



Theory-Based Text-Messaging to Reduce Methamphetamine Use and HIV Sexual Risk Behaviors Among Men Who Have Sex with Men: Automated Unidirectional Delivery Outperforms Bidirectional Peer Interactive Delivery

Cathy J. Reback^{1,2}  · Jesse B. Fletcher¹ · Dallas A. Swendeman² · Mitch Metzner¹

Published online: 13 July 2018
© Springer Science+Business Media, LLC, part of Springer Nature 2018

Abstract

Project Tech Support2 was a randomized controlled trial that tested three methods of text message delivery for reducing methamphetamine use and HIV risks among MSM. From March 2014 to January 2016, 286 methamphetamine-using MSM were randomized into: (1) interactive text conversations with Peer Health Educators, plus five-times-a-day automated theory-based messages, plus a weekly self-monitoring text-message assessment (TXT-PHE; $n = 94$); or, (2) the daily automated messages and weekly self-monitoring assessment (TXT-Auto; $n = 99$); or, (3) weekly self-monitoring assessment only (AO; $n = 93$). All three conditions demonstrated reductions in methamphetamine use (coef. = -0.10), sex on methamphetamine (coef. = -0.09), and condomless anal intercourse (CAI) with casual male partners (coef. = -0.06). Only participants in TXT-PHE and TEXT-Auto also reduced CAI with main male partners (coef._{TXT-PHE} = -0.19 ; coef._{TXT-Auto} = -0.16), and only TEXT-Auto participants reduced CAI with anonymous male partners (coef. = -0.05). Additionally, both theory-based text-messaging interventions achieved sustained reductions in five of the six outcomes through 9 months. Overall, automated delivery outperformed peer-delivered messaging.

Keywords Men who have sex with men (MSM) · Methamphetamine · HIV · mHealth · Text messaging (SMS)

Introduction

Methamphetamine Use and Sexual Risk Among Men Who Have Sex with Men

In the United States (U.S.), methamphetamine use is estimated to be between two-to-four times higher among gay, bisexual, and other men who have sex with men (MSM) relative to their heterosexual counterparts [1, 2], and among MSM methamphetamine use is associated with increased numbers of sexual partners and increased engagement in condomless anal intercourse (CAI; 3), as well as increased risk for transmission of HIV [3–5]. Though often

characterized as a drug predominantly used by Caucasian/White MSM, research has long demonstrated significant uptake of methamphetamine among African American/Black [6–9] and non-white Hispanic MSM [10–12]. Relative to Caucasian/White MSM methamphetamine users, African American/Black MSM methamphetamine users are less likely to inhabit traditionally gay social spaces and institutions, are more likely to be HIV positive, have lower educational attainment, and have lower income [9]. Similarly, Hispanic/Latino MSM methamphetamine users are unlikely to rate highly on “Hispanicism,” are more likely to identify as gay and, relative to Caucasian/White MSM methamphetamine users, have lower educational attainment, and are less likely to be fully employed [10, 13].

Technology-Based Interventions to Improve MSM Health

Research has demonstrated that MSM utilize Internet resources for locating sexual partners [14–16]. Among

✉ Cathy J. Reback
reback@friendsresearch.org

¹ Friends Research Institute, Inc., 1419 N. La Brea Ave., Los Angeles, CA 90028, USA

² Center for HIV Identification, Prevention and Treatment Services, University of California, Los Angeles, CA, USA

MSM, Internet sites and mobile phone applications (apps) used for sexual partner selection have been associated with increased odds of both methamphetamine use and HIV sexual risk behaviors [17]. Mobile phone ownership is higher among MSM than among their non-MSM counterparts [18, 19], including racial minority MSM [20, 21], and MSM report high levels of comfort in seeking out and receiving health-related information, including sexual health-related information, from their mobile phones [18, 22–25].

Intervention delivery via Internet-based and mobile phone technology has consistently demonstrated promising results among stigmatized populations including MSM, substance users, the obese, those with suicidal ideation, the homeless, and persons living with HIV and other chronic medical conditions [19, 26–31]. Meta-analytic evidence suggests that the primary barriers discouraging MSM methamphetamine users from accessing methamphetamine abuse treatment are psychosocial in nature (e.g., stigma/embarrassment, privacy concerns; [32, 33]), obstacles which are endemic to brick-and-mortar treatment modalities but which can easily be addressed through technology-based delivery. The ability to send and receive text messages has been highlighted as a particularly well-suited tool to intervene in the risk behaviors of MSM [34, 35]. In contrast to other technology-based interventions, (1) text messaging is reliant only upon cellular, rather than more expensive and/or inconsistent Internet connectivity, and (2) unlimited SMS functionality is a common inclusion service in most contemporary mobile phone contracts. Furthermore, text message interventions can be easily and inexpensively modified to be targeted, tailored, and personalized to specific participants.

Use of text messages in mobile health (mHealth) interventions for MSM have shown numerous beneficial effects, including significant increases in study retention specifically among minority MSM [36]. Evidence demonstrates that methamphetamine-using MSM provide particularly complete records of their methamphetamine use when queried periodically via text message than when assessed on computer-administered interview alone [37, 38]. Among HIV-negative MSM, administration of text messages related to sexually transmitted infections (including HIV) significantly increases rates of STI/HIV testing [39], and among MSM living with HIV, receiving text messages has been associated with increased medication adherence and improved viral load/CD4 outcomes [40].

Our prior text-messaging research demonstrated associations between application of theory-based text messages and reduced reports of methamphetamine use and HIV risk behaviors among MSM, though the pilot study employed a small sample and lacked the control group necessary to isolate specific intervention effects [41–43], indicating the need for a randomized controlled trial. Extending upon such preliminary evidence, this randomized controlled trial isolated

the immediate and sustained effects of three nested methods of text message delivery designed to reduce methamphetamine use and HIV sexual risk behaviors among out-of-treatment MSM. It was hypothesized that among this sample of non-treatment seeking methamphetamine-using MSM, the magnitude of reductions in reported days of methamphetamine use and episodes of condomless sexual behaviors would be greater from theory-based interactive text messages transmitted by Peer Health Educators (TXT-PHE) than by unidirectional text messages transmitted by automation (TXT-Auto), which in turn will produce significantly greater reductions than the assessment only (AO) attentional control condition based on self-monitoring principles. The widespread adoption of mobile phone-based text-message interventions are dependent upon the identification and optimization of efficacious delivery methods.

