Drug and Alcohol Dependence 242 (2023) 109718

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

# Crystal methamphetamine use and bacterial sexually transmitted infections (STIs) among gay, bisexual and other sexual minority men in Canada

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ARTICLE INFO

*Keywords:*
Crystal methamphetamine
Sexual Behavior
Sexually Transmitted Infections
Condom attitudes
Escape motives
Gay
Men Who Have Sex With Men

ABSTRACT

*Objective:* While crystal methamphetamine use by gay, bisexual, and other men who have sex with men (GBM) is associated with increased risk for sexually transmitted infection (STI) transmission, less is understood about the causal pathways between crystal methamphetamine use and STIs. We examined whether the association between greater crystal methamphetamine risk and prevalent bacterial STI diagnosis among GBM was mediated by two types of attitudinal variables: attitudes toward condoms, and sexual escape motives, defined as the use of substances to escape self-awareness during sex, and by sexual behaviors.

*Methods:* We used computer-assisted self-interview questionnaires from 2449 sexually active GBM (18% living with HIV; median age = 33, interquartile range, 27–45) recruited via respondent-driven sampling in Vancouver, Toronto, and Montreal, Canada. Using the baseline data from the Engage cohort study, we fit a series of structural mediation models of the associations between greater crystal methamphetamine risk and bacterial STI (syphilis, gonorrhea, and chlamydia) diagnosis. We estimated indirect paths from greater crystal methamphetamine risk,

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https://doi.org/10.1016/j.drugalcdep.2022.109718

Available online 7 December 2022

attitudes toward condoms, sexual escape motives, and sexual risk behaviors, adjusting for self-reported demographic variables.
*Results:* In the mediated model, the direct association between greater crystal methamphetamine risk and bacterial STI diagnosis was non-significant; however, five indirect paths were significant. Greater crystal methamphetamine risk was associated with bacterial STIs via condom use attitudes and escape motives, which in turn were associated with number of male anal sex partners, condomless anal sex, and oral sex.
*Discussion:* Public health and counselling interventions for GBM who use crystal methamphetamine and who are at higher risk for STIs should target evidence-based causal paths that consider sexual attitudes and sexual practices.

## 1. Introduction

Among Canadian gay, bisexual, and other sexual minority men (GBM) 8–20% report having used crystal methamphetamine in the past 6–12 months (Card et al., 2018; Colyer et al., 2020). Similar rates have been reported in the United States (U.S.), the United Kingdom, and Australia (Bourne et al., 2014; Curtis et al., 2020; Lea et al., 2016; Rivera et al., 2021). Crystal methamphetamine use among GBM is frequently used with other substances to enhance sexual pleasure (e.g., Drysdale et al., 2020; Halkitis et al., 2014). A growing body of literature supports an association between crystal methamphetamine use and STIs among GBM (Colyer et al., 2018; Drückler et al., 2018; Frankis et al., 2018; Maxwell et al., 2019; Reback and Fletcher, 2018). A longitudinal study by Hoenigl et al. (2016) found that initiation of crystal methamphetamine use by GBM in San Diego after their first study visit was the strongest predictor of behaviours that increase one's risk for STIs at 12-month follow-up (e.g., CAS; condomless anal sex).

### 1.1. Background

#### 1.1.1. Sexually transmitted infections (STIs) among GBM

GBM continue to be disproportionately affected by STIs. Research suggests increasing incidence of syphilis among GBM in high-income countries (Read et al., 2015), with GBM accounting for 71% of all reported syphilis cases among men in Canada in 2020 and 47.1% of reported cases in the U.S. in 2019 (Aho et al., 2022; Centers for Disease Control and Prevention, 2018). There have also been documented increases in gonorrhea diagnoses: cases among U.S. GBM have doubled between 2010 and 2015 and there has been a 242% increase in diagnoses among Canadian men in the general population from 2009 to 2018 (Public Health Agency of Canada, 2021; Stenger et al., 2017). Some of these increases may be related to increases in CAS due to HIV Pre-Exposure Prophylaxis (PrEP) medications, which are highly effective in reducing the risk of contracting HIV when exposed to HIV via CAS (Colyer et al., 2022; Murchu et al., 2022), and to the increased frequency of STI testing among people who use PrEP, who undergo screening for bacterial STIs at quarterly medical appointments (Koester & Grant, 2015).

#### 1.1.2. Crystal methamphetamine use involvement and STTs

Most studies on HIV and STI risks have examined crystal methamphetamine use or non-use as a binary variable, which may imply that any crystal methamphetamine use is problematic or harm-inducing. However, among people who use crystal methamphetamine, there may be differences in risks for STIs, and the association between greater risk of crystal methamphetamine use-related harms and HIV may increase in a dose-response relationship. One older study found lower HIV prevalence among people who occasionally use crystal methamphetamine versus higher HIV prevalence among people who regularly use crystal methamphetamine, and even greater HIV prevalence among people who use in outpatient treatment (Shoptaw, 2006). This suggests that it may be more useful to examine how greater risk of crystal methamphetamine-related harms, defined by the frequency of use and use that leads to substance use disorder symptoms or harms (e.g., health or social problems, an inability to meet personal expectations; Humeniuk et al., 2008), may be associated with bacterial STI incidence, as opposed to a binary predictor of presence/absence of crystal methamphetamine use.

#### 1.1.3. The causal pathway between crystal methamphetamine and bacterial STI via behavioral variables

Understanding the causal pathways between crystal methamphetamine use and STIs among GBM can inform preventive interventions. To date, behavioral factors have received the most empirical support with a large body of cross-sectional research demonstrating an association between crystal methamphetamine and behaviors that increases the chances of passing STIs (Maxwell et al., 2019; Tomkins et al., 2019). The strength of these data is bolstered by smaller number of longitudinal studies demonstrating that both crystal methamphetamine use over time and initiation of crystal methamphetamine use are associated with, and in the latter case temporally precede, behaviours that increase the chances of transmitting STIs (Halkitis et al., 2009; Hoenigl et al., 2016). Again, most of these studies focus on presence/absence or simple frequency of crystal methamphetamine use as opposed to risk of crystal methamphetamine-related harms. Cross-sectional studies have found that, when compared to GBM not reporting recent crystal methamphetamine use (e.g., past 6–12 months), GBM reporting use in the past 6–12 months reported a greater number of recent sexual partners and more CAS (Colyer et al., 2018; Curtis et al., 2020; Frankis et al., 2018; Melendez-Torres et al., 2016). Similarly, longitudinal studies have examined initiation (yes/no) of crystal methamphetamine or frequency of use over time, again finding both to be associated with a greater number of sexual partners and CAS (Halkitis et al., 2009; Hoenigl et al., 2016). Moreover, qualitative studies indicate that increasing crystal methamphetamine use may affect individuals' condom use decision making processes: even participants who report intentions to use condoms during anal sex prior to using crystal methamphetamine report engaging in CAS after using (Tomkins et al., 2019). Although oral sex is examined less frequently in the literature, it is consistently associated with bacterial STIs (Glynn et al., 2017; Robbins et al., 2019). However, evidence linking crystal methamphetamine use and oral sex among GBM is lacking.

#### 1.1.4. Attitudinal variables

Research examining attitudinal variables related to safer sex among GBM has focused on how attitudes toward condoms are associated with CAS. Cross-sectional evidence suggests that individuals who perceive condoms as a barrier to their sexual experience report more CAS (e.g., Doyle et al., 2009; Golub and Gamarel, 2017). Thus, given the association between crystal methamphetamine use and sexual sensation seeking (e.g., Vu et al., 2017) in cross-sectional studies, GBM who use crystal methamphetamine may be more likely to perceive condoms as a barrier to sexual pleasure (i.e., negative attitudes toward condoms), compared with their non-using counterparts (Hammoud et al., 2020).

