted)?	14. Were all randomized participants analyzed in the group to which they were originally assigned, that is, did they use an intention-to-treat analysis?	Total score
Fehrs et al. ³³	N	NA	NA	NA	NA	NR	NA	NA	NR	NR	Y	Y	NA	NA	2
Wilton et al. ²⁰	Y	CD	NR	NR	NR	Y	Y	Y	NR	Y	Y	Y	Y	Y	7
Martínez-Donate et al. ³⁴	N	NA	NA	NA	NA	Y	NA	NA	NR	NR	N	Y	NA	NA	7
Outlaw et al. ³⁵	Y	Y	NR	N	NR	Y	Y	Y	Y	Y	Y	Y	Y	Y	10
Hirshfield et al. ²⁶	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	N	Y	Y	6
Young et al. ³⁶	Y	Y	Y	Y	NR	NR	Y	Y	Y	NR	Y	Y	Y	Y	11
Bauermeister et al. ³⁸	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	N	N	6
Katz et al. ³⁹	N	NA	NA	NA	NA	N	NA	NA	NA	NR	Y	Y	NA	NA	2
Rhodes et al. ⁴²	Y	CD	NR	NR	NR	Y	NR	NR	NR	NR	N	Y	NR	NR	4
Bauermeister et al. ⁴³	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	NR	NR	6
Frye et al. ²²	Y	Y	Y	N	Y	Y	Y	Y	NR	NR	N	Y	Y	Y	10
McCoy et al. ⁴⁶	N	NA	NA	NA	NA	Y	Y	Y	NR	NR	Y	Y	NA	NA	4
Rhodes et al. ⁴⁹	Y	NR	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	7
Washington et al. ⁵⁰	Y	CD	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	N	5
Ybarra et al. ⁵¹	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	9
Bauermeister et al. ⁵³	Y	CD	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	CD	3
Bauermeister et al. ⁵⁴	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	Y	5
Kuhns et al. ⁵⁷	Y	Y	Y	Y	Y	NA	NA	NA	NA	NA	N	Y	Y	CD	6
Katz et al. ⁵⁹	Y	Y	Y	N	Y	NR	Y	Y	NR	NR	N	Y	N	N	7
Lightfoot et al. ⁶⁰	N	NA	NA	NA	NA	Y	Y	Y	NR	NR	N	Y	Y	NA	2
MacCarthy et al. ⁶²	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	NA	7
Merchant et al. ⁶⁴	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	7
Stephenson et al. ⁶⁵	Y	Y	Y	Y	NR	NA	NA	NA	NA	NA	N	Y	Y	CD	5
Wray et al. ⁶⁷	Y	Y	Y	N	NR	NA	NA	NA	NA	NA	N	Y	Y	Y	8
Bello et al. ⁶⁸	Y	Y	Y	N	NR	NA	NA	NA	NA	NA	N	Y	Y	Y	4
Ganarel et al. ⁷¹	Y	CD	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	CD	2
Liu et al. ⁷²	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	CD	5
Sullivan et al. ⁷³	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	CD	3
Edwards et al. ⁷⁴	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	Y	6
Harawa et al. ⁷⁵	Y	Y	Y	Y	Y	Y	Y	Y	NR	NR	N	Y	N	N	6
Horvath et al. ²³	Y	NR	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	N	N	5
MacGowan et al. ⁷⁶	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	8
Muessig et al. ⁷⁸	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	NR	4
Mustanski et al. ⁷⁹	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	NR	4
Rhodes et al. ⁸⁰	Y	Y	NR	NR	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	7
Frye et al. ²¹	Y	Y	Y	N	NR	Y	Y	Y	NR	NR	N	Y	Y	Y	9
Reback et al. ⁸¹	Y	Y	NR	NR	NR	NA	NA	NA	NA	NA	N	Y	Y	Y	5

RCT: randomized controlled trials; CD: cannot determine; N: no; NA: not applicable; NR: not reported; Y: yes.

Table 3. Quality assessment of pretest-posttest studies.