Methods

Participants

Participants (N = 286) enrolled from March 2014 through January 2016. Eligibility criteria were self-identified MSM, between the ages of 18–65 years, used methamphetamine within the previous three months, reported CAI (includes insertive and receptive behaviors) with a non-primary male partner in the previous 6 months, not currently in treatment or seeking methamphetamine abuse treatment, has a personal cell phone with unlimited texting service and the capacity to charge the phone daily, able and willing to provide informed consent and comply with study requirements. Individuals were excluded if they did not meet all criteria, were unable to understand the Informed Consent Form (unable to pass a consent quiz), or were determined to have a more serious psychiatric condition (Structured Clinical Interview for the DSM-V-MINI [SCID-MINI] verified) that was beyond the safe enrollment of the study procedures.

Procedures

Participants responded to a community-wide recruitment effort designed to reach a diversity of methamphetamine-using MSM, and included street- and venue-based outreach (e.g., sex clubs, bathhouses, dance clubs, stroll streets, bars), print media (e.g., magazines that target gay communities), online social media site advertisement and geolocation-based dating apps, flyers and posters distribution, and participant referral. Potential participants were screened for eligibility and scheduled for an in-person intake, including all baseline evaluations, within 24–48 h of their initial inquiry. Following screening and informed consent, participants completed a baseline Audio Computer Assisted Self Interview (ACASI)

assessment comprised of the behavioral measures. All study procedures were conducted in English. At the completion of the ACASI assessment, participants were administered the SCID-MINI by a research assistant, and biomarker testing for HIV, STIs and drug screening. Participants received a follow-up ACASI at 8-weeks (intervention completion), 3-, 6-, and 9-months post-enrollment. Participants were encouraged to notify study staff immediately if they lost their cell phone or changed their cell phone number; given that the SMS intervention phase only lasted 8 weeks, lost phones or changed numbers were rare. Per CDC guidelines for HIV and STI testing (i.e., every 3 months for high-risk individuals), the biomarkers were tested at all follow-up time points with the exception of the 8-week assessment. Participants were compensated with a \$25 gift card for completing all the admission procedures, a \$25 gift card for completing the 8-week follow-up assessment, and a \$50 gift card for completing the 3-, 6-, and 9-month follow-up assessments. All research activities occurred at a community research center in the Hollywood area of Los Angeles County, California that had worked continuously with methamphetamine-using MSM for over two decades; such rapport and familiarity assisted in overcoming stigma associated with methamphetamine use or other characteristics. Study procedures were approved by the Friends Research Institute Institutional Review Board and the University of California, Los Angeles Institutional Review Boards.

Interventions

TXT-PHE: Interactive Text-Messaging Conversations with Peer Health Educators, Plus Theory-Based, Gay-Specific Text Messages Transmitted by Automation, Plus Weekly Self-Monitoring Text-Based Assessments

Participants assigned to this condition engaged in interactive text message conversations with a PHE, received five automated scripted text messages per day, plus a brief weekly text-based assessment querying their methamphetamine use and HIV sexual behaviors in the previous 7 days. The text messages transmitted via a PHE were interactive and adaptive to the needs of the individual participant, and focused on health promotion and referrals. PHEs initiated text messages to participants and also responded to participant-initiated queries and participant responses to the PHE messages. To allow the text message conversation to flow, the PHE also transmitted extemporaneous HIV prevention text messages, which were found during the pilot study to be easily integrated with the scripted text messages [42].

Before each participant left the study site, immediately following the baseline visit, the participant received the first welcome message. The initial message was not a theory-based or gay-specific message, but rather a welcome

message that verified that the participant was properly registered into the text-messaging platform such as “Thank you for your participation!” or “Welcome to PTS!”

Immediately following the initial welcome message, the five-per-day automated scripted messages began. Participants who responded to the scripted text messages or initiated queries or requests for support were sent real-time messages back from the PHE. To maintain dosing consistency between text messaging correspondences, the PHE had an upper limit of approximately 20 messages sent per party (i.e., 20 messages from the PHE to the participant and 20 messages from the participant to the PHE), or 40 messages total per text-messaging conversation. The PHE could engage in a maximum of four “text-messaging conversations” per day, per participant. Text messages were transmitted and responded to in real time, at the peak hours of high-risk activities, which were determined in the pilot study [35] to be: Monday and Tuesday 12:00PM to 8:00PM, Wednesday and Thursday 12:00PM to 1:00AM, Friday 12:00PM to 2:00AM, Saturday 3:30PM to 2:00AM, and Sunday 3:30PM to 12:00AM. Participants never received the same scripted text message twice.

Following the 8-week intervention period, participants received post-intervention “stay in touch” such as “Hi! Your follow-up visit is a couple weeks away. It will be good to see you again.” The “stay in touch” messages were used to maintain a high follow-up rate and to schedule the follow-up appointments.

TXT-Auto: Theory-Based, Gay-Specific, Text Messages Transmitted by Automation, Plus Weekly Self-Monitoring Text-Based Assessments

Participants assigned to the TXT-Auto condition received the same theory-based, gay-specific, scripted text messages as those transmitted in the TXT-PHE condition and followed the same procedures for the 8-week intervention as the TXT-PHE condition but without the interactive component consisting of participant-initiated queries or the extemporaneous text messages transmitted by PHE. For the 8-week intervention the participant received five automated scripted text messages per day. All text messages sent by automation were transmitted in real time during the same identified high-risk hours as the TXT-PHE condition. Similarly, participants in the TXT-Auto condition also received the brief weekly text-based assessment on their methamphetamine use and HIV sexual behaviors in the previous 7 days and follow-up appointment reminder messages.

AO: Weekly Self-Monitoring Text-Based Assessments

Participants assigned to the AO condition received the same welcome message and brief weekly text-based assessment

on their methamphetamine use and HIV sexual behaviors in the previous 7 days, as well as follow-up appointment reminders, but did not receive any other text messages. The AO condition provided an attentional control and ensured that intervention effects from the TXT-PHE and TXT-Auto conditions were not merely the result of receiving weekly assessments regarding their methamphetamine use and HIV sexual risk behaviors as such repeated assessments may act as a low-intensity self-monitoring intervention [25].

The Project Text Support 2 Text-Message Library and Platform

Six-hundred-and-sixteen scripted text messages were written for the study, in collaboration with community/peer focus groups. Each was based on one of the theoretical constructs identified during the pilot study: Social Support Theory, Social Cognitive Theory, and Health Belief Model [43]. These theories of behavioral change were originally selected in the pilot study as each contain theoretical principles that have proven efficacy in numerous evidenced-based behavior change studies, and each represent a distinct yet complementary theoretical design. All scripted text messages were gay-specific, i.e., used gay cultural references and/or language such as the following Social Support Theory (Informational Support) message scripted for a participant who is HIV positive, “Poz N using? Not a good cocktail. You deserve to be healthy.” Or the following Social Cognitive Theory message scripted for a participant who is an injection drug user, “You have a choice, don’t trade your rig for sex.” Or the following Health Belief Model message scripted for a participant who is the insertive partner in condomless anal sex, “Using? Tops get STDs, too.”