'Escape motives' refer to one's expectations that using substances during sex will lead to greater sexual enjoyment by allowing people who use to disengage from negative thoughts, emotions, and sexual pressures (e.g., performance standards, fears of passing/acquiring HIV; McKirnan

et al., 1996). Substance use-related sexual escape motives may partially account for the association between crystal methamphetamine use and STIs. Thus, individuals reporting greater escape motives may be more likely to forego condom-protected sex and engage in sex with a greater number of sexual partners after using crystal methamphetamine compared with individuals with lower escape motives, a hypothesis supported by cross-sectional studies (Alvy et al., 2011; Card et al., 2019; Colyer et al., 2018, 2020).

#### 1.1.5. Limitations of existing literature

Much of the research on crystal methamphetamine and STIs has focused on behaviors without clear evidence of medical outcomes. Second, most existing research has focused on GBM living with HIV, which limits generalizability to all GBM (Maxwell et al., 2019). Third, the extant literature has primarily relied on purposive sampling methods with less representative samples (Curtis et al., 2020; Maxwell et al., 2019; Tomkins et al., 2019); as a result, the generalizability of these previous findings remains undetermined (Hoenigl et al., 2016). Lastly, despite widely available measures of crystal methamphetamine use-related harms (e.g., The Alcohol, Smoking and Substance Involvement Screening Test; ASSIST; Humeniuk et al., 2008; World Health Organization, 2003), most literature on STIs has focused on crystal methamphetamine use as a binary variable.

### 1.2. The Present Study

This study aimed to address the gaps in the literature by using a more representative sample of GBM recruited for a large, multicity study. In a cross-sectional design, we hypothesized that greater risk of crystal methamphetamine-related harms as defined by a continuous score on the ASSIST, would be associated with increased probability of bacterial STI diagnosis via two cognitive variables: negative attitudes toward condoms and escape motives. Further, we hypothesized that ASSIST scores would be associated with a greater probability of bacterial STI diagnosis via three sexual risk behaviors in the past 6 months: CAS, number of sex partners, and oral sex.

## 2. Methods

### 2.1. Participants

Details of the Engage Cohort Study (ECS) methodology have been published elsewhere (Cox et al., 2021; Hart et al., 2021a). The ECS combines data from computer-assisted self-interviewing (CASI) and the detection of HIV and other selected STBBIs (e.g., syphilis, gonorrhea, chlamydia, hepatitis C) using biological samples. In the baseline sample, a total of 2449 GBM in Montreal (n = 1179), Toronto (n = 517) and Vancouver (n = 753) were recruited from February 2017-August 2019. GBM were eligible to participate in the study if 1) ages $\geq$ 16 years, 2) self-identified as a man (cisgender or transgender), 3) able to complete a survey in English or French, 4) lived in the metropolitan area of a data collection city, and 5) had engaged in sexual activity with another man in the six months prior to their study visit. For this analysis, we used the baseline data of the ECS.

### 2.2. Procedures

Participants were recruited using respondent-driven sampling (RDS). RDS is a modified form of chain-referral sampling designed to approximate probabilistic samples by adjusting for selection bias (Heckathorn, 2002). RDS starts with non-randomly selected initial participants (called "seed participants") who recruit eligible members from their social networks; subsequent participants are also asked to recruit a maximum of six eligible potential participants from their social networks, until the target sample size is reached. After providing written informed consent, seed participants and subsequent participants completed the study questionnaire and biological sampling for STIs. Participants received $50 CAD compensation for participating and a secondary incentive of $15 for each eligible GBM they recruited. The study was approved by research ethics boards at Toronto Metropolitan University, the University of Toronto, St. Michael's Hospital, the University of Windsor, the University of British Columbia, Providence Health Care, the University of Victoria, Simon Fraser University, and the Research Institute of the McGill University Health Centre.

### 2.3. Measures

#### 2.3.1. Socio-demographic variables

Participants reported their socio-demographic characteristics including age, ethnoracial identity, annual personal income, relationship status, city, sexual identity, self-reported HIV status and PrEP use in the past 6 months. Following other research (Card et al., 2020), we used self-reported HIV status in the present analysis as perceived HIV status is a known correlate of a participant's sexual behaviors.

#### 2.3.2. STI diagnosis

Participants provided a venous blood sample permitting serological testing for HIV and syphilis; these tests were done according to provincial laboratory algorithms, which are similar across the three cities, with some variation, described below. A recent syphilis infection was defined as a positive anti-treponemal antibody test and a rapid plasmin reagin (RPR) titre > 1:16. Participants also provided urine, pharyngeal swabs, and rectal swabs to screen for *Chlamydia trachomatis* and *Neisseria gonorrhoeae* using nucleic acid amplification testing (NAAT) or culture, based on provincial laboratory testing procedures. Any positive result on a urine, pharyngeal, or rectal specimen was coded as a detected infection. Due to provincial differences, for throat and rectal samples, half of the participants in Toronto had a culture and half had a NAAT, whereas in Montreal and Vancouver, all specimens underwent NAAT testing. Gonorrhea and chlamydia rectal results were not available for 20% of Vancouver participants. Study staff provided all participants who newly tested positive for any STBBI with linkage to local care and treatment providers. For this analysis, we defined bacterial STI as any detected gonorrhea, chlamydia, or recent syphilis infection during participants' baseline/enrolment study visit.

#### 2.3.3. Greater risk of crystal methamphetamine use-related harms

The ASSIST (Humeniuk et al., 2008; World Health Organization, 2003) was used to assess risk of crystal methamphetamine use-related harms. For participants who reported any crystal methamphetamine use in the past 3 months, we calculated a total Crystal Methamphetamine Only score (ASSIST-CM) summing only items for people who use crystal methamphetamine. Example items include "In the past three months, how often have you used.," "During the past three months, how often have you failed to do what was normally expected of you because of your use of…," and "Has a friend or relative or anyone else ever expressed concern about your use of"). The total score ranged from 0 (no use) to 39 for use-related symptoms and other harms. For the present study, we examined the ASSIST as a continuous variable and standardized the score with a mean = 0 and standard deviation = 1 for ease of interpretation. In our sample, Cronbach's alpha for the ASSIST-CM was 0.84.

#### 2.3.4. Attitude variables: Condom use attitudes and escape motives

Two separate measures were used to assess Condom Use Attitudes as a latent construct: 1-item from the Correct Condom Use Self-Efficacy Scale ("How easy or difficult would it be for you to keep an erection while using a condom?") where scores ranged from 1 (very difficult) to 5 (very easy) (Crosby et al., 2011), and the 7-item Effects on Sexual Experience Subscale of the Condom Barriers Scale (Doyle et al., 2009; St. Lawrence et al., 1999), (e.g., "I feel closer to my partner without a condom") with higher scores indicating fewer barriers to condom use.

The latter is rated on a 5-point Likert-type scale and had good internal consistency in our sample (alpha = 0.88).

For escape motives, we used an adapted version of the 12-item Escape Motives Scale (McKirnan et al., 2001; one item was removed from the original scale). Scores assessed the extent to which GBM believe that substance use reduces their cognitive recognition of sexual risk. Higher scores indicated greater escape motivation (alpha = 0.92).