Study	1. Was the study question or objective clearly stated?	2. Were eligibility/selection criteria for the study population and clearly described?	3. Were the participants in the study representative of those who would be eligible for the test/service/ intervention in the general or clinical population of interest?	4. Were all eligible participants that met the prespecified entry criteria enrolled?	5. Was the sample size sufficiently large to provide confidence in the findings?	6. Was the test/service/ intervention clearly described in and delivered across the study population?	7. Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?	8. Were the people assessing the outcomes blinded to the participants' exposures/ interventions?	9. Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?	10. Did the statistical methods examine changes in outcome measures before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?	11. Were outcome measures of interest taken before the intervention and multiple times?	12. If the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.)	Total score
Rhodes et al. ²⁴	Y	N	CD	CD	NR	Y	N	Y	Y	N	N	N	4
Maksut et al. ⁴¹	Y	Y	CD	Y	N	Y	N	Y	Y	Y	Y	NA	7
Newcomb et al. ⁴⁷	Y	Y	CD	Y	NR	Y	N	Y	Y	Y	N	NA	6
Shelley et al. ²⁵	Y	Y	N	Y	NR	Y	N	N	N	Y	Y	Y	7
Boudewyns et al. ⁵⁵	Y	CD	CD	CD	N	Y	N	NR	Y	Y	Y	Y	5

CD: cannot determine; N: no; NA: not applicable; NR: not reported; Y: yes.

tested for HIV.⁶⁴ Behavioral outcomes included self-reported HIV testing behavior (yes/no),^{20,21,24–26,34,35,38,39,42–44,49–51,54,57,61,67,68,73–75,78–81} number of tests^{59,60,72,76} and repeat testing (two or more tests over time)^{23,45,53,65,71,78} during the follow-up. Other less-reported behavioral outcomes included demand for HIV testing,^{33,36} scheduling an appointment to test for HIV,³⁸ returning or following up for test results^{35,36} and referrals of other MSM to test for HIV.⁶⁴ Only one study evaluated the intervention by measuring the structural (e.g. transportation and distance to testing site) and psychosocial barriers (e.g. fear of testing HIV positive and HIV stigma) to HIV testing rated on a 6-point Likert-type scale.⁴¹ For interventions focused on HIV self-testing (HST), self-efficacy toward testing (confidence in ability to test) was reported.⁶⁸

Theoretical framework

Key elements of theoretical underpinnings guided most studies to address psychosocial factors (e.g. perception, motivation, stigma, and social support), improve HIV knowledge and deliver risk reduction skills training. Commonly reported theoretical frameworks included social cognitive theory,^{20,24,42,44,49,65,68,73–75,80} empowerment education,^{21,24,42,49,80} information motivation behavior model,^{23,47,51,71,72,79} motivational interviewing principles,^{21,35,53,65} self-determination theory,^{38,45,53,65} integrated behavioral model,^{38,43,53,78} model of behavior change,^{20,50,65} social-ecological model,^{21,34} social learning theory^{26,57} and social support theory.^{21,80}

Intervention strategies and findings

Of 42 interventions reviewed in this study, most common interventions were HST interventions, interpersonal-level interventions, personalized/individualized interventions and technology-delivered interventions. The vast majority of these interventions were developed from 2016 and onward. The types of interventions in this study were not mutually exclusive (e.g. an interpersonal-level intervention might incorporate personalized elements). Hence, the types we presented here were used to provide the readers with examples of various interventions.

Interventions for HIV self-testing. Generally, for interventions aimed at promoting HST, participants received information on HST and self-administration of the testing via social media groups, video chat, mobile app, online videos or peer educators. Then they received or requested the test kits from the research teams or ordered the kits online.^{21,36,41,59,68,76} As an emergent tool for HIV screening, HST was proved to be highly acceptable, feasible, efficacious and cost-effective.^{21,36,41,59,70,76,77} In the “HOPE” study, participants who were delivered information on HIV testing had high acceptance across assessment periods and were more likely to request an HIV testing kit compared to those who received general health information (43.9% vs 20.0%).³⁶

There were two studies evaluating the effect of testing kits distribution strategies on the uptake of testing, which were social network distribution⁶⁰ and online purchase by participants.⁶⁴ We additionally identified an intervention providing counseling and referral of needed services after participants performed self-testing.^{66,67} All of these interventions exhibited efficacy in promoting HST among MSM.^{60,64,66}

Interpersonal-level interventions. There were two couples-based interventions for MSM, “2GETHER” and ongoing “We Prevent.” Both interventions delivered sessions about communication skills and CHTC.^{47,71} “2GETHER” additionally discussed minority stress, relationship stress and utilization of social and community support.⁴⁷ This study demonstrates feasibility, acceptability and preliminary efficacy among young male couples.⁴⁷

