Brief Drug Interventions Delivered in General Medical Settings: A Systematic Review and Meta-Analysis of Cannabis Use Outcomes

Lauren M. Berny, M.Ed.,[1,a,b] Lindsey M. Nichols, M.S.,[2,a,c] Maria L. Schweer-Collins, Ph.D,[3,b,d] & Emily E. Tanner-Smith, Ph.D.[4,a,b,d]

[a] University of Oregon, Department of Counseling Psychology and Human Services

[b] University of Oregon, Prevention Science Institute

[c] Brown University, The Warren Alpert Medical School

[d] University of Oregon, HEDCO Institute for Evidence-Based Educational Practice

[1] Corresponding Author: Lauren Berny, 5251 University of Oregon Eugene, OR 97403;

Email: lberny@uoregon.edu https://orcid.org/0000-0002-8742-5313

[2] Email: lnichol2@uoregon.edu https://orcid.org/0000-0002-1855-3442

[3] Email: mschweer@uoregon.edu https://orcid.org/0000-0001-8285-9107

[4] Email: etanners@uoregon.edu https://orcid.org/0000-0002-5313-0664

Abstract: There is consistent evidence that brief interventions can be effective in preventing and reducing alcohol use, but support for their effects on illicit drug use is more limited. This meta-analysis builds upon prior research by testing whether brief drug interventions (BDIs) delivered in general medical settings reduce cannabis consumption and severity across post-intervention follow-up periods and explores potential heterogeneity in these intervention effects. Effect sizes from 17 randomized controlled trials were synthesized to compare short and long-term cannabis use outcomes between intervention and control groups. Mixed effects meta-regression models were estimated to examine variability in effects across four intervention characteristics: booster session delivery, delivery setting, intervention target, and target population. Sensitivity tests were also conducted for both main effects and moderation analyses. There was no evidence that BDIs yielded significant short-term reductions in cannabis use (*OR* = 1.20, 95% CI [0.90, 1.62]), frequency (*g* = 0.01, 95% CI [-0.07, 0.09]), or severity (*g* = 0.13, 95% CI [-0.07, 0.33]). Similarly, no evidence of long-term cannabis use (*OR* = 1.19, 95% CI [0.73, 1.86]) or frequency (*g* = 0.04, 95% CI [-0.05, 0.12]) were observed. Although the primary moderation analyses did not provide evidence of variation in effects, sensitivity tests revealed that BDIs delivered in emergency departments evidenced small but significant reductions in long-term frequency of cannabis use. Although these findings do not lend meaningful support for the *overall* effectiveness BDIs on cannabis consumption or severity when delivered in general medical settings, they do indeed provide secondary evidence that BDIs may perform more favorably when delivered in emergency departments. Thus, high-quality trials evaluating the effects of BDIs in emergency departments are needed. Further, given the importance of preventing adverse health outcomes and consequences of cannabis use, further research is clearly needed to improve and evaluate BDI outcomes as well as develop and test alternative prevention and intervention approaches to comprehensively address cannabis use.

Keywords: Brief interventions, cannabis, healthcare, meta-analysis

Cannabis use in the United States has changed dramatically as legal recreational and medical availability of the drug has expanded. Cannabis use has increased in the general population, with past-month use among individuals ages 12 and older increasing by 38% between 2015 to 2019 (Palamar et al., 2021). Cannabis use disorder is also now prevalent: 69.7% of respondents ages 12 and older with an illicit substance use disorder met diagnostic criteria for cannabis use disorder in a recent national survey (Substance Abuse and Mental Health Services Administration [SAMHSA], 2023b). Adverse health effects of frequent cannabis use include but are not limited to cardiovascular and respiratory complications, poor sleep quality, decision-making deficits, and depression and anxiety symptom severity (Fischer et al., 2022; Khalsa & Baler, 2019; Leadbeater et al., 2019; Lovell et al., 2020). Frequent cannabis use during adolescence, in particular, has been associated with poor health and psychosocial outcomes (Hall & Degenhardt, 2009), with prospective studies linking regular cannabis use during adolescence with reduced educational attainment, increased risk of cannabis dependence, other illicit drug use, criminal activity, internalizing disorder symptoms, and suicidality (Degenhardt et al., 2013; Fergusson et al., 2002; Silins et al., 2014). Despite these consequences, treatment utilization rates for cannabis are low: only 7.8% of U.S. adults who met criteria for cannabis use disorder received cannabis-specific treatment in the past year (Wu et al., 2017), with lack of perceived need, affordability, and accessibility being among the most common reasons for not receiving treatment (Kerridge et al., 2017). Given the prevalence and potential consequences of cannabis use, interventions that address these barriers to treatment may be critical for identifying and preventing frequent cannabis use.

One such model is the brief intervention, defined here as a counseling intervention delivered within four or less sessions that aims to increase awareness of substance use consequences and thereby reduce consumption. As a whole, brief interventions are heterogenous in their approach; other than their brevity, these interventions can vary in structure, core components, and delivery methods. Some brief interventions simultaneously target co-occurring alcohol and drug use, whereas others may focus solely on alcohol or participants' drug of choice

(e.g., cannabis); such flexibility allows brief interventions to be administered to broader populations or tailored to specific groups such as adolescents or university students (Mattoo et al., 2018; Roche & Freeman, 2004). Although brief interventions can be delivered in a variety of settings, embedding them into services in general medical settings—such as emergency departments, community health centers, primary care clinics, and student health centers—presents a potential opportunity to make substance use prevention and referral to treatment more accessible. Further, because frequent substance use and substance use disorders are often overrepresented in samples of individuals who receive clinical services in emergency departments and primary care clinics (Cherpitel & Ye, 2008; Pilowsky & Wu, 2012), these settings also facilitate a unique opportunity to address substance use with a high volume of at-risk individuals who may not be seeking substance use treatment. Nonetheless, although clinicians in general medical settings are well-positioned to screen for and discuss substance use with their patients, they often have minimal time and resources to provide services beyond treating presenting conditions. Thus, brief interventions are often appealing in these settings given their short duration, limited need for implementation training, and possible cost-efficiency (Barbosa et al., 2017). Taken together, the potential reach, adaptability, and feasibility of brief interventions delivered in general medical settings make them a pragmatic approach to opportunistically address cannabis use. As such, it is crucial to assess the evidence of their efficacy.

Although reviews of brief alcohol interventions have shown beneficial yet modest reductions in drinking (Kaner et al., 2018), support for brief drug interventions (BDIs) is more limited (Saitz, 2014). Recent meta-analyses of BDIs have revealed mixed results, showing evidence of beneficial reductions in drug use as well as null results (Halladay et al., 2019; Imtiaz et al., 2020; Sahker et al., 2022; Tanner-Smith et al., 2022). It is possible that BDI effects may vary across different study and intervention characteristics and thus contribute to these mixed results. One important such characteristic is the setting in which the intervention is delivered. For example, a recent meta-analysis found no evidence that brief interventions delivered in

outpatient medical facilities reduced frequency of drug use, but effects significantly varied across delivery settings, with subgroup analyses revealing that interventions delivered in emergency departments yielded small positive reductions in drug use frequency (Sahker et al., 2022). It is also possible that these BDIs may have greater beneficial effects in certain populations and/or when specifically targeting specific substances. For instance, another recent meta-analysis found that cannabis-targeted BDIs for adolescent and young adults were associated with small reductions in short-term cannabis use disorder symptoms and higher odds of short-term abstinence (Halladay et al., 2019). However, the same meta-analysis found no evidence of reductions in cannabis use frequency or consequences of cannabis use, suggesting that results may vary across outcomes domains or measures. Differences in the structures and components of interventions are also important to consider when evaluating BDI effects. One such characteristic is whether interventions include booster sessions to help sustain intervention effects. Although booster sessions are often employed with brief interventions, evidence about the impact of boosters is mixed. For instance, when evaluating the effects of brief interventions delivered in general medical settings, Tanner-Smith et al. (2022) found that delivery of a booster in brief alcohol interventions was associated with significant reductions in alcohol use, whereas BDIs delivered without a booster had larger beneficial reductions in mixed substance use (i.e., alcohol and other drug use) compared to BDIs with a booster. Thus, given the variation in BDI effects, attempts to synthesize the literature on BDIs should attend carefully to such potential heterogeneity in effects.

Given the potential consequences of cannabis use and low receipt of treatment for cannabis related problems, the primary aim of this meta-analysis is to evaluate whether BDIs delivered opportunistically in general medical settings result in beneficial reductions in the consumption and severity of cannabis use. As a secondary aim, this meta-analysis examines the variability in effects across patient populations, settings, intervention targets, and booster session delivery. The current meta-analysis builds upon and makes important contributions to the existing literature. Two recent studies have used meta-analytic methods to synthesize the effects

of brief interventions delivered specifically in healthcare settings on cannabis outcomes. First is a synthesis of findings from six studies examining the effects of BDIs delivered in healthcare settings with patients who reported recent cannabis use, which reported no evidence of effects on frequency of cannabis use nor severity or cannabis use (Imtiaz et al., 2020). Second was a review synthesizing findings from 111 studies of brief interventions delivered in general medical settings, which reported a subgroup analysis among 13 studies indicating small beneficial effects of BDIs on cannabis use that attenuated to non-significance after adjusting for multiple comparisons (Tanner-Smith et al., 2022). Both of these reviews therefore suggest that BDIs delivered in general medical settings may have modest to minimal effects on cannabis consumption outcomes. However, neither of these reviews conducted more in-depth analyses to examine whether BDI effects on cannabis use might vary across study or intervention characteristics. Given the likely variability in the ways that BDIs are implemented in different general medical settings, it is essential to explore such potential heterogeneity use before concluding that that they have consistently small or null effects on cannabis use outcomes. Therefore, the present meta-analysis conducts new analyses using data from Tanner-Smith et al. (2022), which expand the current evidence base by examining multiple cannabis use outcomes across different post-intervention follow-up periods as well as estimating meta-regression models to further explore heterogeneity in BDI effects.