#### 2.3.5. Recent sexual behaviors

Participants reported their number of sexual partners, engagement in any CAS, and engagement in oral sex in the last six months with male partners. For the present analysis, number of male anal sex partners was standardized with a mean = 0 and standard of deviation = 1 for ease of interpretation. CAS was operationalized as any anal sex without a condom with at least one partner in the past six months. Oral sex was operationalized as giving or receiving any oral sex in the past six months.

### 2.4. Statistical analyses

Descriptive statistics were generated using frequencies and percentages for categorical data and medians and interquartile ranges (IQRs) for continuous data. The primary analysis was conducted using structural equation modeling (SEM) analysis with weighted least squares means and a variance-adjusted estimator. We used the RDS-II estimator (Volz and Heckathorn, 2008) for all analyses to account for RDS weighting in our analysis.

The SEM model examined the pathways between greater risk of crystal methamphetamine-related harms as defined by the ASSIST (Humeniuk et al., 2008) and any recent bacterial STI (syphilis, gonorrhea, or chlamydia) detected at the study visit. We examined both direct and indirect pathways. Our indirect pathways examined ASSIST scores and STIs via two attitudinal variables, the latent construct of condom use attitudes and escape motives, and the behavioral variables, condomless anal sex, number of sex partners, and oral sex. We used the comparative fit index (CFI), the Tucker–Lewis Fit Index (TLI), and root mean square error approximation (RMSEA) to evaluate overall model fit (Kline, 2011; Weston and Gore, 2006).

We reported standardized indirect path coefficients and 95% CIs. All regression models controlled for age, ethnoracial identity, annual personal income, sexual identity, relationship status, recruitment city, self-reported HIV status and PrEP use in the past 6 months. Descriptive analyses were conducted using Stata/SE 16.1 and the structural models were estimated using MPLUS version 7.4 (Muthén and Muthén, 2015).

## 3. Results

Our sample was predominantly gay (82.4%), white (71.3%), single (71.2%), and had an annual income of < $40,000 CAD (63.8%; see Table 1). Additionally, 18% of our sample reported living with HIV. In the past three months, 9.9% (n = 243/2449) of participants reported crystal methamphetamine use (GBM living with HIV: 30.4% and HIV-negative/unknown GBM: 5.4%). About 18.1% of HIV-negative GBM were currently using PrEP. Among people who use crystal methamphetamine (i.e., a score greater than 0 on ASSIST-CM), the median score was 17 (IQR, 7, 27). For use-related dependence and other harms, there were 25 (10.3%) participants at low risk defined by the ASSIST, 157 (64.6%) at moderate risk, and 61 (25.1%) at high risk. Regarding sexual activity in the past 6 months, 95.9% reported engaging in oral sex, 70% reported CAS, and the median number of male anal sex partners was of 3 (IQR, 1, 9). A minority (11.4%) of participants were diagnosed with a bacterial STI (gonorrhea, chlamydia, or recent syphilis) at the study visit.

Table 2 shows standardised estimates (β), and 95% CI for the bivariate associations of ASSIST-CM scores, any recent bacterial STI diagnosis, escape motives, condom use attitudes, CAS, oral sex, and

**Table 1**
Socio-demographic characteristics of Engage Cohort Study participants by Bacterial Sexually Transmitted Infections, Baseline data (n = 2449), unweighted/crude statistics.

| Characteristics | Overall | Any recent bacterial STI | | |
|---|---|---|---|---|
| | n (%)[1] 2449 | Detected[2] 279 (11.4%) | Not detected[2] 2170 (88.6%) | *p*-value[3] |
| Recruiting City | | | | .46 |
| **Montreal** | 1179 (48.1) | 138 (11.7) | 1041 (88.3) | |
| **Toronto** | 517 (21.1) | 51 (9.9) | 466 (90.1) | |
| **Vancouver** | 753 (30.8) | 90 (11.9) | 663 (88.1) | |
| Ethnoracial identity | | | | .09 |
| **white** | 1747 (71.3) | 187 (10.7) | 1560 (89.3) | |
| **Person of Colour** | 702 (28.7) | 92 (13.1) | 610 (86.9) | |
| Annual Income, CAD | | | | .26 |
| **Less than 40 K** | 1562 (63.8) | 185 (11.8) | 1377 (88.2) | |
| **40–79.9 K** | 686 (28.0) | 78 (11.4) | 608 (88.6) | |
| **80 K or more** | 201 (8.2) | 16 (8.0) | 185 (92.0) | |
| Sexual identity | | | | **.04** |
| **Gay** | 2017 (82.4) | 244 (12.1) | 1773 (87.9) | |
| **Bisexual** | 164 (6.7) | 16 (9.8) | 148 (90.2) | |
| **Other** | 268 (10.9) | 19 (7.1) | 249 (92.9) | |
| Relationship Status | | | | .10 |
| **Single** | 1743 (71.2) | 202 (11.6) | 1541 (88.4) | |
| **Married / Common-law** | 504 (20.6) | 47 (9.3) | 457 (90.7) | |
| **Separated/ Divorced/ Widowed** | 202 (8.2) | 30 (14.8) | 172 (85.2) | |
| Self-reported HIV status | | | | **<.001** |
| **HIV-negative/ unknown** | 2009 (82.0) | 202 (10.1) | 1807 (89.9) | |
| **HIV-positive** | 440 (18.0) | 77 (17.5) | 363 (82.5) | |
| PrEP use in, P6M[4] | | | | **<.001** |
| **No** | 1646 (81.9) | 139 (8.4) | 1507 (91.6) | |
| **Yes** | 363 (18.1) | 63 (17.4) | 300 (82.6) | |
| Condomless anal sex, P6M | | | | **<.001** |
| **No** | 736 (30.0) | 33 (4.5) | 703 (95.5) | |
| **Yes** | 1713 (70.0) | 246 (14.4) | 1467 (85.6) | |
| Oral sex, P6M | | | | .65 |
| **No** | 100 (4.1) | 10 (10.0) | 90 (90.0) | |
| **Yes** | 2349 (95.9) | 269 (11.5) | 2080 (88.5) | |
| Crystal Methamphetamine Use, P3M | | | | **<.001** |
| **No, Use** | 2206 (90.6) | 212 (9.6) | 1994 (90.4) | |
| **Yes, Used** | 243 (9.9) | 67 (27.6) | 176 (72.4) | |
| | **Median (IQR)** | | | *p*-value[5] |
| Age, in years | 33 (27, 45) | 32 (26, 41) | 33 (27,45) | **.04** |
| ASSIST Methamphetamine only[6] | 17 (7.0, 27.0) | 20 (8.0, 29.0) | 15 (7.0, 25.0) | .08 |

(*continued on next page*)

**Table 1** (*continued*)

| Characteristics | Overall | Any recent bacterial STI | | |
|---|---|---|---|---|
| | n (%)[1] 2449 | Detected[2] 279 (11.4%) | Not detected[2] 2170 (88.6%) | *p*-value[3] |
| Condoms Barriers Scale | 19 (14, 25) | 17 (12, 23) | 19 (15, 25) | < **.001** |
| Condom Self-Efficacy Scale | 3 (2, 4) | 3 (1, 4) | 3 (2, 4) | < **.001** |
| Escape Motive Scale | 35 (29, 40) | 38 (32, 43) | 35 (29, 40) | < **.001** |
| Number of male anal sex partners, P6M | 3 (1, 9) | 10 (4, 22) | 3 (1, 7) | < **.001** |

***Note:*** [1]Column percentages; [2]Row percentages; [3]Chi-Square or Fisher's exact test; [4] Among HIV-negative GBM; [5]Wilcoxon rank-sum (Mann–Whitney) test; [6] Among those who reported meth use in the past three months; CAD = Canadian dollars; P6M = Past six months; P3M = Past three months; IQR: Inter-quartile range; Percentages and statistics are crude, not adjusted for RDS weights.

