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Mindfulness treatment for substance misuse: A systematic review and meta-analysis

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ABSTRACT

High rates of relapse following substance misuse treatment highlight an urgent need for effective therapies. Although the number of empirical studies investigating effects of mindfulness treatment for substance misuse has increased dramatically in recent years, few reviews have examined findings of mindfulness studies. Thus, this systematic review examined methodological characteristics and substantive findings of studies evaluating mindfulness treatments for substance misuse published by 2015. The review also includes the first meta-analysis of randomized controlled trials of mindfulness treatments for substance misuse. Comprehensive bibliographic searches in *PubMed*, *PsycInfo*, and *Web of Science*, identified 42 pertinent studies. Meta-analytic results revealed significant small-to-large effects of mindfulness treatments in reducing the frequency and severity of substance misuse, intensity of craving for psychoactive substances, and severity of stress. Mindfulness treatments were also effective in increasing rates of posttreatment abstinence from cigarette smoking compared to alternative treatments. Mindfulness treatment for substance misuse is a promising intervention for substance misuse, although more research is needed examining the mechanisms by which mindfulness interventions exert their effects and the effectiveness of mindfulness treatments in diverse treatment settings.

1. Introduction

Substance misuse is a prevalent global public health concern. Approximately 250 million people worldwide used illicit drugs in 2013, and 27 million people were problematic drug users, (United Nations Office on Drugs and Crime [UNODC], 2015). The global incidence of illicit drug use has increased over the past 5 years (UNOCD, 2015). In the United States, 9.4% of Americans 12 or older (i.e., 24.6 million) were current illicit drug users in 2013 (Substance Abuse and Mental Health Services Administration [SAMHSA], 2014). Further, approximately one-quarter of Americans 12 or older (i.e., 60.1 million) were binge drinkers (i.e., drinking 5 or more alcoholic drinks on the same occasion on at least one day) and 6.3% (i.e., 16.5 million) reported heavy drinking (i.e., drinking 5 or more alcoholic drinks on each of 5 or more days in the past 30 days; SAMHSA, 2014). More than one-fifth of Americans 12 or older (i.e., 55.8 million) were current cigarette smokers (SAMHSA, 2014).

Substance misuse is costly to individuals, families, and society. Approximately 187,100 people worldwide died of drug-related causes in 2013 (UNODC, 2015). Substance misuse also has profound economic costs. The cost of substance misuse to the U.S. including crime, loss of work productivity, and health care, was recently estimated at more than $700 billion annually (National Institute on Drug Abuse [NIDA], 2015).

Effective treatments for substance misuse are urgently needed. In 2013, an estimated 8% of Americans 12 or older met criteria for substance use disorders; however, <1% of people who needed treatment for substance misuse received treatment at a specialty facility (SAMHSA, 2014). Although a variety of evidence-based treatments are available for substance misuse problems, outcomes remain unsatisfactory with relapse rates as high as 60% in the year following treatment (Maisto, Pollock, Cornelius, Lynch, & Martin, 2003; Witkiewitz & Masyn, 2008). Consequently, cost-effective treatments that reduce substance use and prevent relapse are needed.

Mindfulness training is considered a promising treatment for substance misuse (Chiesa & Serretti, 2014; Katz & Toner, 2013; Zgierska et al., 2009). "Mindfulness" refers to maintaining a moment-by-moment awareness of one's thoughts, feelings, bodily sensations, and surrounding environment. According to Kabat-Zinn, "mindfulness emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment" (Kabat-Zinn, 2003, p.145). Mindfulness practice may facilitate meta-cognition that enables people to become aware of their stream of consciousness.

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Enhancing cognitive awareness allows for better monitoring of automatic cognitive and emotional processes (Garland, Gaylord, & Park, 2009). Mindfulness also increases acceptance of thoughts and feelings without judging them. When practicing mindfulness, people tune their thoughts to what they are sensing in the present moment rather than rehashing the past or imagining the future (Kabat-Zinn, 2003).

Many researchers have considered how mindfulness practices could modify risk mechanisms underlying addictive behaviors, craving, and relapse. Mindfulness practices could raise an individual's metacognitive awareness of automatic processes associated with craving, substance seeking and using, and enhance attention to triggers and the presence of urges, thereby enabling an interruption of the cycle of cognitive, affective, and psychophysiological mechanisms through the use of learned positive coping strategies (Garland, Manusov et al., 2014; Witkiewitz, Bowen et al., 2014). Mindfulness practice might also facilitate disengagement of attention from substance-related cues and diminish attentional-bias toward substance-related cues (Garland, Froeliger, & Howard, 2014a). Further, mindfulness training could enable individuals not to react to stress or urges for substance use through cultivation of a metacognitive awareness of present moment experience (Garland, 2014). Metacognitive awareness of present-moment experience could enhance nonreactivity to unwanted thoughts and urges to use psychoactive substances, thereby preventing post-suppression rebound effects from exacerbating cognitions related to substance use that can promote relapse (Garland, Manusov et al., 2014; Garland, Roberts-Lewis, Tronnier, Graves, & Kelley, 2016; Tiffany & Conklin, 2000). Further, mindfulness practice (e.g., mindful breathing and body scan exercises) could help individuals become desensitized to distressing experiences that trigger substance misuse and reorient their attention to the sensation of breathing or other health-promoting stimuli (Garland et al., 2014a; Witkiewitz, Bowen et al., 2014). In addition, mindfulness training could enhance stress management and reduce stress-precipitated substance use (Garland, Froeliger, & Howard, 2014b; Kabat-Zinn & Hanh, 2009). Current neurobiological evidence suggests that mindfulness practice may change brain function and cognitions associated with rumination and reactivity to substance-related cues, and thereby reduce risk for craving and relapse (Garland et al., 2014b; Hölzel et al., 2011).

Many studies have evaluated different types of mindfulness treatment for substance misuse problems that are based on formal mindfulness meditation, including Vipassana Meditation courses (e.g., Bowen et al., 2006), Mindfulness-Based Stress Reduction (e.g., Davis, Fleming, Bonus, & Baker, 2007), Mindfulness-Based Relapse Prevention (e.g., Bowen et al., 2009), Mindfulness-Oriented Recovery Enhancement (e.g., Garland, Manusov et al., 2014; Garland et al., 2016), modified mindfulness training for smoking cessation (e.g., Davis, Goldberg et al., 2014; Davis, Manley, Goldberg, Smith, & Jorenby, 2014), and treatments combining mindfulness training with therapeutic community treatment (e.g., Marcus et al., 2009). These treatments have been empirically evaluated for their effects vis-a-vis increasing abstinence from substances, and reducing substance misuse, craving for substances, and negative consequences of substance misuse. A broad range of secondary outcomes, including enhancement of patients' affective and behavioral functioning and psychosocial well-being, and treatment adherence have also been examined (Chiesa & Serretti, 2014; Zgierska et al., 2009).

Vipassana Meditation (VM) consists of a standard 10-day, group-based course that involves meditating in silence for 10 to 11 h per day (Ahir, 1999). VM courses teach participants Vipassana meditation techniques, a practice deeply rooted in the Buddhist tradition (Ahir, 1999). The meditation practice is designed to cultivate participants' acceptance of thoughts and awareness of experiences such as craving without reacting to such experiences, and re-orientation away from compulsive thought patterns through the practice of mindfulness meditation (Bowen et al., 2006). VM courses reduce recidivism, psychiatric symptoms, and hostility (Alexander, Walton, Orme-Johnson, Goodman, & Pallone, 2003). The effects of VM courses in reducing substance misuse have been evaluated with adults involved in the criminal justice system (e.g., Bowen et al., 2006).

Mindfulness-Based Relapse Prevention (MBRP) is a manualized treatment that integrates formal mindfulness practice (e.g., meditation and mindful breathing exercises), motivational interviewing, and relapse prevention cognitive therapy (Bowen & Chawla, 2011). MBRP was developed based on two evidence-based manualized mindfulness interventions: Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn & Hanh, 2009) that combines mindfulness meditation with cognitive therapy for stress and mental distress symptoms; and Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2012) that is designed to prevent relapse to major depressive episodes. MBRP used the same structure as MBSR and MBCT of 8-weekly, 2-hour group sessions and daily home practice (Bowen et al., 2009). MBRP and MBSR have been modified to address the needs of diverse client populations (e.g., women; Witkiewitz, Warner et al., 2014) with a variety of substance misuse problems (e.g., cigarette smoking cessation; Davis et al., 2007).

Mindfulness-Oriented Recovery Enhancement (MORE) is a manualized treatment that integrates aspects of formal mindfulness training, "Third Wave" CBT, and positive psychology principles into a cohesive therapeutic approach (Garland, 2013). MORE was originally developed as a group-based treatment for people with alcohol dependence, consisting of 10-weekly, 2-hour group sessions and assigned homework. MORE has also been delivered as an 8-week group-based treatment to address prescription opioid misuse, chronic pain, and psychiatric distress. The developer of MORE translated findings from behavioral science and neuroscience into specific strategies that could modify maladaptive coping and automatic habits underlying addictive behaviors (Garland, Manusov et al., 2014).

Three systematic reviews have been published that support the positive effects of mindfulness treatment on substance misuse problems; however, these reviews examined studies published before 2012 (Chiesa & Serretti, 2014; Katz & Toner, 2013; Zgierska et al., 2009), and a large number of studies evaluating mindfulness treatment for substance misuse were published after 2011. Further, to our knowledge, no meta-analyses have been published that examined the efficacy of mindfulness treatment in reducing substance misuse and enhancing psychosocial well-being. Thus, we conducted a systematic review and meta-analysis that included studies of mindfulness treatment for substance misuse published by December 2015. The aim of this systematic review was to evaluate the methodological characteristics and substantive findings of recent studies evaluating effects of mindfulness treatment for substance misuse. Meta-analyses were conducted to estimate treatment effects of mindfulness treatment on substance misuse, and affective and behavioral outcomes. Findings of this study will increase understanding of the efficacy of mindfulness treatment.

2. Material and methods

2.1. Literature search

A literature search was conducted in the bibliographic databases *PubMed*, *PsycInfo*, and *Web of Science*. Reference sections of retrieved articles were also mined for relevant publications. Initial searches were conducted in May 2015. The search string mindfulness OR mindfulness intervention OR mindfulness meditation OR mindfulness treatment OR mindfulness-based relapse prevention OR mindfulness-based stress reduction AND (substance *use OR alcohol* OR cocaine OR opioid OR tobacco OR marijuana OR drug) was used to conduct free-text searches with no limits in all bibliographic databases. This search yielded 128 relevant records in *PubMed*, 203 records in *PsycInfo*, and 106 records in *Web of Science*. In addition, 32 articles were retrieved from reference sections of published literature reviews of mindfulness interventions/mindfulness meditation (Black, 2014; Chiesa & Serretti, 2014; Goyal et al., 2014; Katz & Toner, 2013; Rösner, Willutzki, & Zgierska, 2015;

Zgierska et al., 2009). To ensure that we included more recent studies published after the first search, we conducted another round of searches using the same search terms in December 2015. Three additional studies were identified and included in this systematic review during the second round of searches.

2.2. Selection of studies

The search included all mindfulness studies published in English up to December 30th 2015. Studies were included if they 1) examined effects of a mindfulness treatment; 2) used quasi-experimental designs with repeated-measures, or randomized controlled trial (RCT) designs with repeated-measures; 3) targeted client populations with substance misuse problems (alcohol, drugs, and tobacco); and 4) were published in peer-reviewed journals. Studies were excluded if they 1) were book reviews, books, book chapters, published abstracts, dissertations, systematic/literature reviews, or treatment guidelines or manuals; 2) only reported qualitative results; 3) used pre-experimental designs; 4) did not assess substance use-related outcomes; and 5) examined interventions that did not teach formal mindfulness practices (e.g., Acceptance and Commitment Therapy, Dialectical Behavior Therapy, and Spiritual Self-Schema Therapy), because these studies may have limited clinical implications for interventions based on mindfulness training.