Most interpersonal-level interventions were peer-mentored or peer-led. Peers, who shared sociodemographic characteristics with participants, delivered information on HIV testing, provided support or directly distributed HST kits to MSM.^{35,36,41,54,60,74,75,80} Peer-mentored interventions were efficacious in reducing barriers to HIV testing, promoting uptake of testing and returning for testing results.^{35,36,41,60,75,80} The “HOLA” intervention targeted Latino MSM, and participants who received help from peer leaders had more than eight times the odds of getting the test at 12 months compare to those assigned to the general health education comparison group (OR=8.3, 95% CI: 3.0–23.0).⁸⁰

We identified two interventions that friends participated in together, “HealthMpowerment 2.0” and “TRUST.”^{21,78} In the “HealthMpowerment 2.0,” participants invited their friends to join the study via the mobile app, but they had no access to detailed information of enrolled friends.⁷⁸ In the “TRUST” study, however, friend pairs engaged in HIV testing and intervention sessions together. Evidence suggested that friend pairs were more likely to receive HST during the study period.²¹

Social campaigns. We observed two campaigns, “Hombres Sanos” [Healthy Men] and “Testing Makes Us Stronger” (TMUS). The elements of “Hombres Sanos” campaign included print materials, radio advertisements and community-based outreach. Favorable changes in HIV testing among Latino MSM were not observed for “Hombres Sanos.”³⁴ The TMUS incorporated more Internet-based components such as online advertisements, a dedicated website and social media outreach. The number of HIV testing among Black MSM in the implementation cities of TMUS was found to increase at a rate of 6.22 tests per month (95% CI: 2.31–10.12).⁵⁵

Structural interventions. In 1986, Oregon began offering anonymous HIV counseling and testing services in which numbers were used to identify clients. It is reported that the availability of anonymity increased HIV testing among gay

men by 125%.³³ Another structural intervention was the integration of HIV testing into sexually transmitted diseases (STD) partner services (PS) program in Washington State.³⁹ This program was highly effective in promoting HIV testing (63% pre-intervention to 91% during) among MSM with an STD and was also cost-effective.^{39,40}

Personalized/individualized interventions. Personalized interventions were developed by customizing the content based on participants' self-reported information (e.g. demographic characteristics, sexual behaviors, psychosocial factors and prior HIV testing experiences). Most personalized interventions were aimed to improve individual-level information (e.g. HIV prevention information and HIV risk assessment), motivation (e.g. HIV testing reminder, risk reduction and wellness plan, guidance from mentors) and behavioral skills (e.g. safer sex skills).^{38,41,43,53,54,65,68,72-75} Individualized interventions were found to be acceptable, feasible and efficacious in enhancing HIV testing among MSM.^{38,41,70,75}

At the structural level, two interventions, "Get Connected" and "Get Connected 2.0," employed tailoring to link participants to the HIV testing sites that were most appropriate to their needs (e.g. privacy, confidentiality and clinic environment).^{38,53} The "All About Me" intervention provided a personalized recommendation of an optimal HIV testing approach (HST, facility-based testing or CHTC) for participants.^{22,44} "All About Me" improved HIV testing among Black MSM during follow-up compared to the non-tailored control (75.9% vs 70.9%), although the difference was non-significant.²²

Technology-delivered interventions. Development and evaluation of technology-delivered interventions exploded from 2010 and onward. Different from venue-based interventions, participants received intervention content including HIV prevention, HIV testing and sexual risk reduction information through online videos, text messages, websites, web apps or social media.^{26,38,50,51,53,76} We additionally identified interventions providing online consultation to participants. In these studies, well-trained counselors provided social support and information on HIV testing or assisted participants in setting health goals via chat room, video chat or social media.^{24,36,41,42,54,71,79} Technology-delivered interventions for HIV testing were shown to be acceptable, feasible, efficacious, and cost-effective among MSM.^{24,36,38,41,42,50-52,76,77}

Most interventions delivered via text message, web app or mobile app provided not only information on HIV and local resources (e.g. HIV testing sites, PrEP clinics and community events), but online interactive activities to boost participants' engagement. Commonly reported activities were individual risk assessments, setting health goals, using sexual diaries, and engaging in forums, polls, games, and/or quizzes.^{23,43,54,57,61,68,72-74,78,81} In addition, participants could directly order prevention commodities (e.g. HST kits, mail-in self-tests or condom variety packages) and follow-up on

unreported HIV test results through the apps.^{68,72,73,78} For participants who tested positive during the study, information on referral and linkage to HIV services in the local communities were provided.^{72,78} Efficacy of technology-delivered interventions was unclear because most studies were ongoing.^{43,54,73,74,78,81}