The scripted text messages were categorized in an electronic database, by their theoretical construct and by the participants’ profile (e.g., HIV status, whether a participant is an injection drug user). Each participant’s risk profile was electronically created based on responses to questions administered in the baseline ACASI, and included: (A) HIV status; (B) ART adherence [only if also HIV positive]; (C) injection drug user; (D) drug use and sex location (e.g., public sex environment and/or commercial sex venue); (E) insertive anal sex partner only; (F) receptive anal sex partner only; and (G) no additional risk profile other than methamphetamine use and sexual risk based on eligibility criteria. Participants only received text messages that fit their specific risk profile (e.g., only a participant reporting injection drug use would receive a text message about safer needle practices). Participants received theory-based text messages personally tailored to fit their self-reported risk profile; the text messages were then randomly selected at baseline for automated administration during the 8-week intervention.

During the 8-week intervention period, each participant in the TXT-PHE and TXT-Auto conditions received a total of 280 scripted theory-based, gay-specific text messages (5 messages/day \times 7 days/week \times 8 weeks = 280 messages). If a participant self-reported additional A–F risk profile(s), the general message(s) would be replaced with a tailored risk profile message. Thus, 56 messages were written for each risk profile (1 message/day \times 7 days/week \times 8 weeks = 56 messages). Given that there were six additional risk profiles (i.e., A–F risk profiles), in total, 336 additional risk profile messages were written (6 risk profiles \times 1 message/day \times 7 days/week \times 8 weeks = 336 risk profile messages). In sum, 616 theory-based, gay-specific messages were written for the 8-week intervention (280 general methamphetamine use and sexual risk reduction messages plus 336 risk profile messages).

Dimagi Inc. (www.dimagi.com), a mHealth development company, programmed the text messaging software system and hosted the system on their HIPAA secure servers. The study investigators provided Dimagi with the 616 pre-written text messages and schedules for automatically delivered messages (i.e., welcome messages, weekly assessments, appointment reminders, and five random messages sent each day). The text-message platform included a menu-driven web-interface for selecting text messages by a PHE to send one of the 616 scripted text messages, through the searchable key word feature. To easily select a scripted text message from the message library and/or to craft an appropriate extemporaneous message, the PHE’s dashboard displayed the risk profile for each participant in the TXT-PHE condition. Message histories were displayed on the dashboard, which allowed different PHEs to maintain continuity of personalized responses. The web-based, menu-driven system also allowed automatic logging, tracking, and reporting of the specific messages sent, by which PHE, when, and to whom, including reporting and a dataset based on message categories and theoretical constructs.

Measures

Behavioral Risk Assessment-Lite (BRA-Lite): The BRA-Lite is a reduced version of the Behavioral Risk Assessment developed by the first author. The BRA-Lite assessed participant sociodemographic characteristics (e.g., sexual identity, race/ethnicity, educational attainment).

Behavioral Questionnaire—Amphetamine (BQA): The BQA gathered information on HIV-related drug and sexual risk behaviors. Developed by investigators at the University of California at San Francisco, Center for AIDS Prevention Studies [44] and modified, in consultation with the developers, for behavioral studies with methamphetamine-using MSM [45], the BQA collected detailed data on sexual behaviors with main, casual, anonymous, and exchange

partners, as well as engagement in sexual risk while under the influence of alcohol/drugs. A main partner was defined as a person with whom the participant had a relationship where they felt committed to above anyone else and with whom they have had sex. A casual partner was defined as a person that the participant knew, with whom they had sex, but did not consider their main partner. An anonymous partner was defined as someone the participant had sex with, but who they did not know before the sexual encounter and might not know their name. An exchange partner was defined as someone the participant had sex with in exchange for something the participant needed such as money, drugs, shelter, or food.

Structured Clinical Interview for Diagnostic Statistical Manual of Mental Disorders—Fifth Edition (SCID) Mini International Neuropsychiatric Interview (MINI): The SCID-MINI elicits symptom criteria for DSM-5 for substance use disorder severity [46, 47]. The SCID-MINI was administered at baseline only.

HIV Testing: Participants were asked to self-report their HIV status via an ACASI, thus reducing the likelihood of false reporting. Following the baseline ACASI all HIV-negative and status-unknown participants (including any participant unable to provide documentation of their HIV positive status) received a rapid HIV-antibody finger stick blood test (OraQuick). If the test was reactive, the participant was retested with a second rapid finger stick blood test (Clearview Complete). If that test was reactive, the participant was presumed to be positive for HIV antibodies and referred for additional evaluation and treatment. If the second test produced a negative result, then the opposing results of the first test and second test were said to be discordant and the participant was referred for additional evaluation and treatment. Participants who showed documentation of their HIV-positive serostatus (e.g., ART medication, laboratory results) were not given a HIV-antibody test.

STI Testing: Participants were tested for urinary *N. gonorrhoea* and Chlamydia; pharyngeal and rectal swabs were taken for *N. gonorrhoea* and Chlamydia (Aptima). Syphilis was tested by serum RPR, and confirmed by FTA-ABS testing. Positive STI results were reported per state guidelines and participants were immediately referred to care.

Statistical Analysis

The primary outcomes were days of methamphetamine use, episodes of sex while under the influence of methamphetamine, and number of episodes of CAI with main male, casual male, anonymous male, and/or exchange male partners. All data were self-reported and all variables used a 30-day recall period. Descriptive statistics were calculated for all variables according to their level of measurement (counts and percentages for nominal variables, means and

standard deviation for counted and continuous variables). Contrasts across random study condition assignment were carried out using Chi square tests for categorical variables and ANOVAs for count and continuous variables. During bivariate contrasts it was discovered that the three study conditions demonstrated significantly different patterns of HIV sexual risk behaviors at baseline, in spite of randomization. To account for such baseline differences during multivariable analyses, and to overcome potential “floor” effects for conditions demonstrating lower baseline risk, outcome variables were standardized [i.e., mean = 0; standard deviation (SD) = 1] within study condition according to each condition’s observed baseline values. Multivariable analyses took the form of six discrete robustly estimated generalized linear longitudinal multilevel models with the Gaussian family and identity link function (to account for the positive/negative values and continuous nature of the standardized outcome variables). Observations were nested within participants, and outcomes were regressed simultaneously on random group assignment, study time point, and their interaction. Age and HIV status were included in all multivariable models as statistical controls, given their known associations with both methamphetamine use and HIV sexual risk behaviors among MSM. All statistical analyses were carried out using Stata 13SE, and all multivariable statistical tests are two-tailed. Given the inclusion of multiple interaction effects and thus the inflated probability of a Type-II hypothesis error, results are flagged at $p \leq 0.10$.