Titles and abstracts of identified studies ($N = 473$) were screened for relevance. After removing duplicates, non-empirical studies, and studies that did not target populations with substance misuse problems, 93 studies were assessed for inclusion criteria independently by three raters (W.L., E.L.G., and M.O.H.). There was near unanimity of the three raters (W.L., E.L.G., and M.O.H.) with regard to identification of relevant articles and a consensus on the selection of pertinent studies was achieved via discussion. A total of 51 studies were excluded because they did not meet the selection criteria. Fig. 1 presents a flow chart depicting the literature search process.

2.3. Outcome variables

The primary outcomes examined in this systematic review and meta-analysis were decreases in substance misuse-related behaviors and problems, including severity of substance misuse, craving for substances, and substance use-related problems at posttreatment and follow-up assessments. The forms of substance misuse examined included polysubstance misuse, alcohol abuse/dependence, cigarette smoking, and other illicit drug misuse. Primary treatment outcomes examined in this systematic review and meta-analyses also included abstinence from substance use at posttreatment and follow-up assessments. Secondary outcomes were examined including a) improvements in affective and behavioral functioning (i.e., reductions in mental distress) at posttreatment and follow-up assessments, 2) increases in mindfulness (e.g., acceptance, awareness, and nonjudgment of thoughts and feelings) at posttreatment and follow-up assessments, and 3) treatment adherence and completion rate.

2.4. Data extraction and synthesis

A data extraction form was developed to extract data from each selected study. Extracted data included study aims and hypotheses, sample sizes and characteristics, brief descriptions of the mindfulness treatment and comparison conditions (e.g., treatment modality, length, and duration of each session, and treatment fidelity), outcome measures, and outcome results. The data extraction protocol was pilot-tested with two randomly selected studies, and refined accordingly. The first author (W.L.) read all selected studies in their entirety twice and abstracted the studies using the data extraction protocol. The second author (M.O.H.) then read all studies independently to ensure the accuracy of extracted data. Disagreements regarding extracted data were few and resolved via mutual discussion. All authors reviewed all entries in Tables 2 and 3 to ensure their accuracy.

The methodological quality of each study was rated using the Methodological Quality Rating Scale (MQRS; Miller et al., 1995). This scale assesses 13 dimensions of methodological attributes (see Table 1). Scores range from 0 (low quality) to 16 (high quality). The MQRS has been widely used in systematic review and meta-analyses examining treatments for substance misuse (e.g., Apodaca & Miller, 2003; Vaughn & Howard, 2004). Each study was assessed and rated independently by two raters using the MQRS. Cohen's κ was used to determine interrater agreement. Any discrepancies of rating were discussed and resolved between the two raters. The two raters included detailed notes regarding their discrepancies on a certain item of a study, and how they reached agreement. Then the discrepancies and notes were reviewed and double checked by a master rater (W.L.).

Meta-analyses were performed to estimate effect sizes of mindfulness treatment on treatment outcomes including substance misuse, abstinence, craving for substance use, stress, and mindfulness at posttreatment compared to control or alternative treatment conditions.

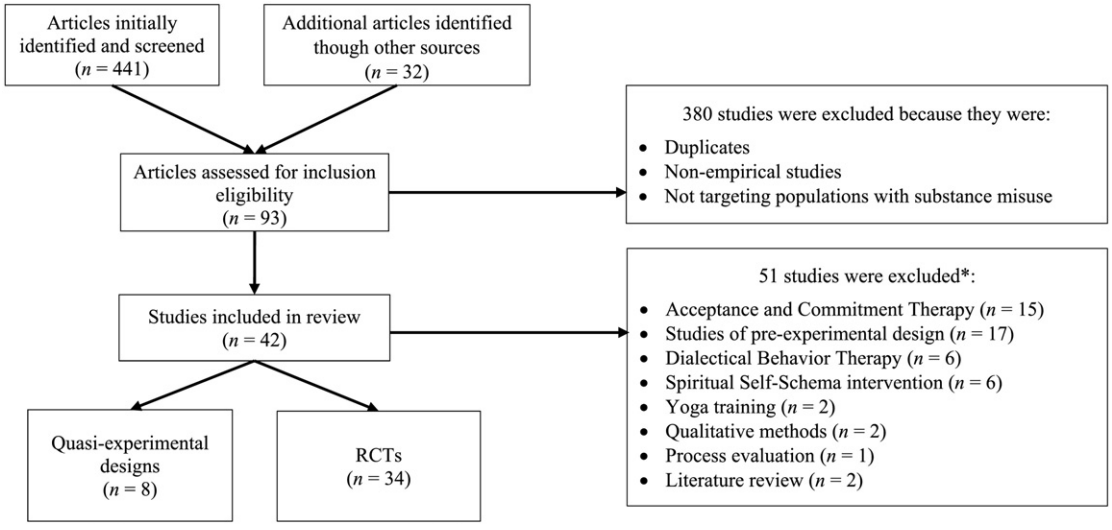

Fig. 1. Flow chart for literature search and screening results. Note: *These studies were excluded because they may have limited information and implications with regard to effects of interventions for substance misuse based on formal mindfulness training.

Table 1
Methodological quality characteristics of studies of mindfulness treatment for substance misuse ($N = 42$).

Methodology attributes	% (*N*)	Cohen's κ
Study design		0.93
Quasi-experimental study	19.0% (8)	
Randomized controlled study	81.0% (34)	
Replicability: procedures contain detail sufficient to replicate study	97.6% (41)	0.93
Baseline: sample characteristics and outcome measures at baseline were reported	100% (42)	1.00
Quality control: intervention standardization by manual, procedures, and specific training	83.3% (35)	0.55
Follow-up length		1.00
<6 months	83.3% (35) ()	
6 to 11 months	11.9% (5)	
12 months or longer	4.8% (2)	
Dosage: dosage of treatment presented	69.0% (29)	0.63
Collateral informants interviewed	2.4% (1)	0.65
Objective verification of treatment outcome (e.g., urine tests)	45.2% (19)	0.81
Dropouts/attrition enumerated and discussed	88.1% (37)	0.61
Adequate power with adequate sample size	59.5% (25)	0.93
Independent: follow-up conducted by interviewers blind to group assignments	26.2% (11)	0.63
Appropriate statistical analyses	100% (42)	1.00
Multisite		1.00
Single site	100% (42)	
Parallel replications at two or more sites	0	

Outcome variables used for meta-analyses included levels of substance use at posttreatment measured with standardized measures (e.g., Time-Line FollowBack), point-prevalence of abstinence, craving for substance use measured with standardized measures (e.g., Penn Alcohol Craving Scale), stress measured with standardized measures (e.g., Perceived Stress Scale), and mindfulness measured with standardized measures (e.g., Five Facet Mindfulness Questionnaire). These outcome variables were continuous variables except for point-prevalence of abstinence; therefore, meta-analyses were performed by computing standardized mean differences in posttreatment values of outcome variables between mindfulness and control or alternative treatment conditions (i.e., Cohen's *d* and associated 95% confidence intervals [CI]). Odds ratios and associated 95% CIs were computed and pooled for studies that reported point-prevalence of abstinence.

Only studies that reported statistical results sufficient to compute Cohen's *d* (i.e., means and standard deviations of outcome variables at posttreatment assessments, and sample size per condition), and odds ratios (i.e., number of participants who were allocated to either treatment or comparison condition, and number of participants who achieved abstinence per condition) were included in the meta-analyses. For studies that were not independent (i.e., more than one published study reported data from the same clinical trial), a single trial was included and represented only once in the meta-analysis for a given outcome variable irrespective of whether the data used to compute effect size were extracted from the original paper or a secondary analysis paper. We ensured that the independence of studies included in the meta-analysis of each outcome was not violated.

Cohen's *d*/odds ratios and associated 95% CIs were computed for each study as appropriate and pooled, and then a synthesized effect size was computed for each treatment outcome using the Stata program *metan* (Bradburn, Deeks, & Altman, 1998). Considering that the true value of the estimated effect size for outcome variables might vary across different trials and samples, we used a random effects model rather than fixed effects model, given that the selected studies did not have identical treatment populations. The random effects model incorporates between-study variation into the study weights and estimated effect size (Bradburn et al., 1998; Harris et al., 2008). The magnitude of Cohen's *d* was interpreted using Cohen's description of 0.20 as small, 0.50 as medium, and 0.80 as large (Cohen, 1988). The z scores and *p* values associated with estimated effect sizes were also computed. In addition, heterogeneity among studies was assessed using I^2 and the chi-squared statistic (i.e., Q). I^2 measures the proportion of heterogeneity to the total observed dispersion; 25% is considered low, 50% moderate, and 75% high (Higgins, Thompson, Deeks, & Altman, 2003). All analyses were completed using Stata 12 (StataCorp, 2011).

3. Results

3.1. Characteristics of selected studies

A total of 42 studies examined effects of different types of mindfulness treatment for substance misuse problems and were included in this systematic review: 8 studies using quasi-experimental designs, and 34 studies using randomized controlled trial (RCT) designs. Of the 42 identified studies, 33 were original studies and the remaining 9 studies were secondary analyses of original studies.

Sample sizes ranged from 24 to 459. Of the 42 studies, only one targeted adolescents with substance misuse problems (Himelstein, Saul, & Garcia-Romeu, 2015). The remaining 41 studies evaluated mindfulness treatment for substance misusing adults, including five focused solely on women (de Dios et al., 2012; Nakamura et al., 2015; Price, Wells, Donovan, & Rue, 2012; Witkiewitz, Greenfield, & Bowen, 2013; Witkiewitz, Warner et al., 2014) and four solely focused on men (Garland et al., 2016; Lee, Bowen, & An-Fu, 2011; Murphy, Pagano, & Marlatt, 1986; Tuab, Steiner, Weingarten, & Walton, 1994). In addition, seven studies evaluated mindfulness treatment for people involved with the criminal justice system (Bowen et al., 2006; Bowen, Witkiewitz, Dillworth, & Marlatt, 2007; Himelstein et al., 2015; Lee et al., 2011; Simpson et al., 2007; Witkiewitz, Greenfield et al., 2013; Witkiewitz, Warner et al., 2014).

Further, included studies evaluated different types of mindfulness treatment, including mindfulness training adapted from Mindfulness-Based Stress Reduction (MBSR) for smoking cessation (e.g., Brewer et al., 2011), Mindfulness-Based Relapse Prevention (MBRP; e.g., Bowen et al., 2009), Mindfulness-Oriented Recovery Enhancement (MORE; e.g., Garland, Gaylord, Boettiger, & Howard, 2010), Vipassana Meditation (VM) courses (e.g., Bowen et al., 2006), mindfulness meditation training as an adjunct to goal management training (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-García, 2011), combined motivational interviewing and mindfulness meditation for marijuana misuse (de Dios et al., 2012), mindfulness-based therapeutic community treatment (e.g., Marcus et al., 2009), and mindfulness-based mind-body training (e.g., Price et al., 2012). In addition, six studies evaluated effects of brief mindfulness training in a laboratory setting (e.g., a 1.5-hour

session that provided instructions on coping with urges using mindfulness meditation during a cue exposure trial; Bowen & Marlatt, 2009).

Overall, the methodological quality of the studies was high as exemplified by the majority (81.0%) employing randomized controlled trial designs. Further, all studies reported baseline sample characteristics and outcome measures, and used appropriate statistical analyses that compared differences in outcomes between treatment and comparison groups. The majority of studies provided sufficient information allow for replication (97.6%), employed intervention standardization by manual, procedure, and specific training (83.3%), accounted for treatment dosage (69.0%), and enumerated attrition rates (88.1%). Further, almost half of the studies (45.2%) employed objective verification of outcome variables such as urine tests; however, only 2.4% of studies used collateral interviews to validate participants' self-reports. In addition, few studies followed participants >6 months (16.7%) or conducted follow-up by independent interviewers blind to group assignment (26.2%). Finally, almost half of the studies (40.5%) did not have adequate power for statistical analyses. Table 1 presents the methodological attributes of the studies reviewed using the Methodological Quality Rating Scales (MQRS). The MQRS score of each study is presented in Tables 2 and 3 along with other study characteristics. The MQRS scores across the 42 studies ranged between 6 (Alfonso et al., 2011; Chen, Comerford, Shinnick, & Ziedonis, 2010) and 14 (Bowen et al., 2014; Tuab et al., 1994). The mean score was 9.7 ($SD = 1.8$).