**Table 2**
Bivariate associations of study variables, Baseline data, Engage Cohort Study (n = 2449).

| Outcome | Predictor | Direct effect | | |
|---|---|---|---|---|
| | | β | 95% Confidence Intervals | *p*-value |
| STI | ASSIST-Meth | .11 | .03,.19 | **.01** |
| STI | CAS | .34 | .22,.46 | < **.001** |
| STI | OS | .10 | -.04,.23 | .18 |
| CAS | EM | .20 | .11,.28 | < **.001** |
| CAS | NSP | .79 | .65,.92 | < **.001** |
| CAS | CUA | -.28 | -.38, – .17 | < **.001** |
| OS | EM | .21 | .09,.34 | **.001** |
| OS | NSP | .31 | -.02,.65 | .07 |
| OS | CUA | -.40 | -.58, – .23 | < **.001** |
| NSP | EM | .11 | .05,.15 | < **.001** |
| NSP | CUA | -.08 | -.15, – .01 | **.02** |
| EM | ASSIST-Meth | .19 | .11,.26 | < **.001** |
| CUA | ASSIST-Meth | -.19 | -.29, – .08 | **.001** |

Note. β represents standardized coefficients; ASSIST-Meth = ASSIST Methamphetamine only score; EM = Escape Motive Scale; CUA = Condom Use Attitudes; CAS = Condomless Anal Sex; OS = Oral Sex; NSP = Number of Male Anal Sex Partners. All models were adjusted for age, ethno-racial identity, annual personal income, sexual identity, relationship status, city, self-reported HIV status and prep use in the past 6 months.

number of sex partners after controlling for self-reported HIV status, demographic factors, recruitment city, and PrEP use. We found a positive association between ASSIST-CM scores and current STI diagnosis (β = .11; 95% CI:.03,.19; $p$ = .01). ASSIST-CM scores were also positively associated with escape motives (β = .19; 95% CI:.11,.26; $p < .001$) and negatively associated with favorable condom use attitudes (β = −.19; 95% CI: −.29, −.08; $p$ = .001).

Fig. 1 depicts the SEM after controlling for self-reported HIV status, demographic factors, city, and PrEP use in the last 6 months. The model had an adequate fit to the data (CFI =.92; TLI =.85; RMSEA =.03, 90% CI:.02,.04). Standardised estimates (β), and 95% CI of the mediated model are presented in Table 3. In the mediated model, the direct paths between ASSIST-CM scores and escape motives and condom use attitudes were statistically significant, but the path to STI diagnosis was not (β = .04; 95% CI: −.04,.12; $p$ = .37).

### 3.1. Indirect paths via attitudinal variables and sexual behaviors

We also observed five significant indirect paths from ASSIST-CM score to STIs. Three of these indirect paths included attitudinal variables and CAS: 1) condom use attitudes → CAS → STIs (β = .02; 95% CI:.003,.04; $p$ = .02); 2) escape motives → number of male anal sex partners → CAS → STIs (β = .001; 95% CI:.00,.001; $p$ = .02), and 3) condom use attitudes → number of male anal sex partners → CAS → STIs (β = .01; 95% CI:.001,.01; $p$ = .01). Two paths included attitudinal variables and oral sex: 4) escape motives → oral sex → STIs (β = .02; 95% CI:.004,.03; $p$ = .01); and 5) condom use attitudes → oral sex → STIs (β = .06; 95% CI:.01,.10; $p$ = .001).

## 4. Discussion

In a large multicity sample of community-recruited GBM, we identified pathways by which greater risk of crystal methamphetamine-related harms may be associated with bacterial STI diagnoses. Our model demonstrated that greater risk of crystal methamphetamine harms, as defined by ASSIST scores for people who use crystal methamphetamine, was indirectly associated with the presence of bacterial STIs. ASSIST-CM scores were associated with STI diagnoses via both attitudinal variables and sexual behaviors. Negative attitudes toward condoms and escape motives were associated with CAS and oral sex, and then with the presence of STIs. Although greater risk of crystal

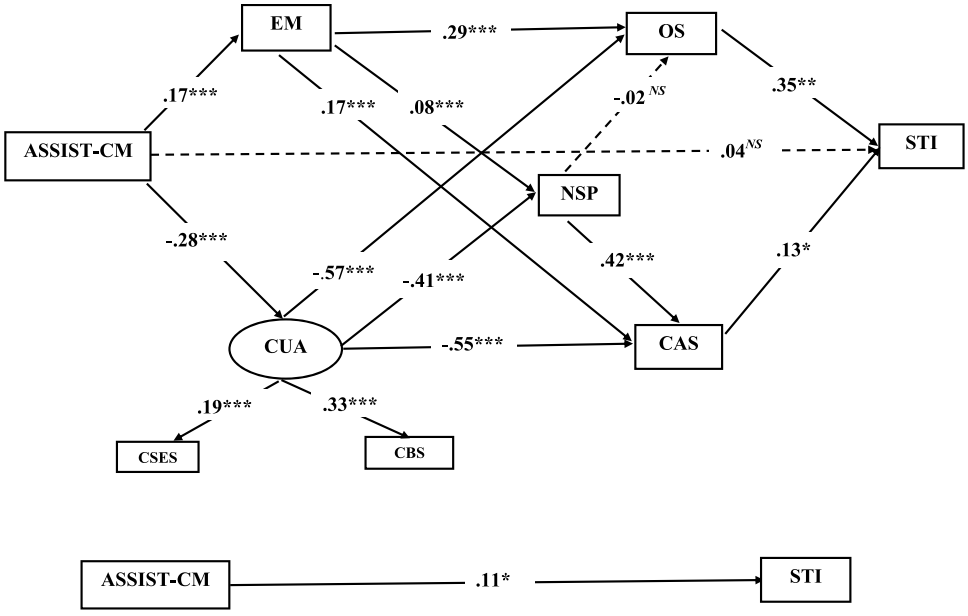


**Fig. 1.** Structural equation model examining the associations between Crystal Methamphetamine use (ASSIST-CM scores) and bacterial Sexually Transmitted Infections (gonorrhea, Chlamydia, or recent syphilis) among Engage Cohort Study participants, baseline data, (n = 2449). Note. Solid lines represent significant paths, dashed lines represent nonsignificant paths. All paths represent standardized estimates. EM = Escape Motive Scale; CUA = Condom Use Attitudes; CAS = Condomless Anal Sex; OS = Oral Sex; NSP = Number of Male Anal Sex Partners; CBS = Condom Barrier Scale (Effects of Sexual Experience Subscale). The model was adjusted for age, ethno-racial identity, annual personal income, sexual identity, relationship status, city, self-reported HIV status and PrEP use in the past 6 months. * $p < 0.05$; * * $p < 0.01$; * ** $p < 0.001$; NS $p > 0.05$.