Results

Study Progression and Retention

Figure 1 illustrates the study progression and retention from initial screening through 9-month follow-up evaluations. In total, 286 out-of-treatment, methamphetamine-using MSM enrolled in the study, of which, 94 were randomized into the TXT-PHE condition, 99 were randomized into the TXT-Auto condition, and 93 were randomized into the AO condition. Total participant follow-up rates were 83.8% at intervention completion (i.e., 8 weeks), 89.7% at 3-months follow-up, 86.3% at 6-month follow-up, and 92.7% at 9-month follow-up.

Participant Characteristics

Table 1 indicates no significant differences in sociodemographic characteristics, methamphetamine use disorder severity, or average response rates to weekly attentional control assessments across random study condition assignment. Participants averaged 42 years of age (range = 18–65 years), predominantly self-identified

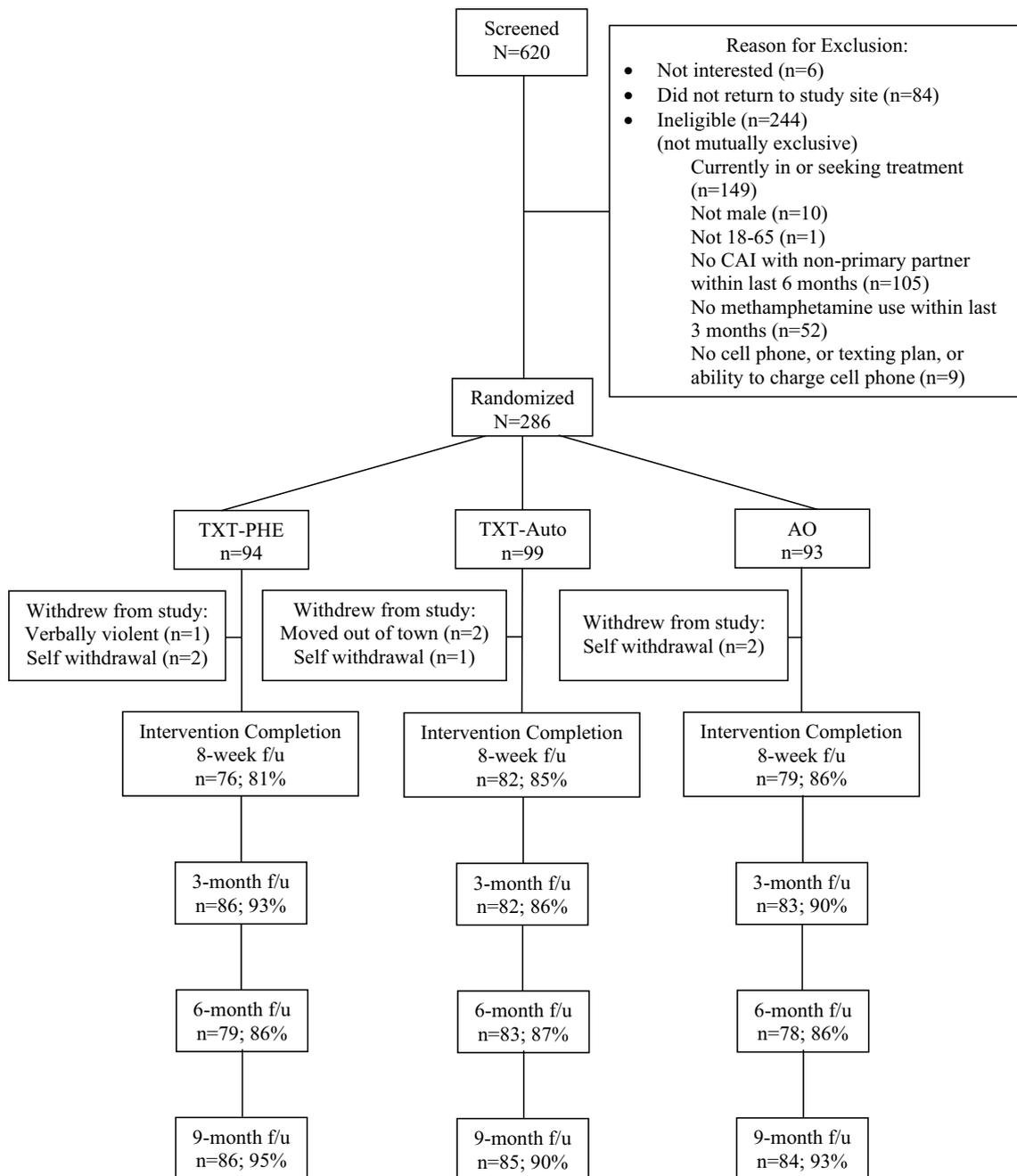


Fig. 1 CONSORT diagram: study progression and retention

as African American/Black (44%) or Hispanic/Latino (25%), self-identified as gay (67%), and most had achieved at least a high school diploma (82%). Biomarker testing and/or medical/pharmacy record verification revealed a HIV-positivity rate at baseline of 41%. Most participants were diagnosed, via the SCID-MINI, with current severe methamphetamine use disorder at intake (64%). The average response rate to the weekly text message assessments was 63%.