3.2. Studies using quasi-experimental designs

3.2.1. Methodological characteristics

Table 2 presents characteristics and major findings of 8 studies that evaluated mindfulness treatment using quasi-experimental designs. Compared to single-group studies, quasi-experimental designs allow for a comparison of effects between a mindfulness treatment and an alternative treatment program (e.g., treatment as usual [TAU]). Comparing a mindfulness treatment to a comparison condition could suggest whether or not components of mindfulness practice contributed to changes in treatment outcomes. All identified studies compared mindfulness treatment to treatment as usual (TAU; e.g., Bowen et al., 2006) or to alternative treatments that were matched to the mindfulness treatment in terms of duration, dosage, and group structure (e.g., Chen et al., 2010).

Further, a majority of quasi-experimental studies assigned participants to mindfulness and comparison groups that were matched on sociodemographic characteristics (e.g., age, gender, and education) and levels of substance misuse at baseline. Such procedures controlled for some pre-existing differences between participants in the mindfulness and comparison conditions. To better control for preexisting differences, some studies used analytic strategies such as mixed linear modeling or Analysis of Covariance (ANCOVA; e.g., Bowen et al., 2006; Chen et al., 2010). Although quasi-experimental designs are more rigorous than single-group studies, findings of these studies were limited by participants' self-selection into treatment or comparison conditions. A lack of random assignment implies that improved treatment outcomes might be attributable to pretreatment differences between treatment and comparison groups that were not adequately controlled for, such as participants' level of motivation to change.

Virtually all quasi-experimental studies relied on self-report measures to assess substance misuse, psychosocial characteristics, mindfulness, and treatment adherence. Several studies had small samples, short-term or no follow-up assessments, and little or no information about treatment fidelity assessment. These limitations might have affected the validity and generalizability of study findings.

3.2.2. Effects of mindfulness treatment on substance misuse

Studies showed consistently positive findings with regard to mindfulness treatment of alcohol and drug misuse in adults (Alfonso et al., 2011; Bowen et al., 2006, 2007; Chen et al., 2010; Simpson et al., 2007). Specifically, mindfulness treatment was more effective in reducing the amount and frequency of substance misuse at posttreatment and subsequent follow-up assessments across all included studies compared to a comparison condition. Additionally, mindfulness treatment outperformed comparison conditions vis-a-vis reducing craving for substance use (Chen et al., 2010), withdrawal symptoms (Chen et al., 2010), and substance use-related consequences (Bowen et al., 2006, 2007; Simpson et al., 2007) at posttreatment and follow-up assessments.

Bowen et al. (2006) conducted a quasi-experimental study that compared effects of a 10-day VM course as an adjunct to TAU to TAU alone for adult jail inmates who had substance misuse problems prior to incarceration. Participants who received VM training had significantly greater reductions in alcohol and drug use over the three-month post-release period compared to participants who received TAU alone. A secondary analysis of Bowen et al. (2006) established that decreased thought suppression in the VM group relative to TAU partially mediated the relationship between participation in VM courses and reduced alcohol use and alcohol-related consequences at 3-month follow-up (Bowen et al., 2007). Simpson et al. (2007) concluded that PTSD severity at baseline was not related to inmates' decisions to participate in the VM condition vs. TAU and that VM was associated with superior treatment outcomes irrespective of PTSD severity.

3.2.3. Effects of mindfulness treatment on secondary outcomes

Quasi-experimental studies had treatment completion rates ranging from 57% to 97%. Compared to comparison conditions, participants receiving mindfulness treatment reported significantly greater reductions in thought suppression (i.e., suppressing unwanted thoughts and urges for substance use; Bowen et al., 2007), psychiatric distress (Bowen et al., 2006; Chen et al., 2010), negative emotions and moods (Chen et al., 2010; Liehr et al., 2010), and stress (Marcus et al., 2009), and significantly greater increases in substance use-related locus-of-control (Bowen et al., 2006), optimism (Bowen et al., 2006), and neuropsychological functions such as working memory, response inhibition, and decision-making ability at posttreatment and follow-up assessments (Alfonso et al., 2011).

Additionally, one quasi-experimental study examined the relationship between meditation practice between-sessions and treatment outcomes, and found that participants' self-rated quality of meditation practice moderated effects of a mindfulness treatment on reducing withdrawal symptoms, craving for substance use, and anxiety symptoms (Chen et al., 2010).

3.3. Studies using RCTs

3.3.1. Methodological characteristics

Table 3 presents study characteristics and major findings of 34 studies that evaluated mindfulness treatment using RCT designs. Of the RCT studies, 16 used an alternative psychotherapeutic treatment matched to the mindfulness treatment in terms of intensity, group structure, and dosage as a comparison condition (e.g., Davis, Manley et al., 2014; Garland et al., 2010, 2016); ten studies used TAU as a comparison condition (e.g., Bowen et al., 2009; Nakamura et al., 2015); and two studies used an inactive control condition (de Dios et al., 2012; Mermelstein & Garske, 2014). In addition, 6 studies compared effects of brief mindfulness training (e.g., a 1.5-hour lab session on mindfulness meditation training) to other treatment strategies for substance misuse in a lab-session (e.g., Bowen & Marlatt, 2009; Ussher, Cropley, Playle, Mohidin, & West, 2009). All studies reported the degree to which randomization successfully equated the groups at pretreatment. When randomization was not completely successful in equating treatment and control conditions, the studies used advanced analytical strategies (e.g., mixed linear modeling and ANCOVA) to control for pre-existing group differences in sociodemographic and outcome variables between participants in the treatment and comparison conditions.

Table 2
Systematic review of mindfulness treatment studies using quasi-experimental designs ($N = 8$).
Refer to table footnote for definitions of acronyms/abbreviations.

Study	Data collection time points	Tx condition	Control condition	Sample characteristics	Outcome measures	Results	Limitations	MQRS score
Alfonso et al. (2011)	Baseline & posttx (7-wk)	Combined MM and GMT as an adjunct to standard community tx: 7-wk, twice/wk, 90-min group sessions; and 7-wk, twice/wk, 60-min MM training sessions.	TAU: usual psychotherapeutic intervention.	34 Spanish adults (GMT + MM: $n = 18$; TAU: $n = 16$) with substance dependence: 94.1% men. Of GMT + mindfulness participants, *Mage* = 41.0 (*SD* = 7.6). Of TAU participants, *Mage* = 34.9 (*SD* = 10.3). There were no significant differences between tx and control groups in baseline demographic or outcome variables.	Neuropsychological functions associated with substance misuse were assessed with the LNS, WAIS-III Arithmetic and Digit Span, Stroop, TMT, and IGT.	GMT + MM participants had significantly greater pre-to-posttx improvements in working memory, response inhibition, and decision-making compared to TAU participants.	Small sample size. Nonrandom assignment to tx or control conditions. No information regarding attrition rates or tests for significant differences between participants who completed and did not complete posttx assessment. No information regarding tx fidelity assessment. No follow-up assessments.	6
Bowen et al. (2006)	Baseline, 3- & 6-mo post-release from a minimum security jail rehab facility	VM courses as an adjunct to TAU: 10 daily, 8–10 hrs sessions. Participants were housed separately from other inmates and not allowed outside contact. During each session, participants practiced meditation 8–10 hrs.	TAU: usual standard care including chemical dependency tx, substance use education, and educational and vocational programs.	305 adult inmates who reported substance misuse prior to incarceration were recruited and 173 participants (VM: $n = 57$; TAU: $n = 116$) completed the study and posttx assessment. *Mage* = 37.5 (*SD* = 8.7); 79.2% men; 61.1% White, 13% African American, 8% Latino/a, 8% American Indian, and 1.2% other. 87 (VM: $n = 29$; TAU: $n = 58$) completed 3-mo follow-up assessment. There were no significant differences between tx and control groups in baseline demographic or outcome variables. There were no significant differences in demographic or outcome variables between participants who complete assessments at posttx and follow-up and those who dropped out.	Substance misuse was measured with the DDQ, DDTQ, and SIP. Self-control was measured with the LCS-D. Thought suppression was measured with the WBSI. Mental distress was measured with the BSI. Optimism was measured with the LOT.	VM participants had significantly greater reductions in # of drinks per peak drinking wk, % of days of crack cocaine and Mj use, and SIP scores compared to TAU participants at 3-mo post-release from the facility. Participation in VM was associated with a significantly greater decrease in psychiatric sxs and significantly greater increases in internal drinking-related locus-of-control and optimism at 3-mo post-release from the facility compared to TAU. Completion rates were 90.5% and 47.9% for VM and TAU groups, respectively.	Nonrandom assignment to tx or control conditions. Relied on self-report measures. No information regarding tx fidelity assessment.	7
Bowen et al. (2007) Secondary data analysis of Bowen et al. (2006)	Baseline, 3- & 6-mo post-release from a minimum security jail rehab facility	VM courses as an adjunct to TAU: 10 daily, 8–10 hr sessions. Participants were housed separately from other inmates and not allowed outside contact. During each session, participants practiced meditation up to 8–10 hrs.	TAU: usual standard care including chemical dependency tx, substance use education, and educational and vocational programs.	Same sample as Bowen et al. (2006).	Substance misuse was measured with the DDQ, DDTQ, and SIP. Thought suppression was measured with the WBSI.	VM participants had significantly fewer total drinks per peak drinking wk, and significantly lower-levels of alcohol-related negative consequences at 3-mo post-release from the facility compared to TAU participants. VM participants had a significantly greater decrease in thought suppression at 3-mo follow-up compared to TAU participants. Changes in thought suppression partially mediated tx effects on alcohol use and alcohol-related consequences at 3-mo post-release from jail.	Nonrandom assignment to tx or control conditions. Relied on self-report measures. No information regarding tx fidelity assessment.	7
Chen et al. (2010)	Baseline, mid-tx (2-wk), & posttx (4-wk)	QM: 2 weekly, 90-min group seminars, and 2 daily, 25-min sessions of QM practice for 2 wks (at least 5 days/wk).	SMRT: 2 weekly, 90-min group seminars and 2 daily sessions of relaxation skills practice for 2 wks (at least 5 days/wk).	350 adults in residential addiction rehab facilities were recruited, 248 completed the study, and 207 (QM: $n = 126$; SMRT: $n = 81$) were included in data analyses. Of QM participants, *Mage* = 35.9 (*SD* = 10.9); 69.8% men; 72.8% White. Of SMRT participants, *Mage* = 30.7 (*SD* = 8.9); 77.8% men; 77.8% White. There were no significant differences between QM and SMRT participants in baseline demographic characteristics or	Withdrawal from substance misuse was measured with the ARSW. Craving for substance use was measured with the SSCS and VC/NMS. Depression was measured with the CES-D. Anxiety was measured with the STAI. Quality of mindfulness practice was measured with a 4-item index.	Participants in both conditions had significant pre-to-posttx decreases in negative mood, craving, withdrawal sxs, anxiety, and depression. QM participants had a marginally significantly ($p < 0.10$) greater reduction in craving compared to SMRT participants over the tx. Gender and quality of meditation practice had moderating effects on tx outcomes regarding withdrawal sxs, craving, and anxiety. Completion rates were	Nonrandom assignment to tx or control conditions. Relied on self-report measures. No information regarding tx fidelity assessment. Study did not test for significant differences between participants who completed and did not complete assessments at posttx. Outcomes were only assessed at posttx.	6

(continued on next page)