**Table 3**
Direct and Indirect (Mediated) Effects of Crystal Methamphetamine use on any recent Bacterial Sexually Transmitted Infections among Engage Cohort Study participants, Baseline data (n = 2449).

| Outcome | Predictor | Direct effect | | |
|---|---|---|---|---|
| | | β | 95% Confidence Interval | *p*-value |
| STI | ASSIST-Meth | .04 | -.04,.12 | .37 |
| STI | CAS | .13 | .03,.22 | **.01** |
| STI | OS | .35 | .12,.58 | **.003** |
| CAS | EM | .17 | .08,.25 | **< .001** |
| CAS | NSP | .42 | .33,.51 | **< .001** |
| CAS | CUA | -.55 | -.71, − .39 | **< .001** |
| OS | EM | .29 | .17,.41 | **< .001** |
| OS | NSP | -.02 | -.13,.10 | .80 |
| OS | CUA | -.57 | -.76, − .37 | **< .001** |
| NSP | EM | .08 | .07,.10 | **< .001** |
| NSP | CUA | -.41 | -.48, − .33 | **< .001** |
| EM | ASSIST-Meth | .17 | .10,.24 | **< .001** |
| CUA | ASSIST-Meth | -.28 | -.34, − .21 | **< .001** |
| **Indirect Path** | | | | |
| ASSIST-Meth →EM→CAS→STI | | .004 | .00,.01 | .06 |
| ASSIST-Meth →CUA→CAS→STI | | .02 | .003,.04 | **.02** |
| ASSIST-Meth →EM→NSP→CAS→STI | | .001 | .00,.001 | **.02** |
| ASSIST-Meth →CUA→NSP→CAS→STI | | .01 | .001,.01 | **.01** |
| ASSIST-Meth →EM→OS→STI | | .02 | .004,.03 | **.01** |
| ASSIST-Meth →CUA→OS→STI | | .06 | .01,.10 | **.01** |
| ASSIST-Meth →EM→NSP→OS→STI | | .00 | -.001,.00 | .79 |
| ASSIST-Meth →CUA→NSP→OS→STI | | -.001 | -.01,.004 | .79 |
| Total indirect | | .10 | .06,.13 | **< .001** |
| Total | | .14 | .06,.23 | **.001** |

Note. β represents standardized coefficients; ASSIST-Meth = ASSIST Methamphetamine only score; EM = Escape Motive Scale; CUA = Condom Use Attitudes; CAS = Condomless Anal Sex; OS = Oral Sex; NSP = Number of Male Anal Sex Partners. All models were adjusted for age, ethno-racial identity, annual personal income, sexual identity, relationship status, city, self-reported HIV status and prep use in the past 6 months.

methamphetamine use-related harms was associated with STIs in bivariate associations, it was not directly associated with STIs in the full mediation model. Our mediation model suggests that greater risk of crystal methamphetamine use-related harms may be indirectly associated with CAS via a greater number of male sex partners in the past 6 months.

Our findings are consistent with studies showing a relationship between crystal methamphetamine use and sexual risk behaviors (e.g., Colyer et al., 2020; Glynn et al., 2017). The associations between greater risk of crystal methamphetamine-related harms and condom use attitudes and escape motives are consistent with primarily cross-sectional work regarding the associations between crystal methamphetamine use and disinhibitory attitudes toward HIV and sex (Hammoud et al., 2020; Tomkins et al., 2019). The significant covariance between condom use attitudes and substance-related escape motives also suggests that these variables should not be examined in isolation for studies of GBM. The study extends previous HIV research (Armstrong et al., 2018; Colyer et al., 2018; Curtis et al., 2020) by showing that greater risk for crystal methamphetamine use-related harms is associated not only with condomless anal sex but also number of partners and with oral sex.

Our findings have important implications for health providers of people who use crystal methamphetamine. First, this study validates the notion that not all crystal methamphetamine use is equal, as higher ASSIST-CM scores were associated with STIs. Further, interventions are needed to promote sexual health and to reduce STI risks among GBM who engage in riskier forms of crystal methamphetamine use. The present study underscores the calls for improved linkages between substance use providers and medical providers (Salway et al., 2019), including expansion of mental health and substance use care at HIV/STI clinics, expansion of online STI/HIV services, and integration of sexual and mental health services (Gaspar et al., 2021). Health and service providers working in sexual health and substance use should ask participants about HIV and bacterial STIs and crystal methamphetamine use-related harms.

A combination of evidence-based approaches suggested for HIV prevention (Shoptaw and Reback, 2007) may also be beneficial for STI prevention. Our study suggests that STI prevention interventions should consider both attitudes associated with sex and sexual behaviors as potential targets of intervention. A first point of intervention for medical and mental health clinicians may be to ask GBM patients about crystal methamphetamine use, to assess risks for substance use-related harm, and for those at greater risk, to inquire about substance use associated with escaping stress. Behaviorally, clinicians should inquire about oral sex and CAS. The current study also underscores the ongoing role of condom use to prevent STIs and to encourage more frequent screening for STIs among GBM who frequently use crystal methamphetamine. The presence of bacterial STIs may also increase susceptibility to/transmissibility of HIV (Galvin and Cohen, 2004). Clinicians should therefore consider referring GBM who frequently use crystal methamphetamine for STI/HIV testing and antiretroviral medications. As per clinical guidelines, HIV-negative GBM are more likely to be eligible for PrEP if they use crystal methamphetamine (Centers for Disease Control and Prevention, 2021; Tan et al., 2017).

Lower intensity interventions may include social media campaigns to promote harm and risk reduction (Reback et al., 2012). These interventions should consider providing information about the relationship between crystal methamphetamine use, sexual behavior, and related STIs. Given the popularity of social networking applications to meet other GBM, and that 70% of GBM tend to have favorable views of online or app-based HIV prevention programs (Holloway et al., 2014), mobile health interventions may have an important role to play in both HIV and STI prevention for crystal methamphetamine-using GBM (Reback, Fletcher, and Mata, 2021).

More resource-intensive approaches may be needed for those who have the most risk, such as psychotherapies including behavioral activation (Mimiaga et al., 2019), cognitive behavioral therapy (Shoptaw et al., 2008), and contingency management (Reback et al., 2010)). Given the present findings, counseling interventions for GBM who use crystal methamphetamine should also consider the role of negative condom use attitudes and substance-related escape motives in promotion of sexual risk behavior. Substance-related escape motives may be particularly amenable to counseling to help patients to manage stress beyond the use of substances.

### 4.1. *Strengths, Limitations and Future Directions*

Our application of RDS-II weights within a large, multicity dataset supports greater generalizability to urban GBM populations compared with previous studies (Heckathorn, 2002). In addition, the use of structural mediation modeling with microbiologically-confirmed STI diagnoses as the dependent variable responds to calls for the literature to move beyond simple regression models of STI risk behaviors (Miltz et al., 2020). However, as sexually inactive GBM were unable to participate in the study, we may have overestimated the direct and indirect associations between greater risk of crystal methamphetamine use-related harms and bacterial STIs. Additionally, some GBM who use crystal methamphetamine may not be at risk for STIs as they do not use crystal methamphetamine in sexual situations (Evers et al., 2020).

Further, this analysis, which shows a specific association of risks for crystal methamphetamine use-related harms, could be expanded to examine substance use disorder symptoms associated with other substances that are used by GBM during sexualized drug use (Wilkerson et al., 2018), known as “Party ‘n Play” or “chemsex.” Future work may wish to examine whether diagnostically confirmed crystal methamphetamine use disorders are associated with bacterial STIs, and to explore mechanisms explaining this relationship. As PrEP uptake may

continue to increase among GBM, an examination of how PrEP use interacts with CM use in increasing STIs may also be useful.