Methamphetamine Use and Sexual Risk Behaviors Intervention Effects

Immediate reductions in primary outcomes (i.e., days of methamphetamine use, episodes of sex while under the influence of methamphetamine, and CAI with main/casual/anonymous/exchange male partners) refer to reductions observed at intervention completion (i.e., 8-weeks post randomization); sustained reductions in primary outcomes

Table 1 Participant sociodemographic characteristics, methamphetamine use disorder severity at baseline, and response rates to weekly attention control surveys by study condition

	TXT-PHE		TXT-Auto		AO		Total		Significance	
	(n = 94)		(n = 99)		(n = 93)		(N = 286)		Tests	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Metric	Prob.
	Or N	Or %	Or N	Or %	Or N	Or %	Or N	Or %		
Age										
Years	42	11.3	41	11.1	41.4	10.2	41.5	10.9	$F_{(2,283)}=0.22$	$p=0.800$
Racial/ethnic identity										
Caucasian/White	20	21.3%	16	16.2%	20	21.5%	56	19.6%	$\chi^2_{(6)}=3.74$	$p=0.712$
African American/Black	40	42.6%	45	45.5%	40	43.0%	125	43.7%		
Hispanic/Latino	20	21.3%	29	29.3%	23	24.7%	72	25.2%		
Multiracial/other	14	14.9%	9	9.1%	10	10.8%	33	11.5%		
Sexual orientation										
Gay Identified	66	70.2%	68	68.7%	58	62.4%	192	67.1%	$\chi^2_{(2)}=1.47$	$p=0.479$
Non gay identified	28	29.8%	31	31.3%	35	37.6%	94	32.9%		
Educational attainment										
			*n = 97		*n = 92		*n = 282			
Less than HS Graduate/GED	16	17.2%	17	17.5%	17	18.5%	50	17.7%	$\chi^2_{(6)}=3.34$	$p=0.766$
High School Graduate/GED	26	28.0%	32	33.0%	28	30.4%	86	30.5%		
Some College	32	34.4%	27	27.8%	34	37.0%	93	33.0%		
College Graduate	19	20.4%	21	21.7%	13	14.1%	53	18.8%		
HIV status										
HIV positive	37	39.4%	42	42.4%	39	41.9%	118	41.3%	$\chi^2_{(2)}=0.21$	$p=0.899$
HIV negative	57	60.6%	57	57.6%	54	58.1%	168	58.7%		
Methamphetamine use disorder severity (current)										
None	12	12.8%	11	11.1%	8	8.6%	31	10.8%	$\chi^2_{(6)}=3.92$	$p=0.688$
Mild	11	11.7%	10	10.1%	16	17.2%	37	12.9%		
Moderate	13	13.8%	10	10.1%	12	12.9%	35	12.2%		
Severe	58	61.7%	68	68.7%	57	61.3%	183	64.0%		
Weekly attentional control survey										
Overall response rate	61.9%		61.2%		66.5%		63.2%		$\chi^2_{(2)}=5.32$	$p=0.070$

were defined as significant reductions from baseline evident at 9-months post randomization. As Table 2 demonstrates, participants in all three study conditions achieved immediate reductions in self-reported episodes of sex while under the influence of methamphetamine, as well as in self-reported episodes of CAI with casual male sexual partners. Additionally, by 9-months post-randomization, participants in all three conditions sustained significant reductions in self-reported days of methamphetamine use, self-reported episodes of sex while under the influence of methamphetamine, and self-reported episodes of CAI with casual male partners. Both of the intervention conditions (TXT-PHE and TXT-Auto) achieved four of the six immediate reductions and five of the six sustained reductions. The AO control condition achieved three immediate and three sustained reductions.

Findings in Table 2 demonstrated significant baseline differences in two primary outcomes (i.e., episodes of CAI with main and casual male partners), implying the need for

adjusted multivariate analysis. Table 3, therefore, provides the results of six adjusted multivariate models, one for each of the six primary outcomes; results describe six discrete robustly estimated generalized linear multilevel models, each regressing standardized values of one primary outcome onto (a) random study condition assignment, (b) study time point (i.e., baseline and 8-weeks, 3-, 6-, and 9-months post-randomization follow-ups), and (c) their interaction. Results of multivariate models confirmed bivariate results and demonstrate that over time all three conditions evidenced significant reductions in methamphetamine use (coef. = - 0.10), episodes of sex while under the influence of methamphetamine (coef. = - 0.09), and episodes of CAI with casual male partners (coef. = - 0.06). Multivariate models also revealed, however, that participants in the AO condition significantly increased episodes of CAI with main male partners over time (coef. = 0.12), whereas participants in the TXT-PHE (coef. = - 0.19) and TXT-Auto (coef. = - 0.16) significantly

Table 2 Study outcomes by random study condition assignment and study time point

	Days of methamphetamine use (past 30 days)		Episodes of sex on methamphetamine		Episodes of CAI: main partners		Episodes of CAI: casual partners		Episodes of CAI: anonymous partners		Episodes of CAI: exchange partners	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TXT-PHE												
Baseline (n=94)	11.1	9.5	6.6	8.1	4.0 ^b	8.3	4.4 ^b	8.0	3.9	8.2	2.0	14.7
8-Weeks (n=75)	7.5 ^a	8.1	4.0 ^a	6.2	2.0	5.3	1.5 ^a	3.6	1.1 ^a	2.6	0.5	2.8
3-Months (n=86)	8.1 ^a	9.7	3.4 ^a	6.1	0.9 ^a	3.4	1.8 ^a	5.4	0.8 ^a	2.5	0.5	2.3
6-Months (n=79)	8.3	9.5	4.0 ^a	6.2	1.6 ^a	5.3	1.8 ^a	4.6	0.8 ^a	3.7	0.2	1.2
9-Months (n=86)	7.8 ^a	9.8	4.1 ^a	7.6	1.3 ^a	5.1	2.2 ^a	6.0	1.7 ^a	6.6	0.7	3.4
TXT-auto												
Baseline (n=99)	10.7	9.5	6.7	7.4	4.2 ^b	10.6	7.2 ^b	16.4	4.1	9.8	2.0	6.4
8-Weeks (n=83)	9.3	10.0	4.4 ^a	7.0	0.9 ^a	2.8	2.9 ^a	6.8	1.6 ^a	5.0	2.1	14.6
3-Months (n=82)	7.1 ^a	8.8	2.8 ^a	5.6	1.4 ^a	4.7	0.8 ^a	2.1	1.2 ^a	4.7	4.7	37.1
6-Months (n=83)	6.9 ^a	9.2	2.6 ^a	5.4	0.8 ^a	2.5	1.3 ^a	3.4	0.9 ^a	2.4	0.6	2.6
9-Months (n=85)	7.0 ^a	9.9	2.3 ^a	4.5	2.4	8.9	1.5 ^a	4.3	0.6 ^a	2.6	0.1 ^a	0.7
AO												
Baseline (n=93)	10.3	9.0	6.1	6.3	0.9 ^b	2.9	3.0 ^b	7.0	2.2	7.0	1.5	7.6
8-Weeks (n=79)	6.7 ^a	8.1	3.0 ^a	5.0	1.0	3.4	1.2 ^a	2.5	1.5	4.4	0.6	2.7
3-Months (n=83)	5.2 ^a	7.4	2.4 ^a	4.8	0.8	4.0	1.2 ^a	3.7	0.9	3.5	0.1	0.8
6-Months (n=78)	7.2 ^a	9.3	3.2 ^a	6.5	2.5	17.5	1.3	4.0	1.1	4.9	0.3	1.8
9-Months (n=84)	5.7 ^a	7.9	3.3 ^a	6.7	1.9	6.4	0.9 ^a	3.0	1.5	5.2	0.1	0.4

^aWithin-group (i.e., study condition) contrast: two-sample *t* test indicates a significant ($p \leq 0.05$, two-tailed) decrease from baseline

^bBetween-group (i.e., study condition) contrast: ANOVA indicates a significant ($p \leq 0.05$) difference between groups at baseline

reduced episodes of CAI with main male partners over time. Additionally, participants in the TXT-Auto condition significantly outperformed participants in the AO condition in their reductions of episodes of sex while under the influence of methamphetamine (coef. = - 0.05), as well as in their reductions of episodes of CAI with anonymous male partners (coef. = - 0.05).