Table 2 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample characteristics	Outcome measures	Results	Limitations	MQRS score
				outcome variables, except age, degree of spirituality ($M = 4.7$, $SD = 2.4$ vs. $M = 5.5$, $SD = 2.4$) and % of participants who reported alcohol as their main problem (22.2% vs. 38.9%).		92% for QM group, 78% for SMRT group.		
Liehr et al. (2010) Secondary data analysis of Marcus et al. (2009)	Baseline, 1-, 3-, 6-, & 9-mo post-baseline.	MBTC as an adjunct to standard usual care in a TC: 6, 2.5–3 hr weekly group sessions.	TAU: TC usual care	393 adult substance misusers enrolled at TC (MBTC: $n = 253$; TAU: $n = 140$): *Mage* = 35.1 ($SD = 10.0$); 82% male; 56% White, 30% Black, and 13% Hispanic. There were no significant differences in thinking and feeling word use at baseline between MBTC and TAU participants.	Stories of stress as indicators of self-change	Participants in both conditions had significant decreases in negative emotion and anxiety word-use and a significant increase in positive emotion word-use over the 9-mo period; however, the reduction did not differ significantly between MBTC and TAU participants. MBTC participants used a significantly smaller % of negative emotion words than TAU participants over the 9-mo period. 60%, 36%, 27%, and 16% of MBTC participants vs. 58%, 29%, 16%, and 12% of TAU participants completed the 4 assessments over the 9-mo period.	Nonrandom assignment to tx or control conditions. Relied on self-report measures. No information regarding tx fidelity assessment. Study did not test for significant differences between participants who completed and did not complete assessments at posttx.	9
Marcus, Fine, and Kouzekanani (2001)	Baseline & posttx (8-wk)	MBSR in TC as an adjunct to TAU: 8, 2.5-hr group sessions; 45-min to 1-hr, 6 days/wk meditation sessions and homework.	TAU: TC usual care	36 adults (tx condition: $n = 18$; TAU: $n = 18$) with alcohol and drug dependency. Of participants in the tx condition, *Mage* = 32 ($SD = 9.0$); 88.9% were men. Of participants in the control condition, *Mage* = 36 ($SD = 9.0$); 100% men. There were no significant differences between tx and TAU participants in demographic characteristics or yrs of substance use at baseline.	Coping was measured with the WCCL. Mental distress was measured with the SCL-90-R.	Participants in the tx condition had a marginally significant ($p < 0.10$) improvement in self-control at posttx compared to TAU participants. Completion rates were 100% for both conditions.	Nonrandom assignment to tx or control conditions. Small sample size. Relied on self-report measures. No information regarding tx fidelity assessment. No follow-up assessments posttx.	10
Marcus et al. (2009)	Baseline, 1-, 3-, 6-, & 9-mo post-baseline.	MBTC as an adjunct to TAU: 6, 2.5–3 hr group sessions; twice a wk for the first 2 wks, and once a wk for the next 2 wks; 45-min, 6 days/wk meditation sessions.	TAU: 6 hrs of tx a wk, including chemical dependency tx, life skills training, cognitive reconstructing, vocational training, and individual/group counseling.	459 adult substance misusers (MBTC: $n = 295$; TAU: $n = 164$). Of MBTC participants, *Mage* = 34.3; 85.5% men; 53.6% White, 29.8% Black, and 16.9% Hispanic and others. Of TAU participants, *Mage* = 36.2; 76.2% men; 57.3% White, 29.9% Black, and 12.8% Hispanic and others. There were no significant differences between MBTC and TAU participants in baseline demographic or outcome variables, except gender (14.2% women vs. s 23.8% women).	Stress was measured with the SOSI and cortisol sample. Level of engagement was measured on a 5-point scale.	Participants in both conditions had a significant decrease in stress during the first 3-mos. MBTC participants had significantly greater reductions in stress at 9-mo follow-up compared to TAU participants. Among MBTC participants, an increase in participation level was significantly associated with a decrease in likelihood of dropping out of the TC.70% of MBTC participants completed ≥10 hrs of classes; 33.3% completed all 17 hrs.	Nonrandom assignment to tx or control conditions. Study did not test for significant differences between participants who completed and did not complete assessments at posttx and follow-ups.	9
Simpson et al. (2007) Secondary data analysis of Bowen et al. (2006)	Baseline, 3- & 6-mo post-release from a minimum security jail rehab facility.	VM courses as an adjunct to TAU: 10 daily, 8–10 hr sessions. Participants housed separately from other inmates and not allowed outside contact. During each session, participants practiced meditation 8–10 hrs.	TAU: usual standard care including chemical dependency tx, substance use education, and educational and vocational programs.	303 inmates were recruited. 88 participants (VM: $n = 29$; TAU: $n = 59$) who completed assessment at 3-mo follow-up were included in analyses. Of all participants, *Mage* = 37.6 ($SD = 8.7$); 67.2% men; 59.3% White, 12.9% African American, 6.6% Latino/a, and 7.3% Native American. There were no significant differences between tx and control groups in demographic or outcome variables at baseline. There were no significant differences in baseline demographic or outcome variables between participants who completed and did not complete 3-mo follow-up assessment.	Substance misuse was measured with the DDQ, DDTQ, and SIP. Mental distress was measured with the BSI. Stress was measured with the PCL-C.	After controlling for baseline drinking and gender, participation in VM tx was significantly negatively associated with # of drinks and frequency of drug use during the peak wk of drinking or drug use, and consequences of drinking at 3-mo post-release from jail. PTSD sxs were significantly positively associated with consequences of drinking at the 3-mo post-release from jail.	Nonrandom assignment to tx or control conditions. Relied on self-report measures. No information regarding tx fidelity assessment.	7

Despite the strengths of the RCT design, identified studies suffered from several limitations regarding study design and data analyses. Many studies relied on self-report measures to assess substance misuse, mindfulness, and psychosocial outcomes. Almost half of the studies had small samples ($N < 50$); these studies may have been under powered to detect treatment effects. Further, many studies had high attrition rates at posttreatment and follow-up assessments, and did not use intent-to-treat analyses. In such cases, randomization may have been compromised and biases may have been introduced by differential attrition.

3.3.2. Effects of mindfulness treatment on substance misuse

Virtually all studies found that mindfulness treatments were associated with superior substance misuse treatment outcomes at posttreatment and follow-up assessments compared to comparison conditions (with the exception of Brewer et al., 2009). Specifically, mindfulness treatment was superior to control conditions (e.g., TAU, relapse prevention treatment, CBT, and active support group) in reducing the frequency and amount of alcohol and drug use, number of alcohol and drug-related problems, and level of craving for substance use, and in increasing abstinence rates (e.g., Bowen et al., 2009, 2014; Garland, Manusov et al., 2014; Garland et al., 2016; Witkiewitz, Warner et al., 2014).

Five RCTs compared mindfulness treatment combined with TAU to TAU alone in samples of adults and adolescents with alcohol and drug misuse problems (Alterman, Koppenhaver, Mulholland, Ladden, & Baime, 2004; Bowen et al., 2009; Himelstein et al., 2015; Nakamura et al., 2015; Price et al., 2012). Mindfulness treatment plus TAU was more effective in reducing number of days of substance use, craving, and substance-related problems, and in increasing number of days of abstinence during follow-up periods, compared to TAU alone (Bowen et al., 2009; Nakamura et al., 2015; Price et al., 2012). However, two secondary analyses of Bowen et al. (2009) established that the treatment gains of MBRP were not maintained at 4-month follow-up (Hsu, Collins, & Marlatt, 2013; Witkiewitz, Bowen, Douglas, & Hsu, 2013). Witkiewitz and Bowen (2010) found that MBRP participation moderated the mediation effects of craving on substance use outcome; compared to TAU recipients, MBRP recipients were less likely to experience craving in response to depressive symptoms at 2-month follow-up; and the attenuated reactivity to depressive symptoms and reduced craving led to significantly fewer days of substance use at 4-month follow-up among MBRP recipients.

Another RCT compared MBRP to CBT and relapse prevention treatment in substance-misusing adults and found that MBRP had more enduring treatment effects in reducing craving and enhancing abstinence at follow-up compared to CBT and relapse prevention interventions (Bowen et al., 2014; Witkiewitz, Warner et al., 2014). Contrary to the positive findings described above, Brewer et al. (2009) did not observe significant differences between a mindfulness treatment and CBT in reducing the number of days of alcohol and/or cocaine use at posttreatment. However, this study may have been limited by low statistical power due to a small sample size ($N = 14$).

The RCTs consistently found greater effects of mindfulness treatment on cigarette smoking cessation compared to an alternative treatment (with the exception of Davis, Manley et al., 2014). Four RCTs indicated that participation in mindfulness treatment for smoking cessation was associated with significantly greater increases in abstinence at follow-up compared to the American Lung Association's Freedom from Smoking Program and Tobacco Quit Line (Brewer et al., 2011; Davis et al., 2013; Davis, Goldberg et al., 2014). Further, Tang, Tang, and Posner (2013) documented greater effects of a mindfulness treatment in reducing cigarette smoking compared to a relaxation training program. Additionally, Ruscio, Muench, Brede, and Waters (2015) found greater effects of a brief mindfulness treatment that was implemented on a Personal Digital Assistant (PDA) on reducing the number of cigarettes smoked per day over the course of a 2-week intervention compared to a guided sham-meditation practice that was implemented on a PDA.

Two RCTs evaluated effects of Mindfulness-Oriented Recovery Enhancement (MORE) compared to an active support group and CBT in adults with alcohol misuse problems, and found that MORE was superior in reducing level of craving for alcohol at posttreatment compared to CBT (Garland et al., 2016), and in decreasing attentional bias toward alcohol-related cues and thought suppression at posttreatment (Garland et al., 2010). Further, Mermelstein and Garske (2014) compared a brief mindfulness treatment that consisted of an "urge surfing" exercise and mindfulness meditation to an inactive control condition in university students with binge drinking problems. Students who received mindfulness training had a significantly greater decrease in number of binge drinking episodes over the 4-week follow-up compared to students who received no intervention. Contrary to the positive findings, three RCTs evaluating mindfulness treatments in alcohol-misusing adults did not observe significant effects of mindfulness treatments vis-a-vis decreasing alcohol consumption compared to CBT (Brewer et al., 2009), EMG Biofeedback (Tuab et al., 1994), and running exercises (Murphy et al., 1986).

Two RCTs demonstrated that mindfulness treatment was more effective in reducing prescription opioid abuse in adults with chronic pain at posttreatment and 3-month follow-up, compared to a support group (Garland, Manusov et al., 2014; Garland et al., 2014b); and was more effective in reducing frequency of marijuana use at follow-up compared to an inactive control condition in a sample of adult women (de Dios et al., 2012). Garland, Manusov et al. (2014) concluded that effects of MORE on prescription opioid misuse were mediated by an increase in nonreactivity; and participation in MORE was associated with a decreased correlation between craving and opioid misuse. A secondary analysis of the parent investigation indicated that MORE participants evidenced less opioid cue-reactivity compared to support group participants (Garland et al., 2014b).

3.3.3. Effects of mindfulness treatment on secondary outcomes

Treatment completion rates ranged from 43% to 100%. Compared to comparison conditions, mindfulness treatment was superior in reducing psychiatric distress and negative affective states (Brewer et al., 2009; Garland et al., 2016; Price et al., 2012; Ruscio et al., 2015; Tuab et al., 1994), stress (Davis, Manley et al., 2014; Garland et al., 2010, 2016; Price et al., 2012), dissociation experiences (Price et al., 2012), and pain severity and functional interference (Garland, Manusov et al., 2014). Mindfulness treatments significantly increased mindfulness (e.g., Bowen et al., 2009; Davis, Manley et al., 2014; Garland et al., 2016; Mermelstein & Garske, 2014), emotion regulation (Davis, Goldberg et al., 2014), attentional control (Davis, Goldberg et al., 2014), self-efficacy to refuse substance use (Lee et al., 2011; Mermelstein & Garske, 2014), and self-control capacity (Tang et al., 2013) to a greater level relative to comparison groups.