Methods

Methods and findings are reported following the PRISMA 2020 reporting guidelines for systematic reviews with meta-analysis (Page et al., 2021). The protocols for both the parent systematic review and meta-analysis as well as this secondary analysis were pre-registered and posted on Open Science Framework. There were two post hoc deviations from the analysis protocol that were exploratory in nature, as described in greater detail below: (1) the addition of sensitivity tests to assess the impact of effect size selection based on follow-up time and intervention modality; and (2) applying effect size selection sensitivity tests to moderation analyses.

Eligibility Criteria and Search Strategy

This meta-analysis analyzes a subset of studies from a larger parent meta-analysis evaluating the effectiveness of brief substance use interventions delivered in general medical settings (Tanner-Smith et al., 2022). The parent meta-analysis included brief interventions targeting alcohol use, other drug use, or mixed substance use (i.e., both alcohol and other drug use). To be eligible for inclusion in the parent meta-analysis, studies had to evaluate substance use brief interventions delivered in four or fewer sessions to patients recruited from general, non-specialized medical service settings. Eligible studies were required to use a randomized controlled trial design to compare the brief interventions with less active comparison conditions (e.g. no treatment, sham, and treatment as usual) and report at least one post-intervention measure of substance use or substance use-related consequences. To be eligible for inclusion in the present analytic sample, studies were required to evaluate the effects of a BDI—defined here as explicitly targeting drug use either singularly or in conjunction with alcohol use—and report post-intervention measures of cannabis consumption or severity. As such, studies evaluating interventions that only targeted alcohol but measured cannabis consumption or severity as secondary outcomes were ineligible (Bernstein et al., 2010; Cancilliere et al., 2018).

The parent meta-analysis used a comprehensive search strategy to identify relevant published and unpublished studies, which yielded the studies considered for inclusion in the present meta-analysis. The following databases (hosts) were searched from 1990 through March 31, 2020: PubMed; Nursing/Academic Edition (EBSCO); ERIC, Applied Social Sciences Index and Abstracts, Dissertations and Theses Global, Social Services Abstract (ProQuest); PsycINFO (PsycNET); Cochrane Central Register of Controlled Trials; World Health Organization (WHO) International Clinical Trials Registry; and National Institutes of Health (NIH) RePORTER. Reference lists of all screened and eligible studies and those in prior narrative reviews and meta-analyses were reviewed. Hand searches were also performed of the 1990 to 2020 table of contents in *Addiction*, *Addictive Behaviors*, *Campbell Systematic Reviews*, and *Journal of Studies on Alcohol and Drugs*.

Study Selection and Data Extraction

A rigorous three-stage study selection and data extraction process was conducted by trained research assistants as part of the parent meta-analysis' protocol. First, two reviewers independently screened titles and abstracts to eliminate studies that did not meet the search criteria. Any of the studies considered potentially relevant for inclusion by at least one reviewer proceeded to the second stage, during which two reviewers independently reviewed the full texts to determine final eligibility. At the third stage, two reviewers independently coded and extracted data for all eligible studies. Any disagreements during the second and third stages were resolved by the Principal Investigator. This data extraction process followed a pre-registered, standardized coding protocol (see Tanner-Smith et al., 2022 for additional details). The Cochrane Collaboration's risk of bias tool for randomized controlled trials was used to assess risk of bias in the included studies (Higgins et al., 2011).

In the current meta-analysis, the first author (LMB) reviewed the studies that met its inclusion criteria to determine whether BIs were designed to target cannabis, which was a moderator of interest. After that independent review, the second author (LMN) reviewed the coding for consensus.

Outcomes

To comprehensively examine BDI effects on cannabis use, we examined three outcomes: (1) frequency of use (defined as number of days cannabis was used or quantity of cannabis used; continuous outcome); (2) general use (any cannabis use; binary outcome); and (3) severity of use (defined as continuous ASSIST scores; WHO ASSIST Working Group, 2002). These outcomes were assessed separately for short-term and long-term follow-up periods, defined as 0-5 months and 6-12 months post-intervention, respectively.

Moderators

The present meta-analysis examined the following potential effect size moderators: (1) delivery of a booster session (yes vs. no); (2) primary setting (emergency department, community health centers, student health centers, hospital-based primary care, or multiple

settings); (3) BDI target (cannabis-targeted BDIs vs. BDIs targeting other drugs or mixed substance use); and (4) sample population (adolescents only, adolescents and young adults, mixed/adults only, and university students).

Statistical Methods

Effect Size Metrics

Continuous outcomes of interest were measured using the small-sample corrected standardized mean difference (Hedges' *g*; Hedges, 1981), with positive values indicating beneficial effects (i.e., greater reductions in cannabis use or severity compared to control conditions). For the binary outcome of general cannabis use, we used log odds ratio effect sizes, with higher values indicating greater odds of *not* using cannabis compared to the control conditions. Log odds were transformed to odds ratios in narrative interpretations of those outcomes.

Effect Size Independence

To ensure each meta-analysis pooled a set of statistically independent effect sizes, only one effect size from each study was included for each analysis model. If studies reported multiple measures of cannabis use frequency, the following hierarchy was used for effect size selection, in order of preference: (1) frequency of use measured in days (e.g., days of cannabis use over the past month); (2) frequency of use measured in times cannabis was used over a week or longer time period (e.g., number of times cannabis was used over the past month); and (3) quantity of cannabis consumed (e.g., number of cannabis joints smoked over the past month). If studies reported general cannabis use for multiple recall periods, the effect size closest to the modal recall period was selected.

For studies that measured the same outcome at multiple timepoints within the short-term and long-term follow-up periods, the effect size closest to the modal timepoint was selected. In the event a modal timepoint was not present, preference was given to the earlier timepoint. Additionally, some studies included multiple intervention groups. For multi-arm studies that tested different intervention enhancements, the contrast between the most minimal control group

and most intensive intervention was selected. When multi-arm studies evaluated interventions delivered both in person and electronically, effect sizes for in-person interventions were retained as that was the most common modality in the analytic sample.

Analytic Strategy

First, we estimated random-effects models with the restricted maximum likelihood estimator for τ^2 to synthesize effect sizes of short-term and long-term results, defined as being measured at 0-5 months and 6-12 months post-intervention, respectively. Because only one study measured severity at a long-term follow-up, only short-term severity results were synthesized. Next, mixed effects meta-regression models were estimated with the Knapp and Hartung adjustment to examine the moderators of interest (Knapp & Hartung, 2003). For subsequent subgroup analyses, the between studies variance (τ^2) was computed within subgroups; then, each estimate of τ^2 was pooled and applied to all the subgroups. Forest plots were used to visually display these results.

Sensitivity tests were conducted to assess the impact of effect size selection based on timepoint, intervention intensity, and BDI modality. For studies that reported multiple effect sizes within a follow-up period, we assessed whether choosing an alternative follow-up timepoint, less intensive intervention contrast, or electronic modality, impacted the findings. These sensitivity tests were only conducted for cannabis frequency and use outcomes because none of the severity outcome analyses were affected by these selection factors. Additionally, timepoint sensitivity tests were limited to outcomes that were reported at multiple timepoints in the included studies. Thus, because the effect size selection process described above resulted in all selected short-term effect sizes being measured at three months post-intervention, timepoint sensitivity tests were not conducted for short-term outcomes. Last, for outcomes with ten or more effect sizes included in the synthesis, funnel plots, regression tests for funnel plot asymmetry, and trim and fill analysis were used to assess for potential publication bias (Egger et al., 1997; Rothstein et al., 2005). All analyses were conducted in R using the metafor package (version 4.4; Viechtbauer, 2010).

Results

The PRISMA flow chart is displayed in Figure 1. The parent study included effect sizes from 111 studies in the overall meta-analysis. Seventy-three of those studies were excluded from the present analysis due to an ineligible intervention (i.e., alcohol focused interventions). Among the remaining 38 BDIs, 21 studies were excluded due to ineligible outcomes (i.e., no cannabis outcomes reported). The remaining 17 studies were eligible for inclusion in the current meta-analysis, comprising data collected from 23 unique study samples and reported in 18 reports. As shown in Table 1, most studies took place in the United States or Canada (82%). Using the Cochrane Collaboration's risk of bias tool for randomized controlled trials (Higgins et al., 2011), the majority of studies were rated as having an unclear risk of bias (82%), with allocation concealment, blinding of outcome assessors, and selective reporting being the domains with the greatest risk for bias (study-level risk of bias ratings are reported in Supplemental Material 1). All studies included a CONSORT diagram. The most common delivery settings were community health centers (41%) and emergency departments (29%). Most interventions targeted mixed age groups or adults only (41%) and adolescents only (29%). Thirty-five percent of the BDIs included a booster, and only six studies (35%) specifically targeted cannabis use vs. other drugs/multiple drugs. Study-level characteristics are reported in Table 2.

Main Effects

Standardized effect sizes and heterogeneity statistics are reported in Table 3 for all estimable time periods and outcomes. Long-term severity effects could not be synthesized because only one eligible study measured cannabis use severity during that follow-up period. Forest plots of these models are also displayed in Supplemental Material 2.