Although we have posited several pathways by which crystal methamphetamine use risk is associated with STIs, the cross-sectional nature of the present study precludes our ability to assert true causality or temporality of findings. However, our findings are consistent with other longitudinal studies of GBM showing that substance use predicts sexual risk behaviors (Parsons et al., 2013). Given the relationship between crystal methamphetamine use and bacterial STIs found in the present study and its known effects on mental health of GBM (e.g., Colyer et al., 2020), future longitudinal research is needed to better understand predictors of crystal methamphetamine use risks. Additional predictors of crystal methamphetamine use for future studies may include heterosexist discrimination, which has been associated with problematic drinking among GBM (Wray et al., 2016), and syndemic social and psychosocial conditions including depression, childhood sexual abuse, and experiences of violence (e.g., Tulloch et al., 2015).

## 5. Conclusion

The present paper demonstrated that greater crystal methamphetamine use is associated with diagnosed bacterial STIs among GBM. Greater crystal methamphetamine use may also be associated with bacterial STIs via escape motives and negative attitudes toward condoms, which in turn are associated with oral sex and CAS. These findings demonstrate the benefit of moving beyond studies of direct effects to understand potential mechanisms leading to STI risk. To reduce the growing incidence of bacterial STIs among GBM, targeted STI prevention interventions are needed that attend to the disproportionate need of GBM who experience risks due to crystal methamphetamine use.

## Role of Funding

Engage is funded by the Canadian Institutes for Health Research (CIHR, #TE2–138299, FDN-143342, PJT-153139), the CIHR Canadian HIV/AIDS Trials Network (#CTN300), the Canadian Association for HIV/AIDS Research (CANFAR, #Engage), the Ontario HIV Treatment Network (OHTN, #1051), and the Public Health Agency of Canada (#4500370314). TAH is supported by an Endgame Leader Chair Award in Gay and Bisexual Men's Health from the Ontario HIV Treatment Network. DMM and NJL are supported by Scholar Awards from the Michael Smith Foundation for Health Research (#5209, #16863). SSS is supported by a CIHR postdoctoral fellowship award. DG is supported by a Canada Research Chair in Sexual and Gender Minority Health. JMS is supported by a CTN postdoctoral fellowship award and a Michael Smith Foundation for Health Research trainee award. The authors would like to thank the participants and staff of the Engage Study and our community engagement committees and community partner organizations.

## CRediT authorship contribution statement

TAH and SWN conceptualized the study. SWN and FT analyzed the data and wrote parts of the manuscript. GWB, SS, and AK wrote up sections of the manuscript. TAH, DHST, GL, DG, JJ, JC, DMM, and NJL collected data for the larger study. All authors provided substantive written feedback on the original content and subsequent revisions.

## Conflicts of Interest

Joseph Cox and Gilles Lambert report nonfinancial support from the Direction r é gionale de santé publique, Centre intégré universitaire de santé et de services sociaux Centre-Sud-de-l'Ile-de-Montréal. Joseph Cox reports grants and personal fees from ViiV Healthcare and Gilead Sciences Canada, and personal fees from Merck Canada, outside the submitted work. David Moore reports a grant from the Michael Smith Foundation for Health Research. Nathan Lachowsky reports grants from the Canadian Institutes of Health Research, the Michael Smith Foundation for Health Research, Canadian Blood Services, the Vancouver Island Health Authority, the Canadian Foundation for AIDS Research, Gilead Sciences Canada, the Vancouver Foundation, the Public Health Agency of Canada, the University of Victoria and Mitacs, outside the submitted work. Darrell Tan reports a grant from the Canada Research Chairs Program; and grants from AbbVie and Gilead Sciences, outside the submitted work. He has been a site principal investigator for clinical trials sponsored by GlaxoSmithKline. Daniel Grace and Trevor Hart report grants from the Canadian Institutes of Health Research, Canadian Blood Services, and the Ontario HIV Treatment Network, outside the submitted work. Trevor Hart also reports editorial fees from the American Psychological Association, outside the submitted work.

## Acknowledgements

The Engage Cohort Study is led by Principal Investigators in Toronto by Trevor A. Hart & Daniel Grace, in Montreal by Joseph Cox and Gilles Lambert; and in Vancouver by Jody Jollimore, Nathan Lachowsky, and David Moore. More information about the Engage Cohort Study can be found here: https://www.engage-men.ca/ We thank the Engage study participants, office staff, and community engagement committee members, as well as our community partner agencies.

## References

Aho, J., Lybeck, C., Tetteh, A., Issa, C., Kouyoumdjian, F., Wong, J., Anderson, A., Popovic, N., 2022. Rising syphilis rates in Canada, 2011–2020. Can. Commun. Dis. Rep. 47 (2–3), 52–60. https://doi.org/10.14745/ccdr.v48i23a01.

Alvy, L.M., McKirnan, D.J., Mansergh, G., Koblin, B., Colfax, G.N., Flores, S.A., Hudson, S., 2011. Depression is associated with sexual risk among men who have sex with men, but is mediated by cognitive escape and self-efficacy. AIDS Behav. 15 (6), 1171–1179. https://doi.org/10.1007/s10461-010-9678-z.

Armstrong, H.L., Roth, E.A., Rich, A., Lachowsky, N.J., Cui, Z., Sereda, P., Card, K.G., Jollimore, J., Howard, T., Moore, D.M., Hogg, R.S., 2018. Associations between sexual partner number and HIV risk behaviors: implications for HIV prevention efforts in a Treatment as Prevention (TasP) environment. AIDS Care 30 (10), 1290–1297. https://doi.org/10.1080/09540121.2018.1454583.

Bourne, A., Reid, D., Hickson, F., Torres Rueda, S., & Weatherburn, P. (2014). The Chemsex Study: Drug use in sexual settings among gay and bisexual men in Lambeth, Southwark and Lewisham (p. 73) [Technical Report]. Sigma Research, London School of Hygiene & Tropical Medicine. Retrieved from: https://researchonline.lshtm.ac.uk/id/eprint/2197245/1/report2014a.pdf.

Card, K.G., Lachowsky, N.J., Armstrong, H.L., Cui, Z., Wang, L., Sereda, P., Jollimore, J., Patterson, T.L., Corneil, T., Hogg, R.S., Roth, E.A., Moore, D.M., 2018. The additive effects of depressive symptoms and polysubstance use on HIV risk among gay, bisexual, and other men who have sex with men. Addict. Behav. 82, 158–165.

Centers for Disease Control and Prevention, 2018. US Public Health Service: Preexposure prophylaxis for the prevention of HIV infection in the United States—2017. Update.: A Clin. Pract. Guidel. https://www.cdc.gov/hiv/pdf/risk/prep/cdc-hiv-prep-guidelines-2017.pdf.

Centers for Disease Control and Prevention, 2021. Natl. Overv. - Sex. Transm. Dis. Surveill. *2019*. https://www.cdc.gov/std/statistics/2019/overview.htm#Disparities.

Colyer, S.P., Lachowsky, N.J., Cui, Z., Zhu, J., Armstrong, H.L., Taylor, M., Edward, J., Olarewaju, G., Hogg, R.S., Roth, E.A., Moore, D.M., 2018. HIV treatment optimism and crystal methamphetamine use and initiation among HIV-negative men who have sex with men in Vancouver. In: Drug and Alcohol Dependence, 185. A longitudinal analysis, Canada, pp. 67–74. https://doi.org/10.1016/j.drugalcdep.2017.12.

Colyer, S.P., Moore, D.M., Cui, Z., Zhu, J., Armstrong, H.L., Taylor, M., Edward, J., Howard, T., Dickie, C., Olarewaju, G., Montaner, J.S., 2020. Crystal methamphetamine use and initiation among gay, bisexual, and other men who have sex with men living with HIV in a treatment as prevention environment. Subst. Use Misuse 15 (14), 2428–2437. https://doi.org/10.1080/10826084.2020.1833925.