Notes to Table 2:
Acronyms/abbreviations: ARSW = Adjective Rating Scale for Withdrawal; BSI = Brief Symptom Inventory; CES-D = Center for Epidemiologic Studies-Depression; DDQ = Daily Drinking Questionnaire; DDTQ = Daily Drug-Taking Questionnaire; hr = hour; GMT = Goal Management Training; IGT = Iowa Gambling Task; LCS-D = Locus of Control Scale-Drinking-related; LNS = Letter # Sequencing; LOT = Life Orientation Test; MBSR = Mindfulness-Based Stress Reduction; MBTC = Mindfulness-Based Therapeutic Community; min = minute; Mj = Marijuana; MM = Mindfulness Meditation; mo = month; MQRS = Methodological Quality Rating Scale; PCL-C = PTSD Checklist-Civilian Version; QM = Qigong Meditation; SCL-90-R = Symptom Checklist-90-Revised; SIP = Short Inventory of Problems; SMRT = Stress Management and Relaxation Training; SOSI = Sxs of Stress Inventory; SSCS = Substance-specific Craving Scale; STAI = State-Trait Anxiety Inventory; sxs = symptoms; TAU = Tx as usual; TC = Therapeutic Community; TMT = Trail Making Test; tx = treatment; VC/NMS = Voris Craving/Negative-mood Scale; VM = Vipassana meditation; WAIS-III = Wechsler Adult Intelligence Scale; WBSI = White Bear Suppression Inventory; WCCL = Ways of Coping Checklist; wk = week; yr = year; # = number; % = percentage/percent.

RCTs also found that amount of mindfulness meditation practice between sessions/at home was significantly positively associated with abstinence from cigarette smoking (Brewer et al., 2011), and significantly negatively associated with amount of cigarette smoking (Brewer et al., 2011), likelihood of marijuana use (de Dios et al., 2012), and levels of alcohol consumption (Murphy et al., 1986). Additionally, changes in mindfulness significantly mediated effects of mindfulness treatment on changes in craving and posttraumatic stress symptoms (Garland et al., 2016; Witkiewitz, Bowen et al., 2013).

3.3.4. Effects of brief mindfulness intervention in a laboratory setting

Six RCTs examined the effects of brief mindfulness intervention (e.g., a 1.5-hour lab session that provided mindfulness meditation training) among adults who were cigarette smokers or heavy drinkers. Findings regarding effects of brief mindfulness training in decreasing acute craving, distress, and substance misuse during a cue-exposure induction and at posttreatment were inconclusive. Positive findings were found in three studies reporting greater decreases in the number of cigarettes smoked and acute craving for cigarette smoking at posttreatment compared to a control condition (Bowen & Marlatt, 2009; Nosen & Woody, 2013; Ussher et al., 2009). In contrast, two studies did not find that a brief mindfulness intervention was superior to decrease cigarette/alcohol consumption or craving during cue-exposure induction or at posttreatment compared to control conditions that either provided distraction strategy or asked participants to suppress craving (Murphy & MacKillop, 2014; Rogojanski, Vettese, & Antony, 2011).

Further, Rogojanski et al. (2011) documented a greater effect of a 20-minute brief mindfulness induction in decreasing negative affect after the smoking cue exposure procedure and at posttreatment compared to asking participants to suppress their craving. Bowen and Marlatt (2009) demonstrated a moderation effect of brief mindfulness practice on the relationship between negative affect and craving for cigarette smoking. In contrast, Vinci et al. (2014) found that a 10-minute guided meditation practice significantly increased acute craving for alcohol drinking and negative affect immediately after the negative affect induction procedure.

3.4. Effect sizes of mindfulness treatment vis-a-vis posttreatment outcomes

Meta-analyses were conducted for RCTs that compared effects of mindfulness treatment to a comparison condition on posttreatment values of outcome variables, including levels of substance misuse, point-prevalence of abstinence, craving, stress, and mindfulness. Of the 8 quasi-experimental studies, we extracted data for meta-analysis (i.e., means and standard deviations of outcome variables at posttreatment, and sample size per condition) on only substance misuse of all meta-analyses outcomes and from only one single trial (data were reported in Bowen et al., 2006, 2007; Simpson et al., 2007) of all quasi-experiment studies. We decided not to group the only quasi-experimental study that provided sufficient statistics for meta-analysis with RCTs, and not to include this trial in the meta-analyses. Therefore, meta-analyses were conducted only for RCTs. The 34 RCTs reported data from 28 independent clinical trials (6 studies were secondary data analyses). A single trial was included and represented only once in meta-analysis of a given outcome variable to avoid the violation of independence.

Fig. 2 illustrates the pooled Cohen's *d*s and associated 95% CIs of mindfulness treatments on levels of substance misuse at posttreatment relative to a comparison condition (i.e., TAU and alternative treatments). Six studies provided sufficient information to calculate effect size, including means and standard deviations for substance misuse at posttreatment, and sample sizes per treatment and comparison conditions. The sample sizes of the 6 studies varied from 38 to 198 ($M = 116.7$, $SD = 58.7$), and the number of participants completing posttreatment/follow-up assessments ranged from 31 to 177 ($M = 93.8$, $SD = 52.2$). Ages of participants ranged from 19 to 48 years ($M = 35.5$, $SD = 9.8$). Two studies examined effects of mindfulness treatment only among women, and 4 studies used samples of women and men.

The included studies used different measures to assess substance misuse, including number of days of substance use/binge drinking episodes ($n = 3$), the Short Inventory of Problem Alcohol/Drug Use ($n = 2$), and the Current Opioid Misuse Measure ($n = 1$). Cohen's *d*s were pooled for studies using different measures. The Cohen's *d*s for studies using different measures were then pooled together to compute an average effect size. Results revealed a significant, small effect size ($d = -0.28$, 95% CI [−0.54, −0.03]) of mindfulness treatment on levels of substance misuse measured with the number of days of substance use/binge drinking episodes; a small effect size ($d = -0.40$, 95% CI [−0.73, 0.07]) on substance misuse measured with the Short Inventory of Problem Alcohol/Drug Use; and a significant medium effect size ($d = -0.51$, 95% CI [−0.88, −0.14]) on opioid misuse measured with the Current Opioid Misuse Measure at posttreatment. Overall, the synthesized effect size was −0.33 (95% CI [−0.88, −0.14]), suggesting that mindfulness treatment had a significant small effect in reducing substance use at posttreatment compared to comparison conditions.

Fig. 3 illustrates the pooled odds ratios and associated 95% CIs of mindfulness treatment on point-prevalence abstinence from cigarette smoking compared to an alternative treatment. We extracted data to calculate odds ratios of point-prevalence abstinence from 4 RCTs, including number of participants who were allocated/received treatment or comparison condition, and number of participants who achieved abstinence at posttreatment per condition. The sample sizes of the 4 studies varied from 55 to 196 ($M = 118.3$, $SD = 61.4$). Ages of participants ranged between 22 and 46 ($M = 38.5$, $SD = 11.2$). One study focused on young adults (Davis et al., 2013), and 3 studies examined mindfulness treatment among middle-aged adults who were in their 40s. All 4 studies used samples of women and men. The synthesized effect size was 1.76 (95% CI [0.98, 3.15]), which suggests that mindfulness treatment participants were 76% more likely to achieve abstinence from cigarette smoking at posttreatment compared to their peers who received alternative treatments. The effect size approached the significance level at 0.05 ($p = 0.056$).

Fig. 4 presents the pooled Cohen's *d*s and associated 95% CIs of 9 RCTs that provided means and standard deviations for the measure of craving for substance use at posttreatment, and sample sizes per treatment and comparison conditions. The sample sizes of the 9 studies varied from 34 to 168 ($M = 87.0$, $SD = 48.6$), and number of participants who completed posttreatment/follow-up assessment ranged from 31 to 133 ($M = 61.4$, $SD = 33.4$). Ages of participants ranged between 20 and 48 ($M = 36.5$, $SD = 9.3$). One study examined effects of mindfulness treatment among only women (Nakamura et al., 2015); one study focused only on men (Garland et al., 2016), and the rest used samples of women and men.

Two sets of meta-analyses were conducted with one including studies of brief mindfulness intervention in a laboratory setting and one excluding these studies. Overall, the synthesized effect size of mindfulness treatment (including brief mindfulness intervention in a laboratory setting) on reducing carving was −0.68 (95% CI [−1.11, −0.25]), suggesting that mindfulness treatment had a significant medium effect on reducing craving at posttreatment relative to comparison conditions. The included studies used two measures to assess craving: the Penn Alcohol/Drug Craving Scale and a numeric rating scale. The synthesized effect size of mindfulness treatment on craving measured with the Penn Alcohol/Drug Craving was −0.65 (95% CI [−1.67, 0.37]). The effect size on craving measured using a numeric rating scale was −0.65 (95% CI [−0.88, −0.42]). The effect size of mindfulness treatment on reducing craving ($d = -0.63$, 95% CI [−1.17, −0.08]) was slightly lower when excluding the studies of brief mindfulness intervention in the meta-analyses.

Fig. 5 presents the pooled Cohen's *d*s and associated 95% CIs of 5 RCTs that provided means and standard deviations for the measure of stress at posttreatment, and sample sizes per treatment and comparison

Table 3
Systematic review of mindfulness treatment studies using randomized controlled group designs ($N = 34$).
Refer to table footnote for definitions of acronyms/abbreviations.

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
Alterman et al. (2004)	Baseline, posttx (8-wk), & 5-mo follow-up	MM + TAU: 8 weekly, 2-hr group sessions, and one 7-hr workshop of MM practice; 30–45 min daily group meditation during the rest of wk days.	TAU: recovery house providing 12-step substance misuse tx, behavioral modification tx, HIV counseling, and other medical, psychiatric, and work-related tx.	31 adult substance misusers (MM: $n = 18$; TAU, $n = 13$) who had been in a recovery house for up to 2 mos. Of all participants, 41.9% White and 58.1% African American. Of MM participants, *Mage* = 36.1 ($SD = 9.4$); 38.9% men; 83.3% participated in the assessment at posttx and 5-mo follow-up. Of TAU participants, *Mage* = 37.0 ($SD = 11.7$); 53.8% men; 76.9% participated in posttx and 5-mo follow-up assessments. There were no significant differences between tx and control groups in baseline demographic or outcome variables, but MM participants had significantly more days of heroin use in the past 30 days ($M = 4.1$, $SD = 8.6$ vs. $M = 0.2$, $SD = 0.8$), yrs. of heroin use ($M = 3.4$, $SD = 7.0$ vs. $M = 0.31$, $SD = 1.1$), and ASI-assessed medical ($M = 0.5$, $SD = 0.3$ vs. $M = 0.2$, $SD = 0.3$) and psychiatric problems ($M = 0.4$, $SD = 0.3$ vs. $M = 0.2$, $SD = 0.2$) compared to TAU participants at baseline.	Substance misuse was measured with the TLFB, ASI and urinalysis. Spirituality was measured with the SAS. Personal meaning was measured with the LAP-R-Purpose and Coherence Subscales. Optimism was measured with the LOT. Affect was measured with the PANAS. Health was measured with the SF-36.	MM participants had a significantly greater decrease in ASI-assessed medical problems over the 5-mo follow-up compared to TAU participants. Participants in the MM and TAU conditions had significant reductions in ASI-assessed alcohol, drug, family, and social problems at posttx and 5-mo follow-up.	Small sample size. No information regarding tx fidelity assessment. Attrition rates were high at posttx and follow-up assessments. ITT analyses were not used.	9
Bowen and Marlatt (2009)	Baseline, post each of the 4 stages of the cue exposure, post the lab procedure, 24-hours & 7-day follow-ups	Mindfulness: a 1.5-hr lab session, providing instructions on coping with urges using mindfulness meditation during cue exposure trial	Control: a 1.5-hr lab session, participants were asked to use any techniques they would naturally use to cope with urges during cue exposure trial	123 college students who were cigarette smokers (mindfulness: $n = 61$; control: $n = 62$). Of mindfulness participants, *Mage* = 20.8 ($SD = 4.5$); 72.1% men; 49.2% Caucasian, 32.8% Asian American, 8.2% mixed race. Of control participants, *Mage* = 19.9 ($SD = 1.3$); 74.2% men. 46.8% Caucasian, 32.3% Asian American, 8.1% mixed race. 94.3% participated in the 24-hr follow-up assessment and 90.2% participated in the 7-	Cigarette smoking was measured with the FTND, SQHQ; quantity and frequency of cigarette smoking was self-reported; affect was measured with the PNANS.	Mindfulness participants had a significantly greater reduction in # of cigarettes smoked over the 7-day follow-up period compared to participants in the control condition. Mindfulness intervention participation moderated the relations between negative affect and urges for smoking at the 7-day follow-up assessment.	Relied on self-report measures.	10