Cannabis Use Frequency

Relative to practice as usual controls, there was no evidence of significant reductions in short-term (k = 12, g = 0.01, 95% CI [-0.07, 0.09], p = .802) or long-term (k = 11, g = 0.04, 95% CI [-0.05, 0.12], p = .413) frequency of cannabis use in participants assigned to BDIs. In other words, there was less than a 0.05 standard deviation difference in reported frequency of cannabis

use between the BDI and control groups during both time periods. Indeed, although 13 of the 23 total cannabis frequency effect sizes were positive, none were statistically significant. There was no evidence of between-study heterogeneity in short-term (τ^2 = 0.00, I^2 = 0.00%) or long-term (τ^2 = 0.03, I^2 = 5.15%) frequency.

Cannabis Use

No evidence of significant reductions in short-term (k = 3, logOR = 0.19, 95% CI [-0.11, 0.48], p = .217) or long-term (k = 4, logOR = 0.18, 95% CI [-0.32, 0.67], p = .488) cannabis use were observed in participants assigned to BDIs relative to practice as usual controls. Interpreted another way, the odds of *not* using cannabis were approximately 20% higher for participants assigned to BDIs versus those assigned to the control groups, but these differences were not statistically significant. Despite four out of seven total cannabis use effect sizes showing positive effects, only one was statistically significant. Although there was no evidence of between-study heterogeneity in short-term cannabis use (τ^2 = 0.00, I^2 = 0.00%), there was evidence of heterogeneity between studies measuring long-term use ($Q_{(3)}$ = 8.61, τ^2 = 0.16%, p = .035), with 63.85% of the observed heterogeneity reflecting variance in true effects rather than sampling error. Thus, considerable variation in the long-term odds of not using cannabis could be expected in future BDI trials (95% PI = [0.47, 3.04]).

Cannabis Use Severity

Synthesis of seven independent effect sizes (81% positive) from four studies showed no evidence of significant reductions in short-term cannabis use severity for participants assigned to BDIs relative to practice as usual controls (g = 0.13, 95% CI [-0.07, 0.33], p = .199). In other words, there was a 0.13 standard deviation difference in reported severity between the BDI and control groups. There was evidence of minimal heterogeneity between these studies (τ^2 = 0.04, $Q_{(6)}$ = 13.39, p = .037), with 63.7% of the observed heterogeneity reflecting variance in true effects rather than sampling error. Thus, considerable variation in short-term effects on cannabis severity could be expected in future BDI trials (95% PI = [-0.31, 0.57]).

Moderation Analysis

Subgroup effect sizes and 95% confidence intervals for the moderation analyses are reported in Table 4. Although short-term use outcomes are reported for completeness, the results should be interpreted with caution due to large standard errors and limited degrees of freedom. Overall, there was no evidence that effects of BDIs were moderated by booster session status (F = 1.12, p = .367), setting (F = 3.02, p = .094), intervention target (F = 3.05, p = .745), nor population (F = 1.40, p = .326). Moreover, none of the subgroups were associated with significant changes in cannabis outcomes during either follow-up period.

Sensitivity Tests

The main effect findings from the sensitivity tests were consistent with those of the primary analysis reported above (full results are reported in Supplemental Material 3). The sensitivity tests for the moderator analysis findings were also generally consistent with the primary findings reported above, with one notable exception. BDIs implemented in emergency departments evidenced small but significant reductions in cannabis use frequency when selecting alternative effect sizes based on follow-up timepoint (g = 0.15 [0.00, 0.30], p = .049), intervention intensity (g = 0.17 [0.03, 0.31], p = .024), and modality (g = 0.16 [0.01, 0.31], p = .042). As shown by the forest plot in Figure 2, these selection choices resulted in a higher effect size for this subgroup than obtained from the primary analytic sample (g = 0.13 [-0.00, 0.27], p = .054). Full moderation results for the sensitivity tests are reported in Supplemental Material 4.

Discussion

This meta-analysis had two primary aims: to (1) evaluate the effects of BDIs delivered in general medical settings on cannabis outcomes; and (2) assess whether those effects varied by booster session status, intervention target, setting, and population. Overall, we found no evidence of consistently beneficial or harmful effects of BDIs on frequency of cannabis use, general cannabis use, or severity of use at both short-term and long-term follow-up periods. There was also no evidence these effects were moderated by booster session status, intervention target, setting, or population. Overall, these findings were generally consistent across a variety of sensitivity tests but may be admittedly conservative; nonetheless, the results do not lend evidence

that implementing BDIs in general healthcare would lead to consistent reductions in medical patients' cannabis consumption or severity.

Findings from the sensitivity analyses, however, suggest these results may be conservative, and there is a subgroup for whom BDIs may lead to beneficial long-term effects on cannabis outcomes. In each of the three sensitivity tests, BDIs delivered in emergency departments were associated with significant reductions in cannabis use frequency, providing secondary evidence that BDIs may perform more favorably when delivered in emergency departments. This is consistent with a recent review that found that only BDIs delivered in emergency departments had significant reductions in drug use frequency (Sahker et al., 2022) and suggests that BDIs may be better suited for implementation in that specific setting. These more favorable results may stem from the high prevalence of emergency department visits attributed to substance use, with cannabis being the second most common illicit drug involved in admissions (SAMHSA, 2023a). It is possible that individuals seeking treatment at an emergency department may have more severe presentations and thus benefit more from a single BDI. Additionally, if the emergency department visit stemmed from cannabis or other drug-related consequences (e.g., cannabinoid hyperemesis syndrome, vehicle accidents), participants may have greater motivation to make behavioral changes and thus be better candidates for BDIs (Hawk & D'Onofrio, 2018).

Nevertheless, the null results for the main effects are consistent with other meta-analyses evaluating BDIs delivered in healthcare settings (Imtiaz et al., 2020; Tanner-Smith et al., 2022). Similarly, other trials have reported no evidence of reductions in cannabis outcomes after delivering brief interventions in healthcare settings (Bernstein et al., 2010; Cancilliere et al., 2018; Poblete et al., 2017). Brief interventions remain a compelling approach to reducing substance use and related consequences given their brevity and low cost, consistent evidence of beneficial effects on reducing alcohol use, and importance as a first step along the continuum of care (Halladay et al., 2019). BDIs, in particular, may be integral in linking individuals to further substance use treatment as prior studies have found that participants who received BDIs were

significantly more likely to attend substance use treatment during the follow-up periods than participants in the comparison groups (Krupski et al., 2010; Tait et al., 2004). However, these null findings clearly warrant consideration of *how* BDIs delivered in general medical settings can be improved upon to address cannabis consumption and severity. Another possibility is that BDIs targeting cannabis use are differentially effective for patients with different identities or presenting characteristics. For example, Schweer-Collins and colleagues (2023) explored whether BDIs varied according to patient sex, age, housing status, relationships status, education level, and baseline severity of drug or alcohol use using individual patient data; however, no evidence of variability was found for any cannabis or drug-use related outcomes. Similar to the current study, there were few studies exploring the outcomes of drug-specific BDIs (k = 2-5) and thus future studies should continue to explore the populations for whom and settings under which BDIs targeting cannabis use are more or less effective.

Limitations

Although this meta-analysis fills important gaps in the knowledge base around BDIs, its findings should be viewed in light of its limitations. First, given the small number of studies evaluating the effects of BDIs on cannabis use, the power to assess heterogeneity was inherently limited. Second, none of the included studies reported outcomes collected after 12-months post-intervention. Therefore, these findings cannot be generalized to longer follow-up periods. Third, both biomarkers and self-report instruments were used to measure cannabis use in the included studies. The validity of self-report instruments in BDI trials is a concern due to social desirability bias and potential underreporting of illicit substance use (Saitz, 2014), which may contribute to differences in intervention effects across studies. Fourth, all synthesized studies included in this meta-analysis were rated as having unclear or high overall risk of bias. Thus, it is unknown how these findings would change if they were conducted with a lower risk of bias.

Future Considerations

As cannabis use continues to evolve in the wake of medical and recreational legalization, it may be beneficial for BDIs targeting people who use cannabis to include more harm reduction

strategies. This could include content about using lower-potency cannabis products and adopting alternative routes of use over smoking cannabis to reduce pulmonary health risks (Fischer et al., 2022). Delaying the onset of cannabis use to adulthood has also been identified as a harm reduction strategy as prior research suggests that doing so can reduce the risk of adverse health outcomes (Fischer et al., 2022), but only two of the trials included in this meta-analysis tested the effects of BDIs targeting youth who reported never using cannabis (Knight et al., 2019; Walton et al., 2014). As such, youth-focused preventive BDIs delivered in general medical settings warrant further exploration, with particular attention to their developmental appropriateness and timing in order to ensure maximal impact (Nation et al., 2003).

In addition, further research is needed to expand and improve upon the current body of evidence. Given the sensitivity results showing some evidence of greater benefit of BDIs in ED settings, high-quality trials evaluating the effects of BDIs in emergency departments are needed. Trials should also be conducted in urgent care centers and free-standing emergency departments to evaluate whether effects may vary across different models of emergency medical treatment. Moreover, it is possible that BDIs implemented in other settings may have greater beneficial effects on cannabis outcomes. For example, a meta-analysis that synthesized the effects of cannabis-targeted brief interventions delivered in school, healthcare, truancy centers, and general community settings found that adolescents and young adults assigned to the intervention groups had higher rates of abstinence (i.e., no use of cannabis) and lower cannabis use disorder symptoms at 1-3 months post-intervention versus those assigned to control groups (Halladay et al., 2019). As such, researchers should continue to synthesize the evidence of BDI trials in other settings to further assess this. Given recent reviews highlighting the importance of the duration and components (e.g., motivational interviewing, personalized feedback) of cannabis-targeted brief interventions (Gex et al., 2024; Parmar & Sarkar, 2017), future meta-analyses should include these characteristics as candidate moderators to investigate if and to what extent the cannabis use outcomes may vary across them. Finally, more effort should be placed into developing and testing alternative prevention and intervention approaches to comprehensively

address cannabis use as well as increasing access to and strengthening referral systems for substance use treatment.