Cox, J., Apelian, H., Moodie, E.E.M., Messier-Peet, M., Hart, T.A., Grace, D., Moore, D.M., Lachowsky, N.J., Armstrong, H.L., Jollimore, J., Skakoon-Sparling, S., Rodrigues, R., Tan, D.H.S., Maheu-Giroux, M., Noor, S.W., Lebouché, B., Tremblay, C., Olarewaju, G., Lambert, G., 2021. Use of HIV pre-exposure prophylaxis among urban Canadian gay, bisexual and other men who have sex with men: A cross-sectional analysis of the Engage Cohort Study. CMAJ Open 9 (2), E529–e538. https://doi.org/10.9778/crystalmethamphetamineajo.20200198.

Crosby, R.A., Graham, C., Milhausen, R., Sanders, S., Yarber, W., 2011. Correct condom use self-efficacy scale (3rd Eds.). In: Fisher, T.D., Davis, C.M., Yarber, W.L., Davis, S. (Eds.), Handbook of Sexuality-Related Measures. Routledge.

Curtis, T.J., Rodger, A.J., Burns, F., Nardone, A., Copas, A., Wayal, S., 2020. Patterns of sexualised recreational drug use and its association with risk behaviours and sexual health outcomes in men who have sex with men in London, UK: A comparison of