Of note, we observed one intervention, "Stick to it," incorporating both online and offline activities. Participants were encouraged to earn points through online activities, such as taking the quizzes and monitoring their plans for HIV screening. Offline activities occurred at health clinics where participants could receive HIV screening and redeem their points for prizes.⁴⁵ The pilot test reported that participants in the intervention group were more likely to repeat an HIV test over the 6 months of follow-up (OR = 2.15, 95% CI: 1.03 - 4.47).⁴⁶

Comparison of evaluation of interventions

Evaluation of acceptability and feasibility was mostly conducted in technology-delivered interventions.^{23,36,38,41,46,47,51,63,70} Participants generally had positive attitudes toward the interventions delivered by website, video or text messages, for example, "I liked the whole goal of the program (Guy2Guy intervention)," and expressed high satisfaction with the program.^{38,41,46,51} Mobile app interventions were also shown to be acceptable based on the high System Usability Scale score.⁷⁰ In terms of feasibility, these programs were able to recruit and retain diverse participants in their interventions.^{38,41,46}

All types of interventions demonstrated efficacy to improve HIV testing uptake among MSM, including increased HIV counseling and testing, repeat HIV testing, and less barriers to HIV testing.^{20,21,24,25,35,36,38,41,46,49,51,55,58,66,76,80} Of note, two peer-delivered interventions, "HOLA" and "HOLA en Grupos," reported more than eight-fold increase in HIV testing among Hispanic/Latino MSM.^{49,80} Few interventions reported non-significant improvement in primary outcomes compared to control groups, including knowledge of testing locations, self-reported HIV testing, motivation to receive testing, and repeat testing.^{22,23,34,47}

Discussion

There have been an increasing number of RCTs of HST implemented in the United States since 2010.^{21,36,59,64,66,69,70,76} High acceptability of HST and its potential to improve HIV testing uptake among MSM is not surprising given the positive attributes associated with the test (e.g. availability at pharmacies, oral fluid collection and rapid provision of results). In addition, HST may have the ability to decrease the stigma and discrimination associated with HIV, both of which are established barriers to HIV testing among MSM,¹⁶ by providing a confidential and private testing environment.^{82,83} HST interventions also proved to be successful

in increasing HIV testing among MSM in China^{84,85} and Australia.⁸⁶

The limitations of HST should be noted. First, a rapid self-test is unable to detect early infection due to lower sensitivity of oral fluid HST than whole blood-based test, long window period of the rapid test and poor test performance caused by lack of training or psychological factors.^{59,64,87,88} For example, almost 10% of participants were found to wait for less than specified amount of time before opening the test kit and interpreting the results.⁵⁹ The findings highlight the importance of provision of training in the performance of HST and technical assistance to help MSM properly conduct the test. With regard to low sensitivity and long window period, a possible solution could be the mail-in self-test. Given the limited evidence and limitations of the mail-in self-test (inability to offer quick results and unavailability at pharmacies), further research is needed to evaluate its efficacy in promoting HIV testing among MSM. Second, linkage to a confirmatory test and HIV primary care after a reactive rapid test remains a challenge due to multi-level barriers.^{89–91} Epidemiological studies have demonstrated that delayed initiation of HIV treatment leads to increased incidence of AIDS or non-AIDS events, decrease in life expectancy and significant number of onward infections.^{92–94} Hence, it is important for future trials to offer follow-up counseling and referral services to participants if needed.⁶⁶ Last, efficacy of HST interventions may be overestimated under experimental conditions where test kits were provided free of charge. A study conducted in urban Philadelphia found that although 90% of participants expressed willingness to use HST kits, whereas only 23% were willing to pay for it.⁹⁵ Further research regarding public funding of HST programs to maximize HST uptake among MSM is warranted.⁹⁶

At the interpersonal level, we identified two interventions trying to promote HIV testing among male couples, “2GETHER” and “We Prevent.”^{47,71} Couple-based interventions were designed to promote knowledge of HIV risk in couples, peer norms about prevention in relationships and sexual health communication, which were all facilitators of uptake of HIV prevention services.^{97,98} CHTC also facilitates the disclosure of HIV status among couples, based on which they could make sexual risk reduction plan, which is especially important for serodiscordant couples. Secondary analyses of “2GETHER” intervention further revealed the increased motivation to test for HIV with one’s partner for MSM with high internalized stigma.⁴⁸ However, given the low coverage of CHTC and multi-level barriers to the implementation but high willingness to use this service among MSM,^{22,99,100,101} there remains a need for more research on the development, implementation and promotion of male couple-based interventions.