Protocol Registration

Protocol for the parent systematic review and meta-analysis was pre-registered in PROSPERO (CRD42018086832). The analytic plan for this review was pre-registered in OSF: https://osf.io/c82vg

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Disclosure of Potential Conflicts of Interest

None of the other authors report any potential conflicts of interest.

Ethical Approval

The University of Oregon Institutional Review Board (IRB) reviewed the protocol for this review and determined that the study activities did not meet the definition of research with human subjects according to Title 45 CFR 46.102 (d-f) and thus did not require IRB approval.

Informed Consent

This meta-analysis did not involve the collection of data from human subjects. As such, no informed consent was required.

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Table 1

Aggregate Characteristics of Included Studies (k = 17)

Characteristic	*k* (%)	Characteristic	*k* (%)
Country		Setting	
United States	14 (82.4%)	Community health center	7 (41.2%)
Africa	1 (5.9%)	Emergency department	5 (29.4%)
Europe	1 (5.9%)	Multiple	2 (11.8%)
Multiple	1 (5.9%)	University health center	2 (12.8%)
		Hospital-based primary care	1 (5.9%)
Risk of Bias			
Random sequence generation		Population	
Low	11 (64.7%)	Mixed ages and adults only	7 (41.2%)
Unclear	6 (35.3%)	Adolescents only	5 (29.4%)
Allocation concealment		Adolescents and young adults	3 (17.6%)
Low	8 (47.1%)	University students	2 (11.8%)
Unclear	9 (52.9%)		
Blinding of outcome assessors		Booster Session	
Low	1 (5.9%)	No	11 (64.7%)
High	1 (5.9%)	Yes	6 (35.3%)
Unclear	15 (88.2%)		
Selective reporting		Intervention Target	
Low	3 (17.6%)	Other drug/mixed substances	11 (64.7%)
High	1 (5.9%)	Cannabis	6 (35.3%)
Unclear	13 (76.5%)		
Incomplete outcome data			
Low	10 (58.8%)		
High	1 (5.9%)		
Unclear	6 (35.3%)		
Other Bias			
Low	13 (76.5%)		
Unclear	4 (23.5%)		
Overall risk of bias			
High	3 (17.6%)		
Unclear	14 (82.4%)		
Consort Diagram			
No	0 (0.0%)		
Yes	17 (100.0%)		

Table 2

Characteristics of Included Studies (*k = 17)*

Study	Outcomes	Modality	Risk of Bias	Population	Setting	Target	Booster	Follow-Up (months)	Intensity
Bernstein et al. (2009)	Frequency	In-person	Unclear	Adolescents and YAs	ED	Cannabis	Y	3, 12	N
Blow et al. (2017)	Frequency	*Electronic*, in-person	High	Mixed ages and adults only	ED	OD/MS	Y	3, 6, 12	*Y*
D'Amico et al. (2008)	Frequency	In-person	Unclear	Adolescents	CHC	OD/MS	Y	3	N
D'Amico et al. (2018)	Frequency	In-person	Unclear	Adolescents	CHC	OD/MS	N	3, 6, 12	N
Goodness & Palfai (2020)	Frequency	Electronic	Unclear	University students	UHC	Cannabis	Y	3, 6	N
Gryczynski et al. (2016)	Use, Severity	Electronic	Unclear	Mixed ages and adults only	CHC	OD/MS	N	3	N
Humeniuk et al. (2012)	Severity	In-person	High	Mixed ages and adults only	Multiple	OD/MS	N	3	N
Knight et al. (2019)**	Use	In-person	Unclear	Adolescents	Multiple	OD/MS	N	12	N
Laporte et al. (2017)	Frequency	In-person	Unclear	Adolescents and YAs	CHC	Cannabis	N	3, 6, 12	N
Mason et al. (2015)	Frequency	In-person	Unclear	Adolescents	CHC	OD/MS	N	3, 6	N
Merchant et al. (2015)	Use, Severity	In-person	Unclear	Mixed ages and adults only	ED	OD/MS	Y	3	N
Mertens et al. (2014)	Severity	In-person	Unclear	Adolescents and YAs	CHC	OD/MS	N	3	N
Palfai et al. (2014)	Frequency	Electronic	Unclear	University students	UHC	Cannabis	N	3, 6	N
Saitz et al. (2014)	Use, Severity	In-person	Unclear	Mixed ages and adults only	HPC	OD/MS	Y	6	*Y*
Walsh et al. (2017)	Frequency	Electronic	High	Mixed ages and adults only	ED	OD/MS	N	3, 6	N
Walton et al. (2013, 2014)**	Frequency, Use	*Electronic*, in-person	Unclear	Adolescents	CHC	Cannabis	N	3, 6, 12	N
Woolard et al. (2013)	Frequency	In-person	Unclear	Mixed ages and adults only	ED	Cannabis	N	3, 6	N

Note. Effect sizes associated with italicized characteristics were only included in sensitivity analyses. CHC = community health center; ED = emergency department; HPC = hospital-based primary care; UHC = university health center; OD/MS = other drugs/mixed substances.

*Study reported outcomes for four independent samples based on recruitment sites.

**Study reported outcomes for two independent samples based on cannabis initiation status.

Table 3

Standardized Effect Sizes, 95% Confidence Intervals, and Heterogeneity Statistics by Outcome and Time Period

	0-5 Months				6-12 Months			
Cannabis Outcome	ES [95% CI]	[95% PI]	τ^2	I^2	ES [95% CI]	[95% PI]	τ^2	I^2
Frequency	0.01 [-0.07, 0.09]$_{12}$	[-0.07, 0.09]	0.00	0.00%	0.04 [-0.05, 0.12]$_{11}$	[-0.07, 0.15]	0.00	5.15%
Use	0.19 [-0.11, 0.48]$_{3}$	[-0.11, 0.48]	0.00	0.00%	0.18 [-0.32, 0.67]$_{4}$	[-0.76, 1.11]	0.16	63.85%
Severity	0.13 [-0.07, 0.33]$_{7}$	[-0.31, 0.57]	0.03	63.73%	—	—	—	—

Note. Subscripts denote the number of independent effect sizes included for each outcome; frequency and severity effect sizes are Hedges' *g* and use effect sizes are logORs; ES = effect size; CI = 95% confidence intervals; PI = 95% prediction intervals.

Table 4

Subgroup Effect Sizes and 95% Confidence Intervals by Outcome Domain and Follow-Up Period

	0-5 Months			6-12 Months	
Subgroup	**Frequency**	**Use**	**Severity**	**Frequency**	**Use**
Booster Session					
No	-0.02 [-0.11, 0.08]$_8$	-0.11 [-5.93, 5.71]$_1$	0.15 [-0.17, 0.47]$_6$	-0.01 [-0.10, 0.12]$_8$	0.39 [-0.59, 1.37]$_1$
Yes	0.14 [-0.07, 0.35]$_4$	0.24 [-5.27, 5.75]$_2$	0.09 [-0.55, 0.72]$_1$	0.16 [-0.08, 0.41]$_3$	-0.33 [-1.61, 0.94]$_3$
Setting					
Community health center	-0.02 [-0.15, 0.10]$_6$	-0.11 [-5.93, 5.71]$_2$	-0.11 [-0.52, 0.74]$_2$	-0.06 [-0.17, 0.06]$_5$	0.00 [-3.89, 3.89]$_1$
Emergency department	0.01 [-0.14, 0.17]$_4$	0.24 [-5.27, 5.75]$_1$	0.09 [-0.70, 0.88]$_1$	0.13 [-0.00, 0.27]$_4$	—
Hospital-based primary care	—	—	—	—	-0.33 [-2.86, 2.20]$_1$
Multiple settings	—	—	0.18 [-0.20, 0.66]$_4$	—	0.57 [-2.09, 3.23]$_2$
University health center	0.22 [-0.11, 0.55]$_2$	—	—	0.21 [-0.09, 0.51]$_2$	—
Target					
Other drugs/mixed substances	0.07 [-0.09, 0.23]$_6$	-0.04 [-5.83, 5.75]$_2$	—	0.05 [-0.15, 0.24]$_5$	0.25 [-1.21, 1.70]$_3$
Cannabis	-0.02 [-0.13, 0.10]$_6$	0.20 [-7.85, 8.26]$_1$	—	0.04 [-0.11, 0.18]$_6$	-0.00 [-2.62, 2.62]$_1$
Population					
Adolescents only	0.01 [-0.12, 0.14]$_5$	0.20 [-7.85, 8.26]$_1$	0.07 [-0.58, 0.72]$_1$	-0.05 [-0.20, 0.10]$_4$	0.39 [-0.59, 1.37]$_3$
Adolescents and young adults	-0.15 [-0.42, 0.11]$_2$	—	—	0.01 [-0.28, 0.30]$_2$	—
Mixed and adults only	0.02 [-0.13, 0.18]$_3$	-0.04 [-5.83, 5.75]$_2$	0.15 [-0.16, 0.46]$_6$	0.13 [-0.05, 0.31]$_3$	-0.33 [-1.61, 0.94]$_1$
University students	0.22 [-0.11, 0.55]$_2$	—	—	0.21 [-0.14, 0.56]$_2$	—

Note. Subscripts denote the number of independent effect sizes in each subgroup; frequency and severity effect sizes are Hedges' *g* and use effect sizes are logORs.