Discussion

This sample of predominantly racial/ethnic minority MSM demonstrated high rates of methamphetamine use, engagement in sex while under the influence of methamphetamine, and engagement in CAI with male partners. The HIV prevalence rate of 41% closely matched the observed HIV prevalence rate of an earlier study with out-of-treatment, methamphetamine-using MSM in the same urban city (i.e., 42%), demonstrating consistently high HIV prevalence in this population [48]. Further, nearly two-thirds of all participants enrolled in the current study were diagnosed with a severe methamphetamine use disorder at baseline, again

corroborating the empirical association between methamphetamine use and risk for HIV infection among MSM.

Results demonstrated that assessments sent weekly via text message and designed to self-monitor both methamphetamine use and HIV sexual risk behaviors (the AO condition) served as a sufficient attentional control to prompt significant reductions in both methamphetamine use and CAI with casual male partners. This is a critical finding, particularly for scalability in resource-limited regions or agencies. Results further suggest that participants randomized to receive automated theory-based text messages (the TXT-Auto condition) outperformed the AO condition along multiple primary outcomes, including episodes of CAI with main and anonymous male partners, as well as episodes of sex while under the influence of methamphetamine. Finally, results indicated no additional benefit from engaging in interactive text messaging conversations with Peer Health Educators (the TXT-PHE condition), contrary to hypothesized outcomes.

Though it was hypothesized that the highest-intensity condition (i.e., TXT-PHE) would be the most effective at eliciting behavioral change, findings demonstrated that self-monitoring weekly text-message assessments only (i.e., AO) were sufficient to prompt reductions in methamphetamine

Table 3 Robust generalized linear longitudinal multilevel model of participant methamphetamine use and HIV sexual risk behaviors on random study condition assignment and study time point; outcomes standardized within study condition by baseline values (N = 286)

	Days of MA use		Episodes of sex while on MA		Episodes of CAI: main partners		Episodes of CAI: casual partners		Episodes of CAI: anonymous partners		Episodes of CAI: exchange partners	
	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI
Main effects-random condition assignment												
TXT-PHE	-0.12	-.37; .12	0.05	-.14; .25	-0.04	-.43; .36	-0.04	-.19; .12	-0.09	-.25; .07	0.00	-.37; .38
TXT-Auto	-0.03	-.21; .14	0.11	-.07; .30	-0.08	-.48; .31	-0.01	-.16; .14	-0.05	-.20; .11	0.17	-.20; .55
AO	-ref	cat-	-ref	cat-	-ref	cat-	-ref	cat-	-ref	cat-	-ref	cat-
Main effect-study time point												
Time [0 thru 4]	-0.10*	-.14; -.06	-0.09*	-.13; -.04	0.12*	.00; .23	-0.06*	-.10; -.02	-0.03	-.06; .01	-0.04	-.15; .06
Interaction effects-condition X time point												
TXT-PHE*Time	0.03	-.02; .09	0.03	-.03; .09	-0.19*	-.35; -.02	0.01	-.04; .06	-0.03	-.08; .02	0.02	-.13; .17
TXT-Auto*Time	0.01	-.04; .06	-0.05†	-.11; .009	-0.16†	-.31; .003	-0.01	-.06; .03	-0.05†	-.10; .003	-0.03	-.18; .11
Constant	0.08	-.22; .38	-0.10	-.39; .19	0.40	-.10; .90	0.11	-.11; .32	0.17	-.06; .40	0.21	-.26; .68

Statistical controls: participant age (years) & HIV status (biomarker confirmed; 0/1)
 MA Methamphetamine, CAI condomless anal intercourse (insertive or receptive)
 * $p \leq 0.05$; † $p \leq 0.10$

use and CAI with casual male partners, and that receiving automated theory-based text messages actually outperformed interactive text message conversations with Peer Health Educators for reducing CAI with anonymous partners. This finding may also be understood by examining the distinction between didactic and Socratic communication methods (represented by “one-way” vs. “two-way” text-messaging communication, respectively; [24]), and their relative appropriateness for methamphetamine-using MSM. Automated text messages are inherently didactic, as they presume a “top-down” approach to information transfer; the model presumes that the participant’s role is to learn, and the phone’s role is to teach. Conversely, the TXT-PHE condition was premised on the Socratic method of communication. Both participants and Peer Health Educators have important information to contribute to the communication, it has become a conversation rather than an explicit opportunity for the participant to learn. The “social distance” between the participant and the purveyor of information is reduced in the Socratic method, as each party is considered a contributing member to the shared knowledge pool. Evidence from this study may indicate that methamphetamine-using MSM exhibit slightly superior responses to didactic methods of instruction (an insight which may have important implications for face-to-face interventions with methamphetamine-using MSM, as well), though further research is needed.

Limitations and Conclusions

These findings must be interpreted in light of the study limitations. This study was limited by its lack of a true control condition, as well as the use of a convenience sample of MSM who voluntarily enrolled in a study to reduce their methamphetamine use and engagement in HIV sexual risk behaviors, both of which limit the ability to distinguish behavioral change in the AO condition from epiphenomenal changes that would have occurred even in the absence of this study. Furthermore, the study was conducted in a large metropolitan city in the southwestern United States and generated a sample whose racial/ethnic composition and level of methamphetamine use do not reflect national averages or broader communities of MSM in the U.S.; results may not be generalizable to MSM who do not use methamphetamine, who do not have a severe methamphetamine use disorder, MSM who live in rural or predominantly Caucasian/White communities, to those who are actively seeking treatment for their methamphetamine use, or other MSM in general.