Another type of interpersonal-level interventions was based on peer mentoring. The strengths of peer-mentored or peer-led interventions lie in efficient peer-based chain recruitment, high acceptance and engagement due to

demographic similarity among peers, and provision of peer support.^{21,36,41,60} Peer-based intervention would be more useful when they are applied to minority groups, for example, Black and Latino MSM.^{35,60,75,80} These groups, who are disproportionately affected by HIV, lack trust in healthcare providers/system and do not have information on access to HIV prevention services.^{80,102,103} For example, fears related to immigration enforcement was reported to be one of the greatest barriers to HIV testing among Latino MSM.⁸⁰ Peer-based interventions bridge these gaps by providing support and creating an opportunity for minority groups to receive culturally congruent information on HIV from credible sources.^{35,60,75,80} Of note, for peer-led interventions, researchers should take caution with selection of peer leaders. Individuals who are both helpful and trusted within their social networks are necessary for the successful implementation of interventions.⁸⁰ It is also critical to deliver training programs to peer leaders to ensure that they could deliver high-quality interventions.

We observed one peer-based intervention, “The Passport to Wellness,” that made an effort to improve social determinants of health among Black MSM by using incentives and peer support.⁷⁵ This intervention is worth noting because it addressed negative social determinants of health including poverty, access to healthy food, stigma and discrimination, all of which were thought to be the root cause of health and barriers to seeking HIV prevention services.^{104,105} There remains a need for more research to integrate and address social determinants of health into HIV prevention and testing programs.

At the structural level, the only intervention implemented in recent years was the STD PS program in Washington State which ensured HIV testing for MSM with an STD and their partners. We observed a pronounced increase in HIV testing among MSM who received the diagnosis of STD from healthcare providers that were not specializing in HIV or STD care.³⁹ This finding highlights the great potential of the healthcare system, especially non-specialty providers, in promoting HIV testing and the importance of collaboration across health departments. However, the generalizability of a similar program in other states are uncertain given the disparity in public health infrastructure across the United States.³⁹

We found an increasing number of interventions incorporating personalized elements in recent years.^{38,41,43,44,53,54,65,72–75} Three novel interventions seeking to connect participants with the most appropriate HIV testing approach were identified.^{22,38,53} Compared to common interventions to promote community- or facility-based testing, these interventions not only addressed institutional barriers to HIV testing (e.g. healthcare providers’ stigmatizing behaviors toward patients) by filtering testing sites based on participants’ past experiences and expectations, they also took into account local testing resources (e.g. geographic coverage of testing sites).^{22,38,53,106} However, it is important to note that the development of tailored intervention remains challenging.

For instance, in the “All About Me” study, development of an algorithm to match individuals to an optimal testing method involved the identification of barriers to testing and consideration of institutional conditions.²² Formative studies to fully understand participants’ needs and exploration of local HIV testing resources are warranted for the successful implementation of personalized interventions.

With the increasing use of the Internet and mobile technology by MSM to find HIV-related information, connect to the gay communities and seek sexual partners,^{107–109} technology has become an effective tool for researchers to conduct HIV prevention interventions among MSM. The technology-delivered interventions are no doubt time-saving and convenient and thereby are cost-effective. With online recruitment, researchers could reach MSM who may be hard to reach through traditional outreach in a cost-efficient means.^{42,110} Flexibility in delivery enables this type of intervention to hold more promise in promoting HIV testing in the context of COVID-19 where reduction of interpersonal contact is required. Nascent technologies (e.g. virtual reality, crowdsourcing and chatbot) were reported to be used in HIV prevention in recent years.^{111–115} More studies to determine their effect on MSM are required since the application of technology to HIV interventions is still at its infancy.