Figure 1

PRISMA Flow Diagram Displaying Numbers of Reports and Studies Included in Review

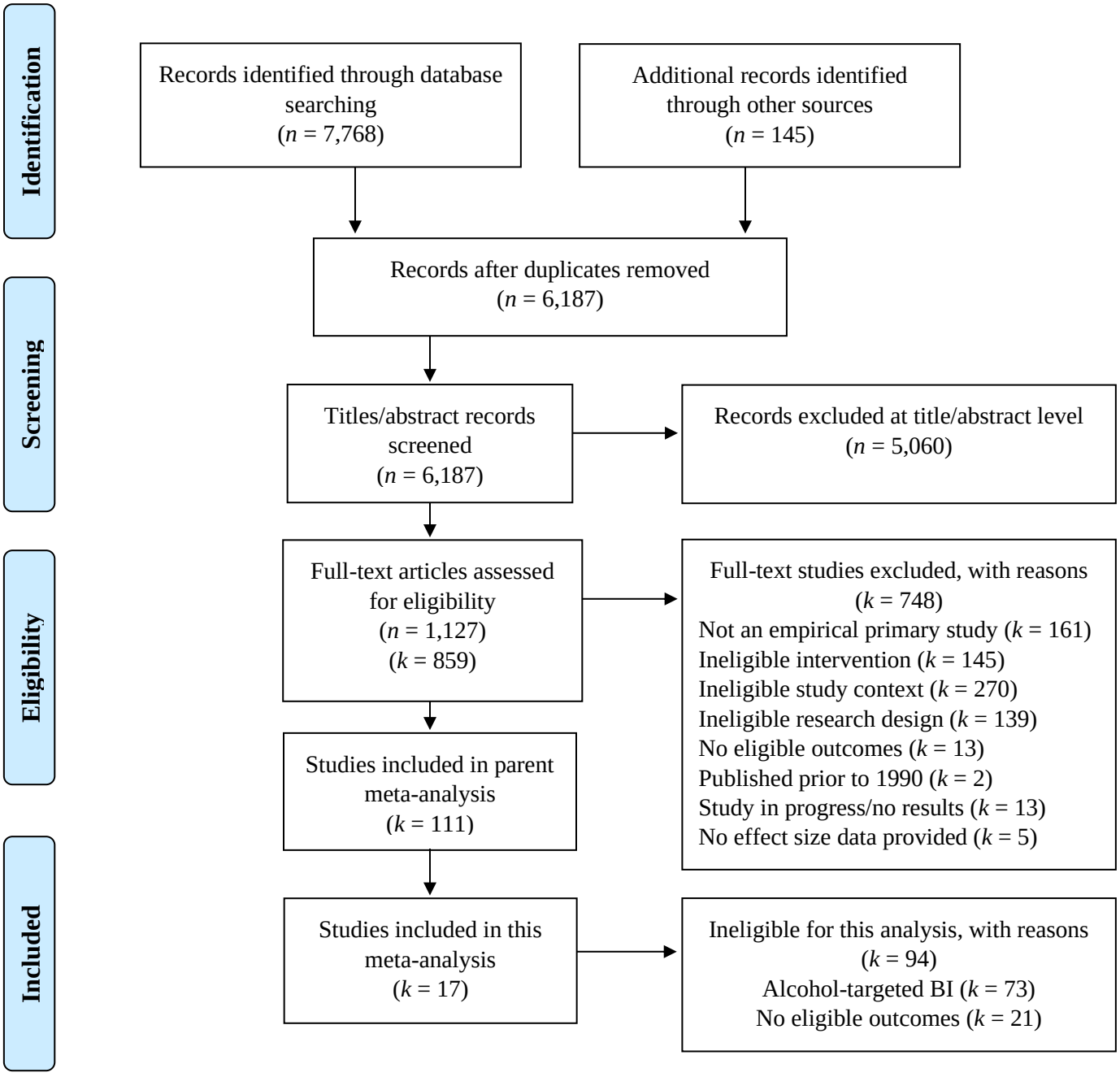
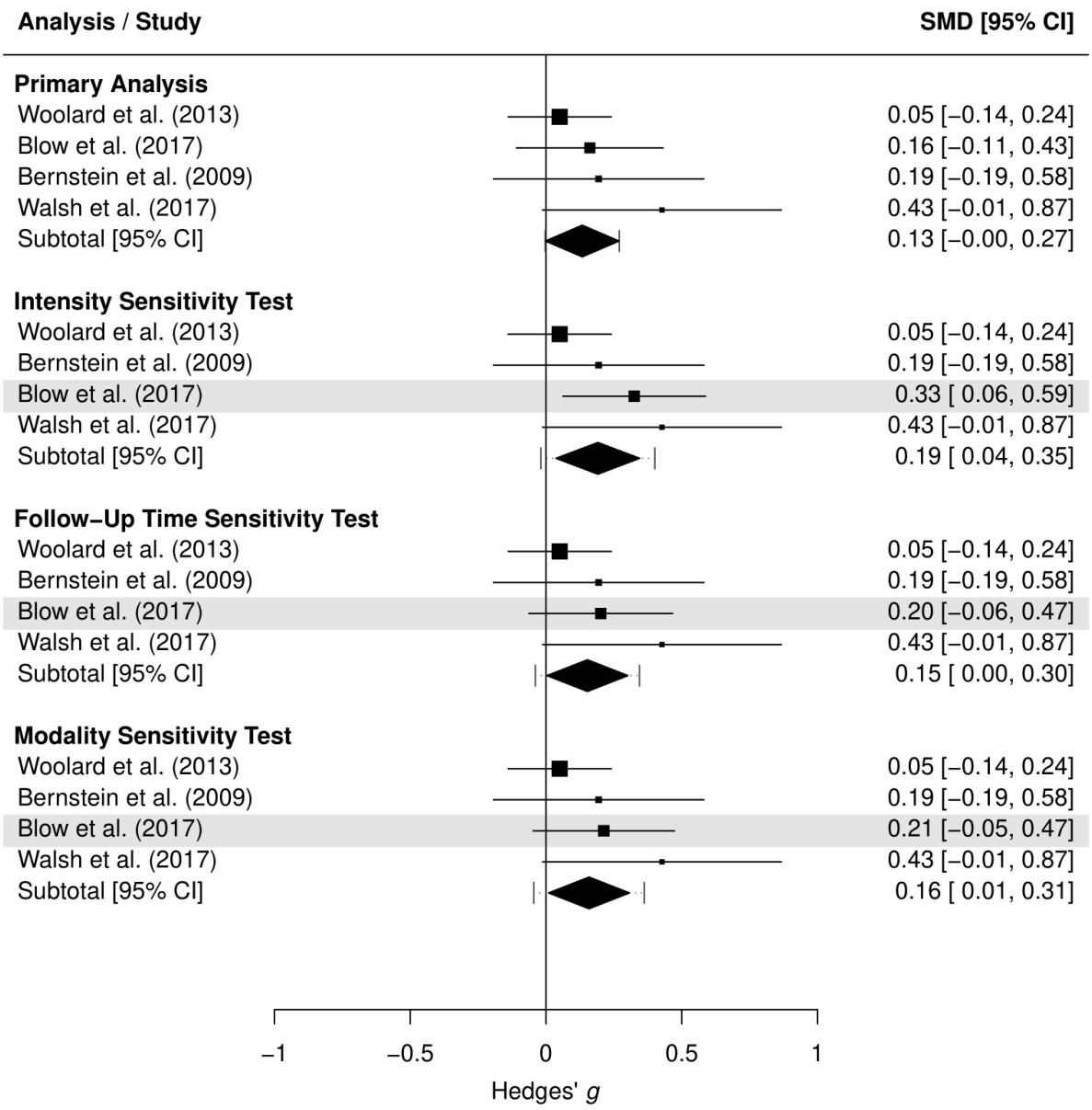


Figure 2

Long-term Cannabis Use Frequency Results for Emergency Department Subgroups



Forest plot illustrating individual study effects (squares, with size representing weight), pooled subgroup effect estimates (diamonds), and prediction intervals (dashed lines extending from diamond). Highlighted study effects differed from those included in the primary analytic sample. SMD = Hedges' *g* standardized mean difference.