The study hypothesis, i.e., that reductions in methamphetamine use and HIV sexual risk behaviors would be greater from interactive text messages transmitted by Peer Health Educators (TXT-PHE) than by unidirectional text messages transmitted by automation (TXT-Auto), which in turn will produce significantly greater reductions than the

assessment only (AO) condition, was not achieved. Rather, in this sample of methamphetamine-using, non-treatment seeking, but risk-reduction seeking MSM, the application of a weekly text message assessment on methamphetamine use and sexual risk behaviors was associated with significant reductions in rates of methamphetamine use, engagement in sex while under the influence of methamphetamine, and CAI with casual male partners. Theory-based text messages sent via automation augmented these results, and further demonstrated reductions in CAI with anonymous male partners; whereas, interactive text messaging conversations with Peer Health Educators failed to improve upon results achieved through automation.

Resource-limited environments and/or service providers working with methamphetamine-using MSM for whom the automated delivery of theory-based text messages is not feasible may consider adopting an intervention consisting of a weekly text-message assessment whereby participants can self-monitor their drug- and sexual-risk behaviors. Findings presented here suggest that, among this sample, even such limited attentional control can have significant positive impacts on methamphetamine use and HIV sexual risk behaviors. For researchers, service providers, and policy makers interested in a higher level of technology-based intervention, automated unidirectional delivery of theory-based text messages may augment weekly self-monitoring assessment to increase positive outcomes, especially HIV sexual risk behaviors outcomes. Additionally, automated messaging is substantially easier to scale compared to peer-mediated messaging as neither staffing nor training are involved. Weekly self-monitoring assessments are even easier to deliver in terms of replication and adaptation, and eliminate the SMS costs (approximately 2 cents per messages in the U.S.). Future replications for other populations and outcomes might consider a staged approach of starting with self-monitoring assessments that may have impacts on some outcomes while the potentially more efficacious theory-based and tailored text-messages may be developed to improve impacts on other outcomes. These findings are very promising for the dissemination and scalability of this and other text-messaging interventions.

Acknowledgements Funding for this study was provided by the National Institute on Drug Abuse, Grant #R01DA035092. Drs. Reback and Swendeman acknowledge additional support from the National Institute of Mental Health (P30MH58107). The authors would like to thank Raymond P. Mata for his outstanding work as senior research assistant during the implementation of the study.

Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

- Center for Behavioral Health Statistics and Quality [CBHSQ]. Key substance use and mental health indicators in the United States: results from the 2015 National Survey on Drug Use and Health (HHS Publication No. SMA 16-4984, NSDUH Series H-51). 2016. Retrieved from <http://www.samhsa.gov/data>.
- Medley G, Lipari RN, Bose J, Cribb DS, Kroutil LA, McHenry G. Sexual orientation and estimates of adult substance use and mental health: Results from the 2015 National Survey on Drug Use and Health. NSDUH Data Review. 2016. Retrieved from <http://www.samhsa.gov/data>.
- Hoenigl M, Chaillon A, Moore DJ, Morris SR, Smith DM, Little SJ. Clear links between starting methamphetamine and increasing sexual risk behavior: a cohort study among men who have sex with men. *J Acquir Immune Defic Syndr*. 2016;71(5):551–7.
- Halkitis PN, Levy MD, Solomon TM. Temporal relations between methamphetamine use and HIV seroconversion in gay, bisexual, and other men who have sex with men. *J Health Psychol*. 2016;21(1):93–9.
- Vu NT, Maher L, Zablotska I. Amphetamine-type stimulants and HIV infection among men who have sex with men: implications on HIV research and prevention from a systematic review and meta-analysis. *J Int AIDS Soc*. 2015;18(1):19273.
- Sexton RL, Carlson RG, Siegal HA, Falck RS, Leukefeld C, Booth B. Barriers and pathways to diffusion of methamphetamine use among African Americans in the rural South: preliminary ethnographic findings. *J Ethn Subst Abuse*. 2005;4(1):77–103.
- Wu E, El-Bassel N, McVinney LD, Fontaine YM, Hess L. Adaptation of a couple-based HIV intervention for methamphetamine-involved African American men who have sex with men. *Open AIDS J*. 2010;4:123.
- Flynn KC, Hoffer LD. Transitioning illicit drug preferences and emerging user identities in Ohio: the proliferation of methamphetamine use among African Americans. *J Ethn Subst Abuse*. 2017. <https://doi.org/10.1080/15332640.2017.1325809>.
- Halkitis PN, Jerome RC. A comparative analysis of methamphetamine use: Black gay and bisexual men in relation to men of other races. *Addict Behav*. 2008;33(1):83–93. <https://doi.org/10.1016/j.addbeh.2007.07.015>.
- Fernández MI, Bowen GS, Warren JC, et al. Crystal methamphetamine: a source of added sexual risk for Hispanic men who have sex with men? *Drug Alcohol Depend*. 2007;86(2):245–52.
- Heinzerling K, Demirdjian L, Briones M, Swanson AN, Wu Y, Shoptaw S. Association of gender and genetic ancestry with frequency of methamphetamine use among methamphetamine-dependent Hispanic and non-Hispanic Whites. *Drug Alcohol Depend*. 2015;156:e94.
- Young SD, Shoptaw S. Stimulant use among African American and Latino MSM social networking users. *J Addict Dis*. 2013;32(1):39–45. <https://doi.org/10.1080/10550887.2012.759859>.
- Niv N, Hser YI. Drug treatment service utilization and outcomes for Hispanic and white methamphetamine abusers. *Health Serv Res*. 2006;41(4p1):1242–57.
- Goedel WC, Duncan DT. Geosocial-networking app usage patterns of gay, bisexual, and other men who have sex with men: survey among users of Grindr, a mobile dating app. *JMIR Public Health Surveill*. 2015;1(1):e4.