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
				day follow-up assessment. No significant differences between mindfulness and control groups in baseline demographic or outcome variables. No significant differences in demographic or outcome variables between participants who completed and who did not complete posttx assessment.				
Bowen et al. (2009)	Baseline, posttx (8-wk), 2-, & 4-mo follow-ups	MBRP + TAU: 8 weekly, 2-hr group sessions.	TAU: standard outpatient aftercare groups designed to maintain abstinence through a 12-step process-oriented format: 1.5-hr group sessions, 1–2 times/wk.	168 adult substance misusers (MBRP: $n = 93$; TAU: $n = 75$) who completed inpatient or outpatient tx: *Mage* = 40.5 (*SD* = 10.3); 63.7% men; 51.8% White, 28.6% African American, 15.3% multiracial, and 7.7% Native American. There were no significant differences between MBRP and TAU groups in baseline demographic or outcome variables, except the MBRP group had a significantly higher proportion of White participants compared to the TAU group (63% vs. 45%). Attrition did not differ significantly between groups at any assessment.	Substance misuse was measured with the TLFB and SIP. Craving for substances was measured with the PACS. Mindfulness was measured with the FFMQ. Acceptance of negative experience was measured with the AAQ. Mindfulness practice at home was self-reported by participants.	Participants in MBRP and TAU groups had significant decreases in # of days of substance use in past 2 mo and negative consequences of substance use at 4-mo follow-up. MBRP participants had significantly greater reductions in # of days of substance use and craving compared to TAU participants by 4-mo follow-up. MBRP participants had a significantly greater increase in acceptance compared to TAU participants at 4-mo follow-up. However, treatment gains for MBRP participants decreased by 4-mo follow-up. MBRP participants had a significant increase in acting with awareness, whereas TAU participants had a decrease in acting with awareness at 4-mo follow-up. MBRP participants attended 65% of tx sessions. There was a significant difference between MBRP and TAU groups in # of tx hrs received during the 8-wk intervention period ($M = 12.8$, $SD = 4.9$ vs. $M = 9.8$, $SD = 8.2$).	Relied on self-report measures. No information regarding tx fidelity assessment.	11
Bowen et al. (2014)	Baseline, 3-, 6-, & 12-mo follow-ups	MBRP + TAU: 8 weekly 2-hr group sessions.	CBT-based RP: 8 weekly, 2-hr group sessions; TAU: standard outpatient aftercare; based on 12-step program; 1–2 times/wk, 1.5-hr group sessions.	286 adult substance misusers (MBRP: $n = 103$; RP: $n = 88$; TAU: $n = 95$) who completed inpatient or outpatient tx. Of MBRP participants, *Mage* = 39.1 (*SD* = 10.9); 73.8% men; 55.3% White, 25.2% African American, 8.7% Hispanic. Of RP participants,	Substance misuse was measured with the TLFB and ASI.	MBRP and RP participants showed a 54% decreased risk of relapse to drug use and 59% decreased risk of relapse to heavy drinking compared to TAU participants. MBRP participants showed a 21% increase in risk of relapse to drug use compared to RP	Relied on self-report measures. High attrition rates at follow-up assessments. ITT analyses were not used.	14

				Mage = 38.9 (*SD* = 10.9); 63.6% men; 48.9% White, 14.8% African American, 11.4% Hispanic. Of TAU participants, *Mage* = 37.2 (*SD* = 10.8); 72.6% men; 48.4% White, 23.2% African American, 13.7% Hispanic. There were no significant differences between tx and comparison groups in baseline demographic or outcome variables, except that TAU participants ($M = 8.5$, $SD = 4.4$) had a significantly lower mean Severity of Dependence score than MBRP ($M = 9.5$, $SD = 4.2$) and RP participants ($M = 10.3$, $SD = 3.7$). Follow-up completion rates were not significantly different across the 3 conditions. Missing data were not significantly associated with participants' baseline demographic characteristics or levels of substance use, except for age.		participants. Among participants who reported heavy drinking days during the follow-up period, RP and MBRP participants reported 31% fewer days of heavy drinking compared to TAU participants. RP and MBRP participants had significantly higher probabilities of abstinence from drug use and heavy drinking compared to TAU participants at 6-mo follow-up. Among participants who reported drug use during the follow-up period, MBRP participants reported 31% fewer drug use days compared to RP participants. MBRP participants had significantly higher probabilities of not engaging in any heavy drinking compared to RP participants at 12-mo follow-up. 46.3%, 48.9%, and 46.6% of participants attended 75% of tx sessions for MBRP, RP, and TAU groups, respectively.		
Brewer et al. (2009)	Baseline & posttx (9-wk); substance use was assessed once a wk over the tx sessions	MT: 9 weekly, 1-hr group sessions.	CBT: 12 weekly, 1-h group sessions	36 adults (MT: $n = 21$; CBT: $n = 15$) with alcohol and/or cocaine use disorders. 25 participants completed baseline assessment (MT: $n = 18$; CBT: $n = 7$). Of MT participants: *Mage* = 35.6 (*SD* = 10.4); 72.2% men; 55.6% White, 33.3% African American, and 11.1% Hispanic. Of CBT participants, *Mage* = 45.0 (*SD* = 13.5); 71.4% men; 85.7% White, and 14.3% Hispanic. 14 participants completed the interventions and were included in data analyses. There were no significant differences between tx and control groups in baseline demographic or outcome variables, except in the % of participants who had never married (28.6% for CBT	Substance misuse was measured with substance use calendar. Mindfulness was measured with the FFMQ. Emotion was measured with the DES. Psychophysiological functions were measured in 1-hr lab session including neutral-relaxing and stress imagery conditions at posttx assessment.	There were no significant differences in # of days of cocaine and alcohol use at posttx between participants in MT and CBT groups. MT participants had significantly lower levels of anxiety, anger, and fear at posttx compared to CBT participants. MT participants had significantly decreased sympathetic/vagal ratios compared to CBT participants at posttx. Participants in MT and CBT groups had significant improvements in mindfulness; however, the improvement in mindfulness did not significantly differ between MT and CBT groups. Completion rates were 43.0% for MT group and 33.3% for CBT group. MT	Small sample size. No information regarding tx fidelity assessment. No follow-up assessments. Study had high attrition rates and did not use ITT analyses. The control condition had more tx sessions than MT.	9

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
				group vs. 61.1% for MT group). There were no significant differences in baseline drug or alcohol use between tx completers and non-completers.		participants who initiated tx ($n = 18$) attended 65% of sessions vs. CBT participants who initiated tx ($n = 7$) attended 34% of sessions.		
Brewer et al. (2011)	Baseline, posttx (4-wk), & 6-, 12-, & 17-wk posttx initiation	MTS: 4-wk, twice-a-wk, 1.5-hr group sessions.	FFS: 4-wk, twice-a-wk, 1.5-hr group sessions	88 adults who smoked an average of 20 cigarettes/day were recruited; 87 adults (MT: $n = 46$; FFS: $n = 41$) were included in data analyses. Of MT participants, *Mage* = 46.5 ($SD = 8.7$); 65.9% men; 58.5% White, 36.6% Black, and 4.9% Hispanic. Of FFS participants, *Mage* = 45.3 ($SD = 11.4$); 58.7% men; 41.3% White, 41.3% Black, and 15.2% Hispanic. There were no significant differences between MT and FFS groups in baseline demographic or outcome variables. There were no significant differences between participants who initiated tx and did not initiate tx in baseline demographic characteristics or cigarette use.	Cigarette smoking was measured with the TLFB and Carbon Monoxide Breath Test. Mindfulness practice at home was self-reported by participants.	MT participants had a significantly greater reduction in cigarette use compared to FFS participants over tx and follow-up periods. MT participants had a significantly greater one-wk point prevalence abstinence rate at 17-wk post-intervention initiation compared to FFS participants. The amount of mindfulness practice at home was significantly inversely associated with cigarette use at posttx. The amount of practice of sitting meditation was significantly associated with one-wk point prevalence abstinence at 17-wk post-intervention initiation. Use of informal mindfulness practice was significantly inversely correlated with the average # of cigarettes smoked at 4-wk and 6-wk follow-ups. MT participants who initiated tx ($n = 33$) attended an average of 6.7 ($SD = 1.7$) of 8 sessions vs. FFS participants who initiated tx ($n = 38$) attended an average of 6.2 ($SD = 2.2$) of 8 sessions.	No information regarding tx fidelity assessment.	11
Davis et al. (2013)	Baseline & 2-wk post-quit-day	MTS: 6 weekly, 2-hr group sessions and a 7-hr Quit Day Retreat; 30-min guided meditation every day during tx.	ILS: combined FFS and Mayo Clinic's Nicotine Dependence Center program; matched to tx condition in time, duration, intensity, and exercises; 30-min walking (not mindful walking) every day during tx.	55 college students (MTS: $n = 30$; ILS: $n = 25$) who smoked ≥10 cigarettes per day. Of MTS participants, *Mage* = 21.7 ($SD = 2.4$); 70.0% men; 90.0% White. Of ILS participants, *Mage* = 22.2 ($SD = 2.7$); 72.0% men; 92.0% White. There were no significant differences between MTS and ILS groups in baseline demographic or outcome variables. There were no	Cigarette smoking was measured with the TLFB and Carbon Monoxide Breath Test. Alcohol use was assessed with the TLFB. Mental distress was measured with the DTS. Stress was measured with the PSS. Mindfulness was measured with the FFMQ. Urge to smoke was assessed with one question rated on a 10-point scale.	MTS participants had a significantly higher 7-day point prevalence abstinence rate and a significantly greater # of days of smoking abstinence compared to ILS participants at 2-wk post-quit-day. MTS participants had decreases in # of drinks per wk from pre-to-post-quit-day, whereas ILS participants had increases in # of drinks per wk from	No follow-up assessments. No information regarding tx fidelity assessment.	9

				significant differences in baseline demographic variables or levels of cigarette/alcohol use between tx completers and non-completers; however, completers reported smoking significantly fewer cigarettes per day at baseline compared to non-completers ($M = 11.9$, $SD = 3.0$ vs. $M = 15.3$, $SD = 7.9$).		pre-to-post-quit-day; however, changes in # of drinks per wk were not significantly different between MTS and ILS participants. # of drinks per wk at 2-wk post-quit-day was significantly negatively associated with relapse to smoking. Completion rates were 50% for the MTS group and 40% for the ILS group.	
Davis, Goldberg et al. (2014)	Baseline, 4- & 24-wk post-quit-day	MTS: one, 7-hr introductory session; 4 weekly, 3-hr group sessions; one, 7-hr Quit Day Retreat; and 4 weekly, 1.5-hr meditation groups along with Nicotine Replacement tx.	QL and 4-wk Nicotine Replacement tx	198 adults (MTS: $n = 105$; QL: $n = 91$) who smoked an average of ≥15 cigarettes/day were recruited; 118 adults (MTS: $n = 59$; QL: $n = 59$) initiated tx. Of all participants, *Mage* = 41.7 ($SD = 13.3$); 50.0% men; 77.0% White, and 11.7% African American. There were no significant differences between MTS and QL groups in baseline demographic or outcome variables. Of tx initiators, the MTS group had heavier smokers, more racial/ethnic minorities, and a larger proportion of participants with post-high school education. Attrition did not differ significantly between MTS and QL participants	Cigarette smoking was measured with the TLFB and Carbon Monoxide Breath Test. Emotion regulation was measured with the DERS. Attentional control was measured with the ACS. Mindfulness was measured with the FFMQ.	Of tx initiators ($n = 118$), MTS participants had a significantly higher 7-day point-prevalence abstinence rate and a significantly higher continuous abstinence rate at 4-wk post-quit-day compared to QL participants. MTS participants had a significantly higher continuous abstinence rate at 24-wk post-quit-day compared to QL participants. 45.8% and 38.7% of MTS participants were abstinent at 4-wk and 24-wk post-quit-day, whereas 20.6% and 25.4% of QL participants were abstinent at 4-wk and 24-wk post-quit-day. MTS participants had a significantly greater decrease in difficulty in emotion regulation, and significant increases in attentional control, non-judgment, and mindfulness at 24-wk post-quit-day assessment compared to QL participants. The # of days smoked post-quit-day was significantly inversely associated with attentional control, difficulty in emotion regulation, and mindfulness at 4-wk post-quit-day assessment. The # of mins of meditation practice at home per day was significantly positively associated with attentional control, difficulty in emotion regulation, and	No information regarding tx fidelity assessment. Attrition rates were high for 4- and 24-wk follow-up; however, ITT analyses were not used when analyzing time-by-group interactions in self-report measures.	11