Supplemental Material S1: Risk of Bias Assessment

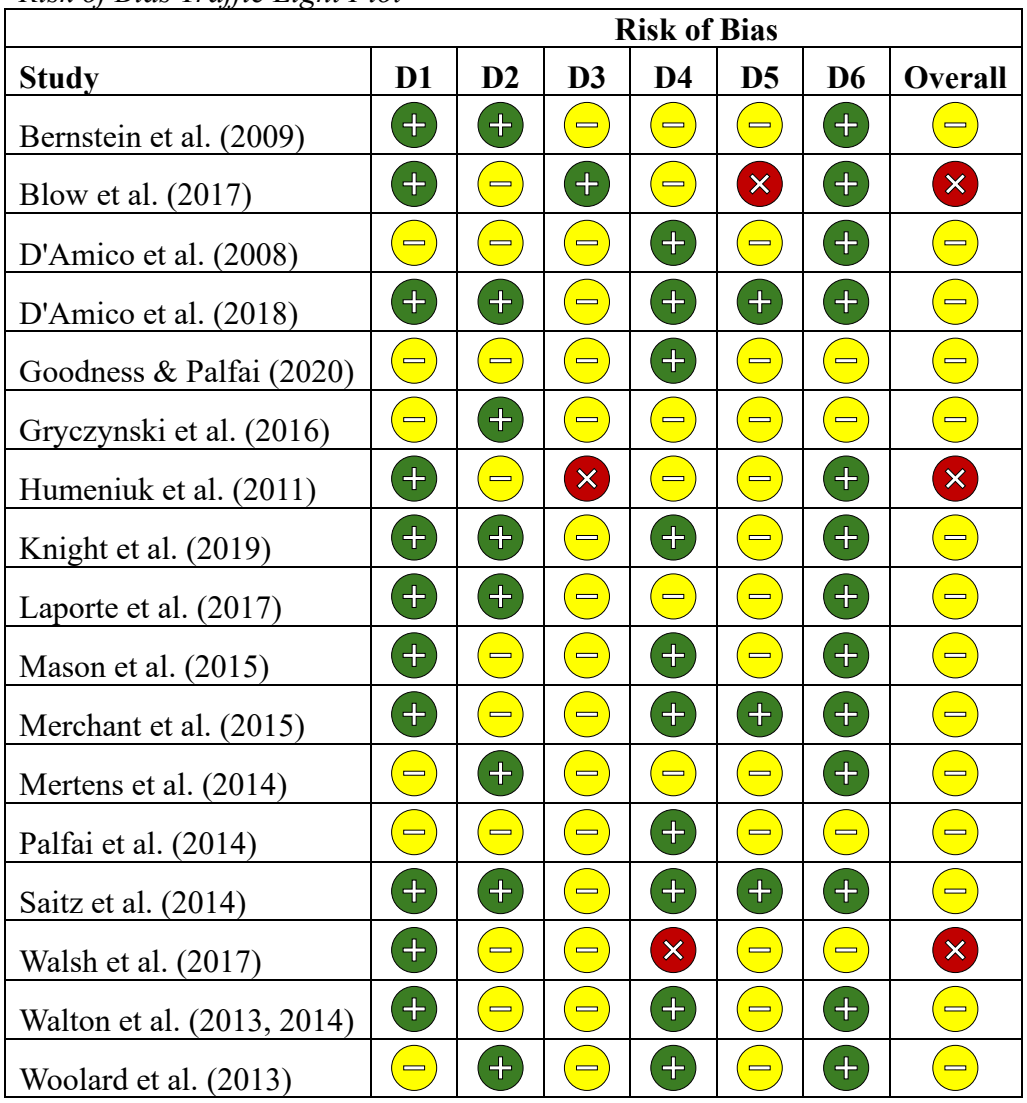
Table 1

Risk of Bias Ratings for the Included Studies (k = 17)

Study	Random Sequence Generation	Allocation Concealment	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting	Other Bias	Overall Bias
Bernstein et al. (2009)	Low	Low	Unclear	Unclear	Unclear	Low	Unclear
Blow et al. (2017)	Low	Unclear	Low	Unclear	High	Low	High
D'Amico et al. (2008)	Unclear	Unclear	Unclear	Low	Unclear	Low	Unclear
D'Amico et al. (2018)	Low	Low	Unclear	Low	Low	Low	Unclear
Goodness & Palfai (2020)	Unclear	Unclear	Unclear	Low	Unclear	Unclear	Unclear
Gryczynski et al. (2016)	Unclear	Low	Unclear	Unclear	Unclear	Unclear	Unclear
Humeniuk et al. (2011)	Low	Unclear	High	Unclear	Unclear	Low	High
Knight et al. (2019)	Low	Low	Unclear	Low	Unclear	Low	Unclear
Laporte et al. (2017)	Low	Low	Unclear	Unclear	Unclear	Low	Unclear
Mason et al. (2015)	Low	Unclear	Unclear	Low	Unclear	Low	Unclear
Merchant et al. (2015)	Low	Unclear	Unclear	Low	Low	Low	Unclear
Mertens et al. (2014)	Unclear	Low	Unclear	Unclear	Unclear	Low	Unclear
Palfai et al. (2014)	Unclear	Unclear	Unclear	Low	Unclear	Unclear	Unclear
Saitz et al. (2014)	Low	Low	Unclear	Low	Low	Low	Unclear
Walsh et al. (2017)	Low	Unclear	Unclear	High	Unclear	Unclear	High
Walton et al. (2013, 2014)	Low	Unclear	Unclear	Low	Unclear	Low	Unclear
Woolard et al. (2013)	Unclear	Low	Unclear	Low	Unclear	Low	Unclear