15. Phillips G, Magnus M, Kuo I, et al. Use of geosocial networking (GSN) mobile phone applications to find men for sex by men who have sex with men (MSM) in Washington, DC. *AIDS Behav.* 2014;18(9):1630–7.
16. Sarbu MI, Georgescu SR. Gay-Related smartphone applications: potential and risk—a review of the medical literature in the field. *J Mind Med Sci.* 2014;1(1):11–8.
17. Landovitz RJ, Tseng CH, Weissman M, et al. Epidemiology, sexual risk behavior, and HIV prevention practices of men who have sex with men using GRINDR in Los Angeles, California. *J Urban Health.* 2013;90(4):729–39.
18. Muessig KE, Pike EC, Fowler B, et al. Putting prevention in their pockets: developing mobile phone-based HIV interventions for Black men who have sex with men. *AIDS Patient Care STDS.* 2013;27(4):211–22.
19. Muessig KE, Nekkanti M, Bauermeister J, Bull S, Hightow-Weidman LB. A systematic review of recent smartphone, Internet and Web 2.0 interventions to address the HIV continuum of care. *Curr HIV/AIDS Rep.* 2015;12(1):173–90.
20. Du Bois SN, Johnson SE, Mustanski B. Examining racial and ethnic minority differences among YMSM during recruitment for an online HIV prevention intervention study. *AIDS Behav.* 2012;16(6):1430–5.
21. Hightow-Weidman LB, Pike E, Fowler B, et al. HealthMpowerment.org: feasibility and acceptability of delivering an internet intervention to young Black men who have sex with men. *AIDS Care.* 2012;24(7):910–20.
22. Aliabadi N, Carballo-Dieguez A, Bakken S, et al. Using the information-motivation-behavioral skills model to guide the development of an HIV prevention smartphone application for high-risk MSM. *AIDS Educ Prev.* 2015;27(6):522–37.
23. Goldenberg T, McDougal SJ, Sullivan PS, Stekler JD, Stephenson R. Preferences for a mobile HIV prevention app for men who have sex with men. *JMIR Mhealth Uhealth.* 2014;2(4):e47.
24. Muessig KE, Baltierra NB, Pike EC, LeGrand S, Hightow-Weidman LB. Achieving HIV risk reduction through HealthMpowerment.org, a user-driven eHealth intervention for young Black men who have sex with men and transgender women who have sex with men. *Digit Cult Educ.* 2014;6(3):164.
25. Swendeman D, Ramanathan N, Baetscher L, et al. Smartphone self-monitoring to support self-management among people living with HIV: perceived benefits and theory of change from a mixed-methods, randomized pilot study. *JAIDS.* 2015;69(s1):S80–91.
26. Afshin A, Babalola D, Mclean M, et al. Information technology and lifestyle: a systematic evaluation of internet and mobile interventions for improving diet, physical activity, obesity, tobacco, and alcohol use. *J Am Heart Assoc.* 2016;5(9):e003058.
27. Buhi ER, Trudnak TE, Martinasek MP, Oberne AB, Fuhrmann HJ, McDermott RJ. Mobile phone-based behavioural interventions for health: a systematic review. *Health Educ J.* 2013;72(5):564–83.
28. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. *Annu Rev Public Health.* 2015;36:393–415.
29. Jones KR, Lekhak N, Kaewluang N. Using mobile phones and short message service to deliver self-management interventions for chronic conditions: a meta-review. *Worldviews Evid Based Nurs.* 2014;11(2):81–8.
30. Luxton DD, June JD, Chalker SA. Mobile health technologies for suicide prevention: feature review and recommendations for use in clinical care. *Curr Treat Options Psychiatry.* 2015;2(4):349–62.
31. Rice E, Lee A, Taitt S. Cell phone use among homeless youth: potential for new health interventions and research. *J Urban Health.* 2011;88(6):1175–82.
32. Cumming C, Troeung L, Young JT, Kelty E, Preen DB. Barriers to accessing methamphetamine treatment: a systematic review and meta-analysis. *Drug Alcohol Depend.* 2016;168:263–73.
33. Parsons JT, Vial AC, Starks TJ, Golub SA. Recruiting drug using men who have sex with men in behavioral intervention trials: a comparison of internet and field-based strategies. *AIDS Behav.* 2013;17(2):688–99.
34. Déglise C, Suggs LS, Odermatt P. Short message service (SMS) applications for disease prevention in developing countries. *J Med Internet Res.* 2012;14(1):e3.
35. Lim MS, Hocking JS, Hellard ME, Aitken CK. SMS STI: a review of the uses of mobile phone text messaging in sexual health. *Int J STD AIDS.* 2008;19(5):287–90.
36. Khosropour CM, Johnson BA, Ricca AV, Sullivan PS. Enhancing retention of an Internet-based cohort study of men who have sex with men (MSM) via text messaging: randomized controlled trial. *J Med Internet Res.* 2013;15(8):e194.
37. Rowe C, Hern J, DeMartini A, et al. Concordance of text message ecological momentary assessment and retrospective survey data among substance-using men who have sex with men: a secondary analysis of a randomized controlled trial. *JMIR Mhealth Uhealth.* 2016;4(2):e44.
38. Zou H, Fairley CK, Guy R, et al. Automated, computer generated reminders and increased detection of gonorrhoea, chlamydia and syphilis in men who have sex with men. *PLoS ONE.* 2013;8(4):e61972.
39. Bourne C, Knight V, Guy R, Wand H, Lu H, McNulty A. Short message service reminder intervention doubles sexually transmitted infection/HIV re-testing rates among men who have sex with men. *Sex Transm Infect.* 2011;87(3):229–31.
40. Lewis MA, Uhrig JD, Bann CM, et al. Tailored text messaging intervention for HIV adherence: a proof-of-concept study. *Health Psychol.* 2013;32(3):248–53.
41. Reback CJ, Ling D, Shoptaw S, Rohde J. Developing a text messaging risk reduction intervention for methamphetamine-using MSM. *Open AIDS J.* 2010;4:116–22.
42. Reback CJ, Grant DL, Fletcher JB, et al. Text messaging reduces HIV risk behaviors among methamphetamine-using men who have sex with men. *AIDS Behav.* 2012;16(7):1993–2002.
43. Reback CJ, Fletcher JB, Shoptaw S, Mansergh G. Exposure to theory-driven text messages is associated with HIV risk reduction among methamphetamine-using men who have sex with men. *AIDS Behav.* 2015;19(2):S130–41.
44. Chesney MA, Barrett DC, Stall R. Histories of substance use and risk behavior: precursors to HIV seroconversion in homosexual men. *Am J Public Health.* 1998;88(1):113–6.
45. Twitchell GR, Huber A, Reback CJ, Shoptaw S. Comparison of general and detailed HIV risk assessments among methamphetamine abusers. *AIDS Behav.* 2002;6(2):153–62.
46. Fletcher JB, Swendeman D, Reback CJ. Associations between major depressive episode, methamphetamine use disorder severity, and engagement in sexual risk-taking among methamphetamine-using men who have sex with men. *AIDS Behav.* 2018;22:1461–6.
47. Fletcher JB, Swendeman D, Reback CJ. Mental health and substance use disorder comorbidity among methamphetamine-using men who have sex with men. *J Psychoactive Drugs.* 2018. <https://doi.org/10.1080/02791072.2018.1447173>.
48. Shoptaw S, Reback CJ. Methamphetamine use and infectious disease-related behaviors in men who have sex with men: implications for interventions. *Addiction.* 2007;102(s1):130–5.