cross-sectional studies conducted in 2013 and 2016. Sex. Transm. Infect. 96 (3), 197–203.
Doyle, S.R., Calsyn, D.A., Ball, S.A., 2009. Factor structure of the condoms barriers scale with a sample of men at high risk for HIV. Assessment 16 (1), 3–15. https://doi.org/10.1177/1073191108322259.
Drückler, S., van Rooijen, M.S., de Vries, H.J., 2018. Chemsex among men who have sex with men: a sexualized drug use survey among clients of the sexually transmitted infection outpatient clinic and users of a gay dating app in Amsterdam, the Netherlands. Sex. Transm. Dis. 45 (5), 325.
Drysdale, K., Bryant, J., Hopwood, M., Dowsett, G.W., Holt, M., Lea, T., Aggleton, P., Treloar, C., 2020. Destabilising the 'problem'of chemsex: Diversity in settings, relations and practices revealed in Australian gay and bisexual men's crystal methamphetamine use. Int. J. Drug Policy 78, 102697.
Evers, Y.J., Hoebe, C., Dukers-Muijrers, N., et al., 2020. Sexual, addiction and mental health care needs among men who have sex with men practicing chemsex - a cross-sectional study in the Netherlands. Prev. Med. Rep., 101074 https://doi.org/10.1016/j.pmedr.2020.101074.
Frankis, J., Flowers, P., McDaid, L., Bourne, A., 2018. Low levels of chemsex among men who have sex with men, but high levels of risk among men who engage in chemsex: analysis of a cross-sectional online survey across four countries. Sex. Health 15 (2), 144. https://doi.org/10.1071/SH17159.
Galvin, S.R., Cohen, M.S., 2004. The role of sexually transmitted diseases in HIV transmission. Nat. Rev. Microbiol. 2 (1), 33–42.
Gaspar, M., Marshall, Z., Adam, B.D., Brennan, D.J., Cox, J., Lachowsky, N., Lambert, G., Moore, D., Hart, T.A., Grace, D., 2021. 'I was just doing what a normal gay man would do, right?': the biopolitics of substance use and the mental health of sexual minority men. Health. https://doi.org/10.1177/1363459321996753.
Glynn, T.R., Operario, D., Montgomery, M., Almonte, A., Chan, P.A., 2017. The duality of oral sex for men who have sex with men: An examination into the increase of sexually transmitted infections amid the age of HIV prevention. AIDS Patient Care STDs 261–267. https://doi.org/10.1089/apc.2017.0027.
Golub, S.A., Gamarel, K.E., 2017. Psychometric evaluation of the Condom Barriers and Motivations Scale (CBMS). J. Behav. Med. 40 (3), 494–505. https://doi.org/10.1007/s10865-016-9815-x.
Halkitis, P.N., Levy, M.D., Moreira, A.D., Ferrusi, C.N., 2014. Crystal methamphetamine use and HIV transmission among gay and bisexual men. Curr. Addict. Rep. 1 (3), 206–213.
Hammoud, M.A., Jin, F., Maher, L., Bourne, A., Haire, B., Saxtion, P., Vaccher, S., Lea, T., Degenhardt, L., Prestage, G., 2020. Biomedical HIV protection among gay and bisexual men who use crystal methamphetamine. AIDS Behav. 24, 1400–1413. https://doi.org/10.1007/s10461-019-02739-7.
Hart, T.A., Moore, D.M., Noor, S.W., Lachowsky, N., Grace, D., Cox, J., Skakoon-Sparling, S., Jollimore, J., Parlette, A., Lal, A., Apelian, H., Sang, J.M., Tan, D.H.S., Lambert, G., 2021a. Prevalence of HIV and sexually transmitted and blood-borne infections, and related preventive and risk behaviours, among gay, bisexual and other men who have sex with men in Montreal, Toronto and Vancouver: results from the engage study. Can. J. Public Health Rev. Can. De. Sante Publique 1–10. https://doi.org/10.17269/s41997-021-00546-z.
Heckathorn, D.D., 2002. Respondent-driven sampling II: deriving valid population estimates from chain-referral samples of hidden populations. Soc. Probl. 49 (1), 11–34. https://doi.org/10.1023/A:1014528612685.
Hoenigl, M., Chaillon, A., Moore, D.J., Morris, S.R., Smith, D.M., Little, S.J., 2016. 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. 71 (5), 551.
Holloway, I.W., Rice, E., Gibbs, J., Winetrobe, H., Dunlap, S., Rhoades, H., 2014. Acceptability of smartphone application-based HIV prevention among young men who have sex with men. AIDS Behav. 18 (2), 285–296. https://doi.org/10.1007/s10461-013-0671-1.
Humeniuk, R.E., Ali, R.A., Babor, T.F., Farrell, M., Formigoni, M.L., Jittiwutikarn, J., Boerngen de Larcerda, R., Ling, W., Marsden, J., Monteiro, M., Nhiwhatiwa, S., Pal, H., Poznyak, V., Simon, S., 2008. Validation of the alcohol smoking and substance involvement screening test (ASSIST). Addiction 103, 1039–1047. https://doi.org/10.1111/j.1360-0443.2007.02114.x.
Kline, R.B. (2011). Principles and practice of structural equation modeling (3rd ed.). New York, NY: Guilford Press.
Lea, T., Mao, L., Hopwood, M., Prestage, G., Zablotska, I., de Wit, J., Holt, M., 2016. Methamphetamine use among gay and bisexual men in Australia: trends in recent and regular use from the Gay Community Periodic Surveys. Int. J. Drug Policy 29, 66–72.
Maxwell, S., Shahmanesh, M., Gafos, M., 2019. Chemsex behaviours among men who have sex with men: a systematic review of the literature. Int. J. Drug Policy 63, 74–89. https://doi.org/10.1016/j.drugpo.2018.11.014.
McKirnan, D.J., Vanable, P.A., Ostrow, D.G., Hope, B., 2001. Expectancies of sexual "escape" and sexual risk among drug-and alcohol-involved gay and bisexual men. J. Subst. Abus. 13 (1–2), 137–154. https://doi.org/10.1016/s0899-3289(01)00063-3.
Melendez-Torres, G.J., Bourne, A., 2016. Illicit drug use and its association with sexual risk behaviour among MSM. Curr. Opin. Infect. Dis. 29 (1), 58–63. https://doi.org/10.1097/QCO.0000000000000234.
Miltz, A.R., Rodger, A.J., Lepri, A.C., Sewell, J., Nwokolo, N.C., Allan, S., Scott, C., Ivens, D., Lascar, M., Speakman, A., Phillips, A.N., Sherr, L., Collins, S., Elford, J., Lampe, F.C., Study Group, A.U.R.A.H., 2020. Investigating conceptual models for the relationship between depression and Condomless sex among gay, bisexual, and other men who have sex with men: using structural equation modelling to assess mediation. AIDS Behav. 24 (6), 1793–1806.
Mimiaga, M.J., Pantalone, D.W., Biello, K.B., Hughto, J., Frank, J., O'Cleirigh, C., Reisner, S.L., Restar, A., Mayer, K.H., Safren, S.A., 2019. An initial randomized controlled trial of behavioral activation for treatment of concurrent crystal methamphetamine dependence and sexual risk for HIV acquisition among men who have sex with men. AIDS Care 31 (9), 1083–1095. https://doi.org/10.1080/09540121.2019.1595518.
Muthén, B.O., Muthén, L.K. (2015). Mplus (Version 7.4). Los Angeles, CA.
Parsons, J.T., Lelutiu-Weinberger, C., Botsko, M., Golub, S.A., 2013. Predictors of day-level sexual risk for young gay and bisexual men. AIDS Behav. 17 (4), 1465–1477. https://doi.org/10.1007/s10461-012-0206-1.
Public Health Agency of Canada, 2021. Reported cases from 1991 to 2018 in Canada—Notifiable diseases on-line. Government of Canada. https://diseases.canada.ca/notifiable/charts?c=yl.
Read, P., Fairley, C.K., Chow, E.P., 2015. Increasing trends of syphilis among men who have sex with men in high income countries. Sex. Health 12 (2), 155–163.
Reback, C.J., Fletcher, J.B., 2018. Elevated HIV and STI prevalence and incidence among methamphetamine-using men who have sex with men in Los Angeles county. AIDS Educ. Prev. 30 (4), 350–356. https://doi.org/10.1521/aeap.2018.30.4.350.
Reback, C.J., Peck, J.A., Dierst-Davies, R., Nuno, M., Kamien, J.B., Amass, L., 2010. Contingency management among homeless, out-of-treatment men who have sex with men. J. Subst. Abus. Treat. 39 (3), 255–263. https://doi.org/10.1016/j.jsat.2010.06.007.
Reback, C.J., Grant, D.L., Fletcher, J.B., Branson, C.M., Shoptaw, S., Bowers, J.R., Charania, M., Mansergh, G., 2012. Text messaging reduces HIV risk behaviors among methamphetamine-using men who have sex with men. AIDS Behav. 16 (7), 1993–2002. https://doi.org/10.1007/s10461-012-0200-7.
Reback, C.J., Fletcher, J.B., Mata, R.P., 2021. A theory-based mhealth intervention (getting off) for methamphetamine-using men who have sex with men: Protocol for a randomized controlled trial. JMIR Res. Protoc. 10 (2), e22572 https://doi.org/10.2196/22572.
Rivera, A.V., Harriman, G., Carrillo, S.A., Braunstein, S.L., 2021. Trends in methamphetamine use among men who have sex with men in New York City, 2004–2017. AIDS Behav. 25 (4), 1210–1218. https://doi.org/10.1007/s10461-020-03097-5.
Robbins, S.J., Dauda, W., Kokogho, A., Ndembi, N., Mitchell, A., Adebajo, S., Gaydos, C. A., Salway, T., Ferlatte, O., Shoveller, J., Purdie, A., Grennan, T., Tan, D.H., Gilbert, M., 2019. The need and desire for mental health and substance use–related services among clients of publicly funded sexually transmitted infection clinics in Vancouver, Canada. J. Public Health Manag. Pract. 25 (3), E1–E10.
Shoptaw, S., 2006. Methamphetamine use in urban gay and bisexual populations. Top. HIV Med. 14 (2), 84–87. https://www.iasusa.org/wp-content/uploads/2006/06/14-2-84.pdf.
Shoptaw, S., Reback, C.J., 2007. Methamphetamine use and infectious disease-related behaviors in men who have sex with men: implications for interventions. Addiction 102, 130–135.
Shoptaw, S., Reback, C.J., Larkins, S., Wang, P.C., Rotheram-Fuller, E., Dang, J., Yang, X., 2008. Outcomes using two tailored behavioral treatments for substance abuse in urban gay and bisexual men. J. Subst. Abus. Treat. 35 (3), 285–293.
St. Lawrence, J.S., Chapdelaine, A.P., Devieux, J.G., O'Bannon, R.E., Brasfield, T.L., Eldridge, G.D., 1999. Measuring perceived barriers to condom use: psychometric evaluation of the condom barriers scale. Assessment 6 (4), 391–404. https://doi.org/10.1177/107319119900600409.
Stenger, M.R., Pathela, P., Anschuetz, G., Bauer, H., Simon, J., Kohn, R., Schumacher, C., Torrone, E., 2017. Increases in the rate of neisseria gonorrhoeae among gay, bisexual and other men who have sex with men-findings from the sexually transmitted disease surveillance network 2010-2015. Sex. Transm. Dis. 44 (7), 393–397. https://doi.org/10.1097/OLQ.0000000000000623.
Tan, D.H., Hull, M.W., Yoong, D., Tremblay, C., O'Byrne, P., Thomas, R., Shafran, S., 2017. Canadian guideline on HIV pre-exposure prophylaxis and nonoccupational postexposure prophylaxis. CMAJ 189 (47), E1448–E1458.
Tomkins, A., George, R., Kliner, M., 2019. Sexualised drug taking among men who have sex with men: a systematic review. Perspect. Public Health 139 (1), 23–33. https://doi.org/10.1177/1757913918778872.
Tulloch, T.G., Rotondi, N.K., Ing, S., Myers, T., Calzavara, L.M., Loutfy, M.R., Hart, T.A., 2015. Retrospective reports of developmental stressors, syndemics, and their association with sexual risk outcomes among gay men. Arch. Sex. Behav. 44 (7), 1879–1889.
Volz, E., Heckathorn, D.D., 2008. Probability based estimation theory for respondent driven sampling. J. Off. Stat. 24 (1), 79–97.
Vu, N.T.T., Holt, M., Phan, H.T.T., La, L.T., Tran, G.M., Doan, T.T., de Wit, J., 2017. The relationship between methamphetamine use, sexual sensation seeking and condomless anal intercourse among men who have sex with men in Vietnam: results of a community-based, cross-sectional study. AIDS Behav. 21 (4), 1105–1116.
Weston, R., Gore, P.A., 2006. A brief guide to structural equation modeling. Couns. Psychol. 34, 719–751, 10.1177/ 0011000006286345.
Wilkerson, J.M., Noor, S.W., Rhoton, J.M., Li, D., Rosser, B.R.S., 2018. Differentially classified methamphetamine-using men who have sex with men: a latent class analysis. Drug Alcohol Depend. 192, 129–136. https://doi.org/10.1016/j.drugalcdep.2018.07.003.
Wray, T.B., Pantalone, D.W., Kahler, C.W., Monti, P.M., Mayer, K.H., 2016. The role of discrimination in alcohol-related problems in samples of heavy drinking HIV-negative and positive men who have sex with men (MSM. Drug Alcohol Depend. 166, 226–234. https://doi.org/10.1016/j.drugalcdep.2016.07.017.