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
						mindfulness states at 4-wk post-quit-day assessment among MTS participants. Completion rate for the MTS group was 74.6%.		
Davis, Manley et al. (2014)	Baseline, 4-, & 24-wk post-quit-day	MTS: 7 weekly, 2.5-hr group sessions and one, 6.5-hr Quit Day Retreat, and 2-wk Nicotine Replacement Therapy; 15–30 mins of meditation at home every day during tx.	FFS: matched to tx condition in time, duration, intensity, and exercises; QL and 2-wk Nicotine Replacement Therapy	175 low-income adults (MTS: $n = 68$; FFS: $n = 67$; QL: $n = 40$) who smoked an average of ≥15 cigarettes/day. 135 participants were randomized to MTS and FFS. Of MTS participants, *Mage* = 43.2 (*SD* = 12.1); 57.4% men; 85.3% White, 2.9% African American, 4.4% Hispanic, and 4.4% American Indian. Of FFS participants, *Mage* = 45.8 (*SD* = 13.4); 49.3% men; 88.1% White, 3.0% African American, 2.2% Hispanic, and 1.5% American Indian. Of QL participants, *Mage* = 45.3 (*SD* = 11.9); 47.5% men; 45.0% White, 50% African American, 0% Hispanic, and 2.5% American Indian. There were no significant differences between MTS and FFS in baseline demographic or outcome variables. MTS/FFS and QL participants differed significantly in race, % of participants who completed high school (70.1% vs. 59.7% vs. 42.1%), and # of prior quit attempts ($M = 9.9$, $SD = 19.9$ vs. $M = 10.4$, $SD = 20.6$ vs. $M = 4.6$, $SD = 5.3$). Attrition was not significantly associated with any baseline variables and did not differ significantly between participants in the MTS, FFS, and QL conditions.	Cigarette smoking was measured with TLFB and Carbon Monoxide Breath Test. Mindfulness was measured with the FFMQ. Urge to smoke was assessed using one question rated on a 10-point scale. Stress was measured with the PSS. Acceptance of negative experiences was measured with the AAQ.	MTS and FFS participants had similar 7-day point prevalence abstinence rates at 4-wk post-quit-day assessment. MTS participants had nonsignificantly higher 7-day point prevalence abstinence rates compared to FFS participants at 24-wk post-quit-day. MTS participants had a significantly greater reduction in urges for smoking compared to FFS participants at 24-wk post-quit-day. Post-quit urge ratings were significantly associated with 7-day point prevalence abstinence rates at 4-wk and 24-wk post-quit-day assessments. MTS participants had significantly greater decreases in experiential avoidance and perceived stress, and a significantly greater increase in non-judgment, acting with awareness, non-reacting, and mindfulness at 24-wk post-quit-day assessment compared to FFS participants. Completion rates were 67.6% for the MTS group, 73.1% for the FFS group, and 57.5% for the QL group. MTS participants attended an average of 5.4 of 8 sessions vs. FFS participants attended an average of 5.2 of 8 sessions.	No information regarding tx fidelity assessment. Attrition rates were high for 4- and 24-wk follow-up; however, ITT analyses were not used when analyzing time-by-group interactions in self-report measures. Participants' self-selected to be either randomized to MTS or FFS or participate in QL.	11
de Dios et al. (2012)	Baseline, posttx (2-wk), & 1-, 2- & 3-mo post-baseline assessments	MI + MM: 2-weekly, 45-min individual sessions	No active intervention; assessment only	34 adult women (MI + MM: $n = 22$; control condition: $n = 12$) who were MJ users. Of MI + MM participants, *Mage* = 22.7 (*SD* = 2.7); 45.5% White. Of participants in the control condition, *Mage* = 23.5	MJ use was measured with urinalysis and the TLFB. Anxiety was measured with the PDSQ-GAD. Meditation practice at home was assessed with the TLFB.	MI + MM participants in the tx condition had significantly greater decreases in the # of days of MJ use over the past 30 days at 1-, 2-, and 3-mo follow-up assessments compared to participants in the	Small sample size. No active control condition.	12

				(*SD* = 3.3); 58.3% White. There were no significant differences between MM and control groups in baseline demographic or outcome variables. Attrition was not significantly associated with participants' baseline demographic or MJ use characteristics and did not differ significantly between participants in the tx and control conditions.		control condition. Among MI + MM participants, participants were 50% less likely to use MJ on days when they practiced meditation than when they didn't practice meditation. 100% of MI + MM participants attended the 1st session and 73% attended the 2nd session.		
Garland et al. (2010)	Baseline, mid-tx, & posttx (10-wk)	MORE: 10 weekly, 2-hr group sessions. Participants were asked to practice mindfulness for 15 mins/day.	SG: 10 weekly, therapist-led social support groups based on the Matrix model IOP tx manual. Participants were asked to journal for 15 mins/day on support group topics.	53 adults (MORE: $n = 27$; SG: $n = 26$) with alcohol dependence, 37 participants completed tx. Of MORE participants, *Mage* = 39.9 (*SD* = 8.7); 81.5% men; 62.9% African American and 42.3% White. Of SG participants, *Mage* = 40.7 (*SD* = 10.2); 76.9% men; 57.7% African American and 42.3% White. There were no significant differences between MORE and SG groups or completers and non-completers in baseline demographic or outcome variables.	Craving was measured with the PACS. Mindfulness was measured with the FFMQ. Mental distress was measured with the BSI. Stress was measured with the PSS. Impairment in response inhibition to drinking behavior was measured with the IARIS. Thought suppression was measured with the WBSI. Physiological and neuropsychological functions were measured with cue-reactivity protocol, dot probe task, and HR variability measurement.	MORE participants had significantly greater decreases in perceived stress, thought suppression, alcohol attentional bias at posttx compared to SG participants. MORE participants had significant pre-to-posttx decreases in perceived stress, psychiatric sxs, alcohol attentional bias, and significant pre-to-posttx improvement in physiological recovery from alcohol cues. Completion rates were 66.7% for MORE and 73.1% for SG. MORE participants completed an average of 8 (*SD* = 2.1) of 10 sessions, whereas SG participants completed an average of 7.3 (*SD* = 3.5) of 10 sessions.	Small sample size. No follow-up assessments posttx. Study had high attrition rates at posttx and did not use ITT analyses.	11
Garland, Manusov et al. (2014)	Baseline, posttx (8-wk), & 3-mo follow-up	MORE: 8 weekly, 2-hr group sessions. Participants were asked to practice mindfulness for 15 mins/day.	SG: 8 weekly, 2-hr, therapist-led social support groups based on the Matrix model IOP tx manual. Participants were asked to journal for 15 mins/day on support group topics.	115 chronic pain patients (MORE: $n = 57$; SG: $n = 58$) who had taken prescription opioids for pain. Of MORE participants, *Mage* = 49.3 (*SD* = 13.9); 30.0% men; 63.0% White, 18% African American, 4% American Indian, and 12% did not respond; 72.0% met criteria for opioid use disorders. Of SG participants, *Mage* = 47.4 (*SD* = 13.6); 34.0% men; 67.0% White, 19% African American, 3% American Indian, and 7% did not respond; 72.0% met criteria for opioid use disorders. There were no significant differences between MORE and SG groups or	Prescription opioid misuse was measured with the COMM. Craving for prescription opioids was measured with a single item rated on a 10-point scale. Mindfulness was measured with the FFMQ. Pain was measured with the BPI. Coping with pain was measured with the CSQ-Pain Sensations. Coping was measured with the CERQ. Stress was measured with the C-SOSI.	MORE participants had a significantly greater proportion of individuals who no longer met opioid use disorder criteria at posttx compared to SG participants. Participants in the MORE and SG conditions had a significant pre-to-posttx decrease in self-reported opioid misuse. MORE participants had significantly greater reductions in urges for opioids, pain severity, functional interference, sympathetic arousal sxs, neurological sxs, and nonreactivity, and significantly greater increases in reinterpretation of pain	Relied on self-reported measures.	11

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
				completers and non-completers in baseline demographic or outcome variables.		sensations and cognitive reappraisal at posttx compared to SG participants. MORE participants had significantly greater reductions in pain severity and pain interference at 3-mo follow-up compared to SG participants.		
Garland , Froeliger,et al. (2014b) Secondary data analysis of Garland, Manusov et al. (2014)	Baseline & posttx (8-wk)	MORE: 8 weekly, 2-hr group sessions. Participants were asked to practice mindfulness for 15 mins/day.	SG: 8 weekly, 2-hr, therapist-led social support groups based on the Matrix model IOP tx manual. Participants were asked to journal for 15 mins/day on support group topics.	69 participants (MORE: $n = 20$; SG: $n = 49$) who completed psychophysiological assessments at posttx in Garland, Manusov et al. (2014) . Of MORE participants, *Mage* = 46. 0 (*SD* = 13.6); 75% women. Of SG participants, *Mage* = 46.9 (*SD* = 14.4); 69% women. There were no significant differences in baseline demographic or outcome variables between MORE and SG participants.	Craving for prescription opioids was measured with a single item rated on a 10-point scale. Pain was measured with the BPI. Physiological and neuropsychological functions were measured with dot probe task and HR variability measurement	MORE participants had significantly greater reductions in subjective opioid cue-reactivity on the dot probe task at posttx compared to SG participants. MORE participants had significantly greater enhancements in HR deceleration during attention to pleasure cues, and significantly greater increases in HR variability from rest during emotional attention to pleasure cues than SG participants. Effects of MORE on craving were mediated by enhanced reward responsiveness.	No follow-up assessments posttx.	11
Garland et al. (2016)	Baseline & posttx (10-wk)	MORE: 10 weekly, 2-hr group sessions. Participants were asked to practice mindfulness for 15 mins/day.	CBT: 10 weekly, 2-hr group CBT sessions adapted from Seeking Safety program that addressed substance misuse and trauma-related issues. Participants were asked to do daily homework. TAU: 10 weekly, 2-hr program adapted from TC program, including participation in a therapeutic milieu, psychoeducation, client-centered, supportive-expressive group therapy, and coping skills groups.	180 adult men who were in a TC for substance misuse problems were recruited (MORE: $n = 64$; CBT: $n = 64$; TAU: $n = 52$). Of MORE participants, *Mage* = 37.7 (*SD* = 10.4); 40% White, 45% Black, and 14% others. Of CBT participants, *Mage* = 36.5 (*SD* = 11.2); 44% White, 44% Black, and 12% others. Of TAU participants, *Mage* = 38.7 (*SD* = 9.8); 42% White, 44% Black, 14% others. There were no significant differences among participants in the 3 conditions or between study completers and non-completers in baseline demographic or outcome variables.	Craving was measured with the PACS. Trauma history was assessed using 9 yes/no questions that asked participants' about their experiences with traumatic events. Stress was measured with the PCL-C. Mental distress was measured with the BSI. Mindfulness was measured with the FFMQ. Affect was measured with the PANAS.	MORE participants had a significantly greater reduction in craving compared to CBT participants at posttx. MORE participants had significant pre-to-posttx reductions in post-traumatic stress, depression and anxiety sxs, and negative affect; and significant pre-to-posttx increases in positive affect and mindfulness. MORE participants had significantly greater reductions in post-traumatic stress and negative affect, and a significantly greater increase in mindfulness compared to CBT participants. MORE participants had significantly greater increases in positive affect	Relied on self-reported measures. No follow-up assessments posttx.	12