We identified three limitations associated with the technology-delivered interventions. First, given the ethnic/racial disparities in the use of technology for health-related purposes, Black and Latino MSM may be less likely to participate in online HIV prevention interventions and use Internet for HIV information.^{116–119} The second is the moderate level of engagement probably due to the lack of direct contact with research team.⁴⁶ For example, a mobile app-based study found that almost 20% of participants never downloaded/opened the app.²³ Potential strategies to improve participants’ engagement may include adoption of existing popular platforms, incorporation of individualized and interactive activities, and reminders sent from research team via text message or email. Last, development of the website or app remains a barrier. Commonly reported issues included insufficient guidance, technical problems (e.g. app crashing or slow responsiveness) and problems with user control and freedom.^{23,46,56,63} When pilot testing the Status Update Project mobile app, some participants appreciated its simplicity and reminders while others thought that it was too simple and repetitive.²³ Formative studies and pilot tests are required to learn participants’ preference and test the usability of the online interventions.

There are several common limitations to current HIV testing interventions regardless of their intervention modalities. First, there might be a mismatch between the complexity of HIV information content and participants’ health literacy. For example, participants with high health literacy thought that the health information was “simplistic” and they “did not fully get the opportunity to learn anything new.”^{47,63} Possible solution could be the development of intervention

content tailored to participants’ educational level and health literacy. Second, we observed diminished effect of the intervention across study periods.^{21–23} Attention should be paid to participants who did not have established HIV testing patterns before joining the study, given the evidence that these people were less likely to follow the intervention.²³ Furthermore, incorporation of personalized elements and booster sessions might be effective in extending the effect of intervention.^{21,64} Third, some people did not return or follow-up for test results^{35,36} while knowledge of HIV status is the first step in the initiation of treatment for HIV. Reminder to follow-up on and provision of testing results via text message, email or mobile app could be useful in promoting knowledge and acceptance of HIV status among MSM. Last, condomless sex may be concomitant with increased HIV testing due to mutual knowledge of HIV-negative serostatus among couples.^{20,59} Therefore, integration of sexual health education into interventions for HIV testing are necessary to reinforce the importance of sexual health while promoting HIV testing among MSM.

Compared to previous reviews of HIV testing interventions among MSM,^{27–29} our study extends the literature by aggregating up-to-date intervention strategies (e.g. gamification, personalization and couple-based intervention), comprehensively evaluating existing interventions in terms of acceptability, feasibility, efficacy and cost-effectiveness, and summarizing gaps/limitations in those interventions. Some limitations are also worth noting. First, the search terms used in this systematic review may not be comprehensive and therefore we were unable to include all relevant studies. Second, in addition to poor or fair methodological quality, some studies reported small sample size and short follow-up period, which might lead to low statistical power.^{23,36,38,41,75,80} High-quality RCTs with a large sample size and a long follow-up period are warranted to replicate their results. Finally, most studies evaluated the efficacy of the interventions by measuring self-reported binary HIV testing, which was prone to recall bias and social desirability bias.^{20,21,24–26,34,35,38,39,42–44,49–51,54,57,61,67,68,73–75,78–81} Objective measures of HIV testing behavior are further required. In addition, future studies should take into account more aspects of HIV testing such as knowledge, attitudes, barriers and repeat HIV testing when evaluating their interventions.

Conclusion

MSM continue to be disproportionately affected by HIV in the United States. Low uptake of HIV testing in general, and of repeat testing among MSM is concerning. Not testing and infrequently testing may exasperate negative health outcomes, late initiation of HIV treatment, further engagement in condomless sex, and potential onward transmission of HIV. Development of interventions to improve MSM’s HIV testing rates and frequency has proliferated in recent years. Most common interventions were those focused on HST,

interpersonal level, personalized, and technology delivered. These interventions hold promise in expanding the coverage of HIV testing among MSM in the United States given their acceptability, feasibility and efficacy. Researchers are presented with opportunities to overcome the limitations we identified in this review and provide more evidence to demonstrate the effect of interventions to improve HIV testing uptake and frequency among MSM in the United States.

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Author contributions

Y.L. designed the research study. Y.W. led the systematic review and drafted the first version of this manuscript. Y.W. and Y.L. conducted title and abstract screening. Y.W. conducted full-text review and extracted data which were cross-checked by Y.L. J.M. reviewed and revised the manuscript. All authors critically interpreted the results and revised the manuscript. All authors have read and approved the final manuscript.

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Supplemental material

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