Figure 1

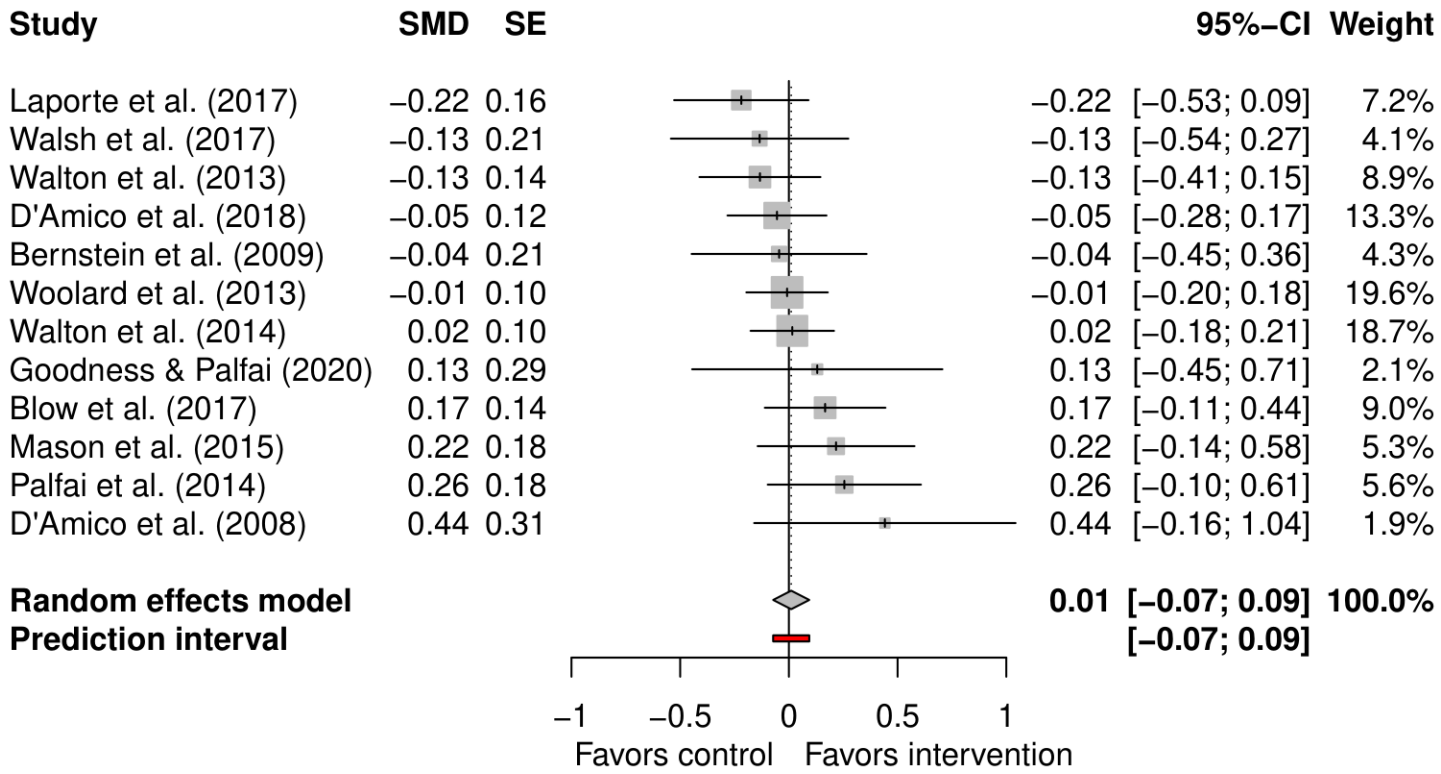
Risk of Bias Traffic Light Plot



Supplemental Material S2: Forest Plots for Main Effect Analyses

Figure 1

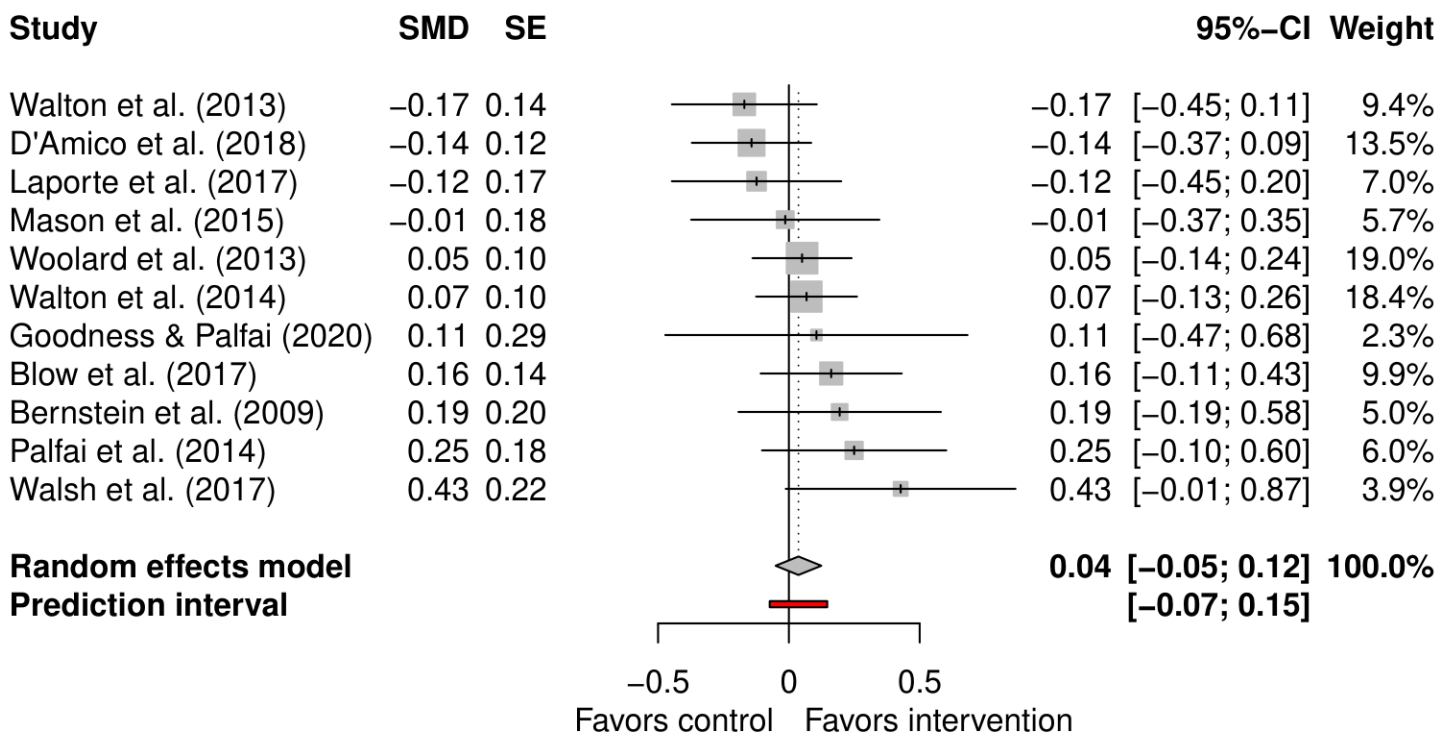
Forest Plot of the Effects of Brief Drug Interventions of Short-Term Cannabis Use Frequency



Note. SMD = Hedges' *g* standardized mean difference; SE = standard error; CI = 95% confidence intervals.

Figure 2

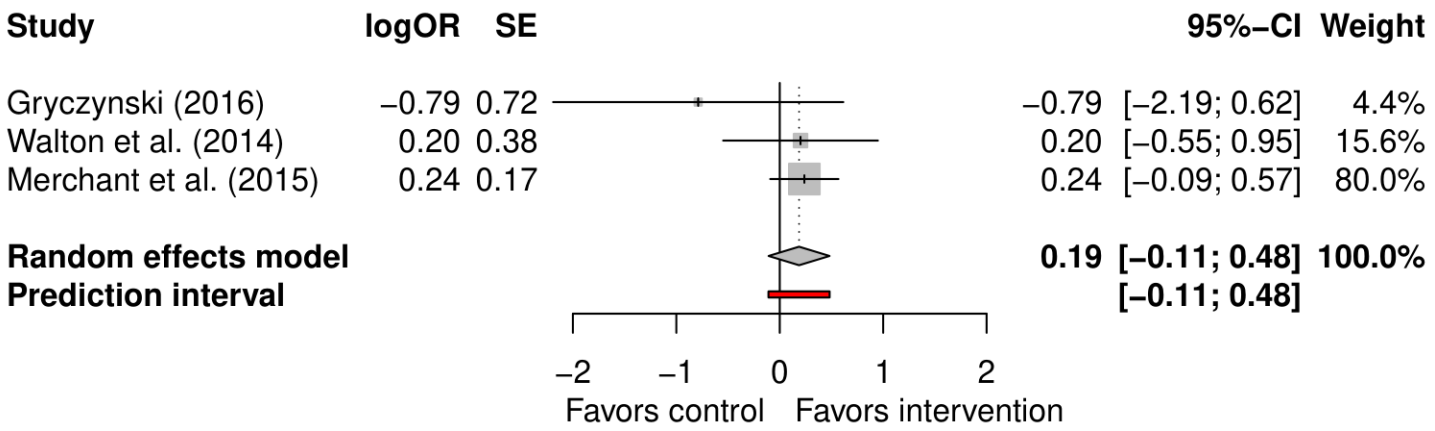
Forest Plot of the Effects of Brief Drug Interventions of Long-Term Cannabis Use Frequency



Note. SMD = Hedges' *g* standardized mean difference; SE = standard error; CI = 95% confidence intervals.

Figure 3

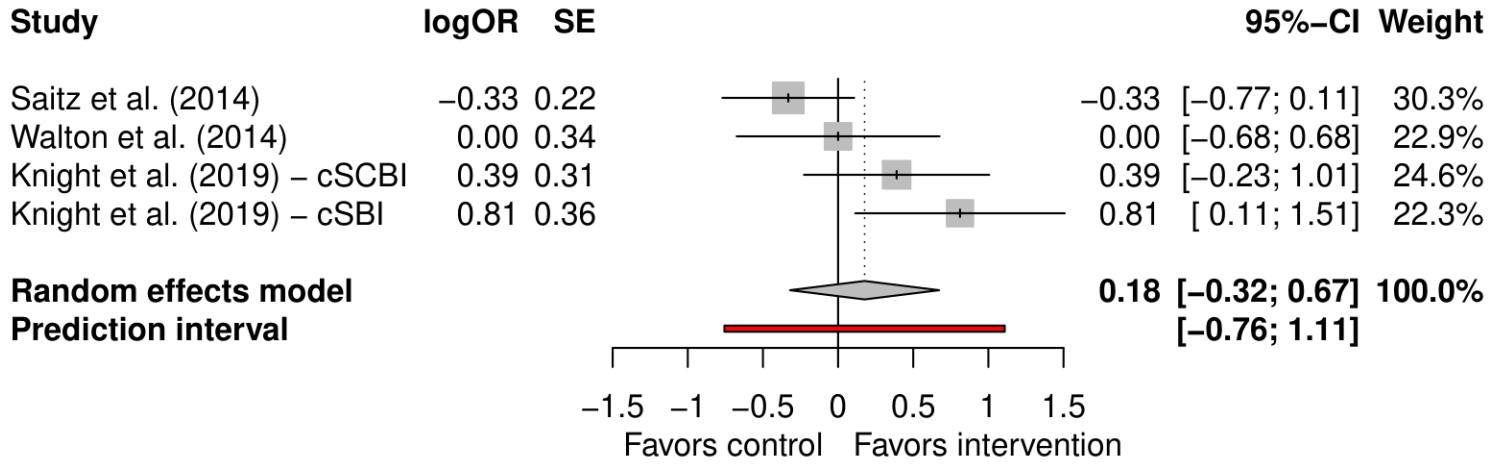
Forest Plot of the Effects of Brief Drug Interventions of Short-Term Cannabis Use



Note. logOR = log odds ratio; SE = standard error; CI = 95% confidence intervals.

Figure 4

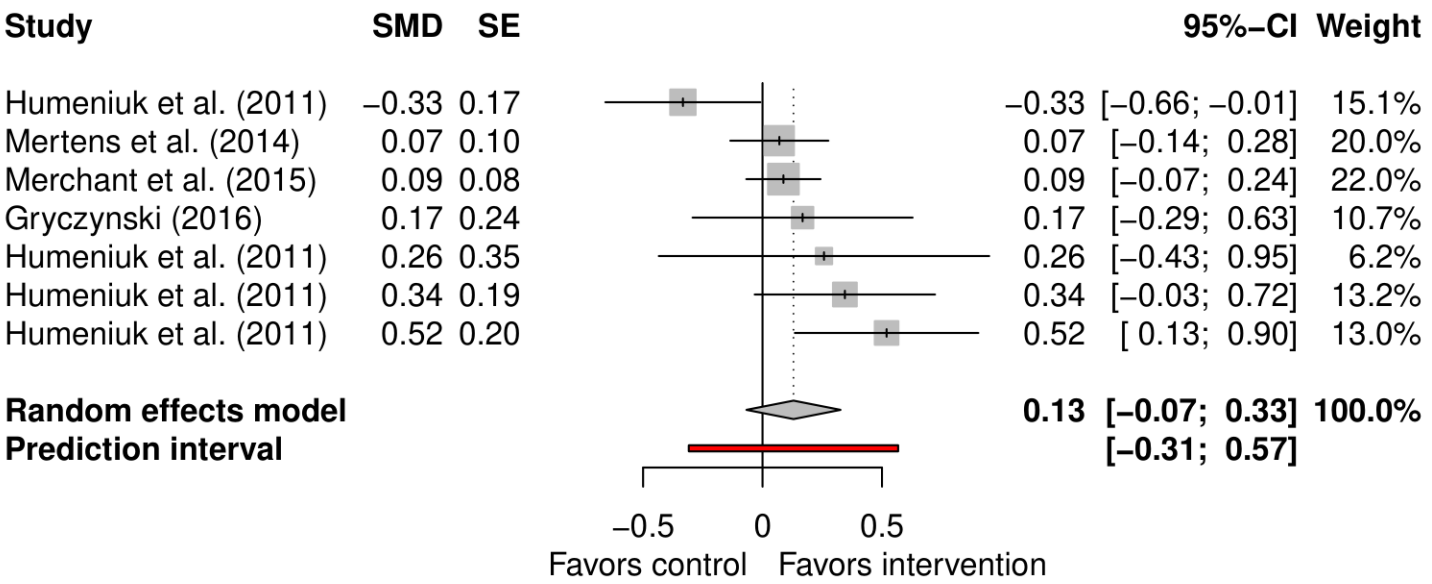
Forest Plot of the Effects of Brief Drug Interventions of Long-Term Cannabis Use



Note. logOR = log odds ratio; SE = standard error; CI = 95% confidence intervals.

Figure 5

Forest Plot of the Effects of Brief Drug Interventions of Short-Term Cannabis Use Severity



Note. SMD = Hedges' *g* standardized mean difference; SE = standard error; CI = 95% confidence intervals.

Supplemental Material S3: Main Effect Results From Sensitivity Tests

There was no evidence of funnel plot asymmetry in the short-term (z = 1.08, p = .278) long-term (z = 1.12, p = .261) frequency outcomes, and trim and fill analyses did not yield different findings.

Despite between-study heterogeneity in long-term cannabis use frequency not being statistically significant, the substantial increase in I^2 values for the timepoint and intervention intensity sensitivity tests reflect greater variability those studies.

Table 4

Standardized Effect Sizes, 95% Confidence Intervals, and Heterogeneity Statistics by Outcome and Time Period for Sensitivity Tests

		0-5 Months				6-12 Months			
Sensitivity test	Cannabis Outcome	ES [95% CI]	[95% PI]	τ^2	I^2	ES [95% CI]	[95% PI]	τ^2	I^2
Intervention intensity	Frequency	0.02 [-0.06, 0.11]$_{12}$	[-0.09, 0.14]	0.00	5.90%	0.06 [-0.05, 0.17]$_{11}$	[-0.18, 0.30]	0.01	36.01%
	Use	0.19 [-0.11, 0.48]$_{3}$	[-0.11, 0.48]	0.00	0.00%	0.22 [-0.18, 0.63]$_{4}$	[-0.46, 0.91]	0.08	46.48%
Timepoint	Frequency	—	—	—	—	0.03 [-0.09, 0.14]$_{11}$	[-0.23, 0.28]	0.01	38.10%
	Use	—	—	—	—	0.24 [-0.24, 0.72]$_{4}$	[-0.67, 1.15]	0.39	64.30%
Modality	Frequency	0.05 [-0.04. 0.13]$_{12}$	[-0.04, 0.13]	0.00	0.00%	0.08 [-0.13, 0.16]	[-0.04, 0.20]	0.00	7.23%
	Use	0.23 [-0.07. 0.52]$_{3}$	[-0.07, 0.52]	0.00	0.00%	0.28 [-0.24, 0.79]	[-0.69, 1.25]	0.18	64.80%

Note. Subscripts denote the number of independent effect sizes included for each outcome; frequency and severity effect sizes are Hedges' g and use effect sizes are logORs; ES = effect size; CI = 95% confidence intervals; PI = 95% prediction intervals.

Supplemental Material S4: Moderation Results From Sensitivity Tests

Table 1

Short-Term Subgroup Effect Sizes and 95% Confidence Intervals by Sensitivity Test

	Intensity		Modality	
Subgroup	Frequency	Use	Frequency	Use
Booster Session				
No	0.02 [-0.10, 0.13]$_9$	0.03 [-0.07, 0.12]$_1$	0.03 [-0.07, 0.12]$_8$	-0.11 [-5.93, 5.72]$_1$
Yes	0.11 [-0.25, 0.48]$_3$	0.15 [-0.06, 0.36]$_2$	0.15 [-0.06, 0.36]$_4$	0.24 [-5.27, 5.75]$_2$
Setting				
Community health center	-0.02 [-0.16, 0.12]$_6$	0.04 [-0.09, 0.17]$_2$	0.04 [-0.09, 0.17]$_6$	-0.11 [-5.93, 5.71]$_2$
Emergency department	0.05 [-0.13, 0.22]$_4$	0.02 [-0.13, 0.18]$_1$	0.02 [-0.13, 0.18]$_4$	0.24 [-5.27, 5.75]$_1$
Hospital-based primary care	—	—	—	—
Multiple settings	—	—	—	—
University health center	0.22 [-0.15, 0.59]$_2$	—	0.22 [-0.13, 0.57]$_2$	—
Target				
Other drugs/mixed substances	0.10 [-0.07, 0.28]$_6$	0.07 [-0.09, 0.24]$_2$	0.07 [-0.09, 0.24]$_6$	-0.04 [-5.83, 5.75]$_2$
Cannabis	-0.02 [-0.14, 0.10]$_6$	0.03 [-0.08, 0.15]$_1$	0.03 [-0.08, 0.15]$_6$	0.20 [-7.85, 8.26]$_1$
Population				
Adolescents only	0.01 [-0.14, 0.16]$_5$	0.08 [-0.04, 0.20]$_1$	0.08 [-0.04, 0.20]$_5$	0.20 [-7.85, 8.26]$_1$
Adolescents and young adults	-0.15 [-0.45, 0.14]$_2$	—	-0.15 [-0.41, 0.10]$_2$	—
Mixed and adults only	0.06 [-0.13, 0.25]$_3$	0.03 [-0.12, 0.18]$_2$	0.03 [-0.12, 0.18]$_3$	-0.04 [-5.83, 5.75]$_2$
University students	0.22 [-0.14, 0.58]$_2$	—	0.22 [-0.09, 0.53]$_2$	—

Note. Subscripts denote the number of independent effect sizes in each subgroup; frequency and severity effect sizes are Hedges' *g* and use effect sizes are logORs.

Table 2

Long-Term Subgroup Effect Sizes and 95% Confidence Intervals by Sensitivity Test

	Intensity		Timepoint		Modality	
Subgroup	Frequency	Use	Frequency	Use	Frequency	Use
Booster Session						
No	0.05 [-0.09, 0.19]$_9$	—	-0.02 [-0.16, 0.12]$_8$	0.46 [-0.20, 1.13]$_1$	0.05 [-0.06, 0.16]$_8$	0.53 [-0.03, 1.10]$_1$
Yes	0.16 [-0.26, 0.58]$_2$	—	0.19 [-0.10, 0.45]$_3$	-0.33 [-1.13, 0.47]$_3$	0.19 [-0.04, 0.43]$_3$	-0.33 [-0.97, 0.31]$_3$
Setting						
Community health center	-0.06 [-0.18, 0.06]$_5$	0.00 [-3.89, 3.89]$_1$	-0.11 [-0.24, 0.02]$_5$	0.28 [-3.12, 3.69]$_1$	-0.00 [-0.13, 0.12]$_5$	0.44 [-3.77, 4.66]$_1$
Emergency department	0.19 [0.04, 0.35]*$_4$	—	0.15 [0.00, 0.30]*$_4$	—	0.16 [0.01, 0.31]*$_4$	—
Hospital-based primary care	—	-0.11 [-2.61, 2.38]$_1$	—	-0.33 [-2.86, 2.20]$_1$	—	-0.33 [-2.86, 2.20]$_1$
Multiple settings	—	0.57 [-2.09, 3.23]$_2$	—	0.57 [-2.09, 3.23]$_2$	—	0.57 [-2.09, 3.23]$_2$
University health center	0.21 [-0.08, 0.50]$_2$	—	0.21 [-0.11, 0.53]$_2$	—	0.21 [-0.11, 0.52]$_2$	—
Target						
Other drugs/mixed substances	0.11 [-0.11, 0.33]$_5$	0.31 [-0.85, 1.47]$_3$	0.06 [-0.18, 0.30]$_5$	0.25 [-1.21, 1.70]$_3$	0.06 [-0.12, 0.25]$_5$	0.25 [-1.21, 1.70]$_3$
Cannabis	0.03 [-0.11, 0.19]$_6$	0.00 [-2.15, 2.15]$_1$	0.01 [-0.17, 0.19]$_6$	0.28 [-2.24, 2.80]$_1$	0.09 [-0.05, 0.22]$_6$	0.44 [-2.25, 3.13]$_1$
Population						
Adolescents only	-0.06 [-0.21, 0.10]$_4$	0.39 [-0.58, 1.37]$_3$	-0.10 [-0.27, 0.08]$_4$	0.46 [-0.20, 1.13]$_3$	0.01 [-0.15, 0.18]$_4$	0.54 [-0.03, 1.10]$_3$
Adolescents and young adults	0.01 [-0.28, 0.30]$_2$	—	-0.04 [-0.36, 0.29]$_2$	—	0.01 [-0.29, 0.31]$_2$	—
Mixed and adults only	0.20 [-0.00, 0.41]$_3$	0.11 [-1.38, 1.15]$_1$	0.16 [-0.05, 0.37]$_3$	-0.33 [-1.13, 0.47]$_1$	0.16 [-0.03, 0.35]$_3$	-0.33 [-0.97, 0.31]$_1$
University students	0.21 [-0.14, 0.55]$_2$	—	0.21 [-0.18, 0.59]$_2$	—	0.21 [-0.15, 0.56]$_2$	—

Note. Subscripts denote the number of independent effect sizes in each subgroup; frequency and severity effect sizes are Hedges' *g* and use effect sizes are logORs.