						and mindfulness compared to TAU participants. Changes in mindfulness were significantly negatively associated with changes in craving and PTSD sxs.		
Himelstein et al. (2015)	Baseline & posttx (12-wk)	MM + TAU: 12 weekly, 1.5-hr individual sessions	TAU: 12 weekly sessions of individual psychotherapy (40–65 min sessions)	35 incarcerated male youth with substance misuse problems: *Mage* = 16.5; 70% Latino, 14% African American, 6% Caucasian, 5% Pacific Islander, and 5% mixed-ethnic.	Attitude toward drugs was measured with the ATD. Mindfulness was measured with the MAAS. Locus of control was measured with the PLCS. Decision-making skills were measured with the DMS. Self-esteem was measured with the RSES. Participants' behavioral regulation was observed and rated by detention camp staff.	Participants in both conditions had significant pre-to-posttx increases in self-esteem and decision-making skills. MM training in addition to TAU was significantly more effective in increasing participants' self-esteem and behavioral regulation at posttx compared to TAU alone.	Small sample size. Relied on self-report measures. No information regarding tx fidelity assessment. Independent *t*-tests used for outcome analyses did not account for repeated-measure effects and missing values at posttx assessment. No follow-up assessments posttx.	9
Hsu et al. (2013) Secondary data analysis of Bowen et al. (2009)	Baseline, posttx (8-wk), 2- & 4-mo follow-up assessments	MBRP as an adjunct to TAU: 8 weekly, 2-hr group sessions.	TAU: standard outpatient aftercare groups: 1.5-hr group sessions, 1–2 times weekly	Same as Bowen et al. (2009)	Substance misuse was measured with the TLFB. Craving for substances was measured with the PACS. Mindfulness was measured with the FFMQ.	MBRP participants had a significantly greater decrease in # of days of substance use over the course of intervention and 4-mo follow-up compared to TAU participants. Participants in both conditions had a significant decrease in # of days of substance use over the course of intervention and 4-mo follow-up. However, treatment gains for MBRP participants decreased by 4-mo follow-up. Distress tolerance moderated tx effects: MBRP participants with lower baseline distress tolerance showed a significantly greater decrease in # of days of substance use compared to TAU participants with lower baseline distress tolerance; however, the treatment gain was not maintained at the 4-mo follow-up.	Relied on self-report measures. No information regarding tx fidelity assessment.	10
Lee et al. (2011)	Baseline & posttx (10-wk)	Modified MBRP: 10 weekly, 1.5-hr group sessions	TAU: substance use education	24 incarcerated adult men in Taiwan (MBRP: $n = 10$; TAU: $n = 14$) who were currently abstinent from drug use. Of MBRP participants, *Mage* = 43.0 ($SD = 5.6$). Of TAU participants, *Mage* = 38.8 ($SD = 7.9$). There were no significant differences between MBRP and TAU	Substance misuse was measured with the DUDIT. Self-efficacy to avoid drugs was measured with the DASES. Depression was measured with the BDI.	MBRP participants had a significantly greater increase in negative outcome expectancies of drug use assessed by DUDIT-negative aspect of drug use subscale compared to TAU participants at posttx. MBRP participants had significant pre-to-posttx changes in	Small sample size. Relied on self-report measures. No information on tx fidelity assessment. Study did not report attrition rates or whether ITT analyses were performed. No follow-up assessments.	7

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
				groups in baseline demographic and outcome variables; however, MBRP participants had significantly less frequent drug use compared to TAU participants at baseline ($M = 3.8$, $SD = 1.8$ vs. $M = 6.9$, $SD = 2.9$).		drug avoidance self-efficacy and positive aspect of drug use assessed by DUDIT.		
Mermelstein and Garske (2014)	Alcohol use & mindfulness practice (only for mindfulness participants) was measured each wk. Cue exposure protocol was implemented after 2 sessions (wk-1 & wk-2). Other measures were administered at baseline, after session 1, & at wk-4.	Brief mindfulness tx: 2 weekly sessions (a 28-min session providing guided instructions for MM practice and urge surfing exercise and a 25-min session on MM). Daily, 1-hr mindfulness practice over 5 wks.	Control group: participants did not engage in any comparable active intervention; but were given instructions to utilize any technique they would normally use to cope with alcohol-related urges during the cue exposure protocol.	76 college students with binge drinking problems (Mindfulness, $n = 38$; Control, $n = 38$): *Mage* = 19.1 ($SD = 1.2$); 50% were men; 91% were White. Participants were blind to tx condition when signing up to the txs. There were no significant differences between tx and control groups in baseline binge drinking, alcohol use, readiness to change, self-efficacy, and mindfulness. All participants completed assessments.	Alcohol use was measured with the DDQ, RAPI, and TLFB; Urge for alcohol was measured with the AUQ. Self-efficacy to refuse drinking was measured with the DRSEQ. Mindfulness was measured with the FFMQ. Mindfulness practice was self-rated by participants on a scale of 0 to 100.	Participants in the mindfulness intervention group had significantly greater decreases in binge drinking episodes and negative consequences of alcohol use compared to control participants during the 4 wks after the initial intervention. Mindfulness intervention participants had significantly greater increases in self-efficacy to refrain from using alcohol and mindfulness compared to participants in the control group during the 4 wks after the initial intervention. Completion rate was 97% for mindfulness intervention. 82% had at least one mindfulness practice each wk and 97% had at least one practice during the 4-wk period.	Relied on self-report measures for alcohol use/binge drinking. No information regarding tx fidelity assessment.	10
Murphy et al. (1986)	Once a day over a 16-wk period	Meditation exercise: 8-wks, 3 times-a-wk, individual sessions, and meditation practice twice-a-day over the 3 wks.	Running exercise: 8-wks, 3 times-a-wk, group sessions; Control: no active intervention	43 male college students (Meditation group: $n = 14$; Running group: $n = 13$; Control group: $n = 16$) who were heavy social drinkers. Of students in the meditation group, *Mage* = 25.0; of students in the running group, *Mage* = 24.9; of students in the control group, *Mage* = 24.5. There were no significant differences in baseline alcohol use of participants in meditation, running, and control groups.	Daily journal including type and amount of alcohol use, and amount of time spent drinking	Participants in the meditation group had significant reductions in alcohol consumption over the 8-wk intervention; however, the reductions in alcohol consumption of the meditation group were not significantly different from participants in the running or control groups. High meditation compliers (i.e., meditated ≥ 5.3 times per wk) reduced their alcohol consumption by 60% compared to 24% in low compliers (meditated ≤ 5.3 times per wk).	Small sample size. Relied on self-report measures. No information regarding tx fidelity assessment. Study did not report attrition rates, or whether ITT analyses were used.	9
Murphy and MacKillop (2014)	Baseline, post-cue exposure and extinction period (7 times), post-lab procedure,	Mindfulness: a 45-min lab session, providing instructions on coping	DST: a 45-min lab session providing instructions on coping with urges using	84 young adults who were heavy drinkers: *Mage* = 22.4 ($SD = 1.8$);	Alcohol consumption was measured with the DDQ; alcohol misuse was	DST participants had significantly greater decreases in acute craving	Relied on self-report measures.	10

	10-day follow-up	with urges using mindfulness strategy during cue exposure procedure	distraction strategy during cue exposure procedure; Control: a 45-min lab session, participants were asked to use any techniques they wanted to cope with urges during cue exposure procedure	50.0% men; 85.0% White, 6.0% Black, 6% Asian, 3% others. There were no significant differences between conditions in baseline demographic or outcome variables. 81% completed follow-up assessment. Attrition did not differ significantly between groups at any assessment.	measured with the AUDIT; craving was measured with the PACS; perceived drinking-refusal self-efficacy was measured with the DRSEQ; mindfulness was measured with the FFMQ; the extent to which participants understood and followed the instructions during the cue exposure procedure was measured with the MC. During the cue exposure procedure, craving for alcohol and craving associated distress were measured with a 7-item, 11-point Likert scale; mood was measured with an 8-item, 11-point Likert scale.	and distress associated with craving during the initial extinction period following the first cue exposure compared to mindfulness and control participants. No significant differences in acute craving and distress associated with craving between mindfulness and control participants during the cue exposure procedure. DST participants reported that the strategy they used during cue exposure procedure was significantly more helpful to cope with alcohol cravings than mindfulness and control participants. All participants had significant decreases in alcohol consumption and craving, and a significant increase in drinking-refusal self-efficacy at follow-up assessment; however, no significant between-group differences were presented.		
Nakamura et al. (2015)	Baseline, mid-tx, & posttx (10-wk)	MBI: 10 wks, 20, 2-hr group sessions in addition to TAU.	TAU: case management, individual, group, and family tx, life skills classes, relapse prevention techniques, behavior management groups, and parenting classes.	38 adult women (MBI: $n = 18$; TAU: $n = 20$) with substance misuse problems in a substance abuse tx facility. Of MBI participants, *Mage* = 30.4 (*SD* = 8.3); 95.0% White. Of TAU participants, *Mage* = 34.7 (*SD* = 10.2); 100% White. There were no significant differences between MBI and TAU groups in baseline demographic or outcomes variables.	Substance misuse was measured with the SIP. Craving for substance was measured with the PACS. Distress caused by traumatic event was measured with the IES-R. Depression was measured with the CES-D. Sleep was measured with the MOS-SS. Mindfulness was measured with the FFMQ. Self-compassion was measured with the SCS. Well-being was measured with the WHO-5.	MBI participants had a significantly greater reduction in craving at posttx compared to TAU participants. Participants in MBI and TAU conditions had significant pre-to-posttx reductions in their severity of alcohol and drug use; however, the reductions were not significantly different between MBI and TAU participants. MBI participants had significant pre-to-posttx decreases in impact of substance abuse-related traumatic events, depressive sxs, and sleeping problems, and significant pre-to-posttx increases in mindfulness, self-compassion, and well-being. Compared to TAU, MBI were significantly more effective in reducing impact of substance abuse-related traumatic events, and sleeping problems, and enhancing participants' mindfulness, self-compassion, and	Small sample size. Relied on self-report measures. No information regarding tx fidelity assessment. No follow-up assessments posttx.	9

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
						well-being at posttx. Completion rates were 70% for MBI group and 94.4% for TAU group.		
Nosen and Woody (2013)	Baseline, 24-hr EMA immediately post-lab session (8 assessments), 4-day follow-up	Mindfulness: psychoeducation on the nature of craving and "urge surfing" technique; practice of "urge surfing" strategy during the smoking cue exposure	Standard: psychoeducation on risk factors and common cessation methods of cigarette smoking. Control: no intervention	176 adults who smoked ≥10 cigarettes/day: *Mage* = 41.5 (*SD* = 13.4); 64.8% men; 77.8% Caucasian. There were no significant differences between conditions in baseline demographic or outcome variables. Only participants who responded to at least 50% of assessments during the EMA ($n = 153$) were included in analyses.	During 24-hr EMA, cigarette smoking was self-reported; craving was measured with the VAS. Craving was measured with the SUQ-B; metacognitive beliefs were measured with the ACQ; negative affect was measured with the DASS; nicotine dependence was measured with the CDS; anxiety was measured with the ASI-R.	Among participants who were fully abstinent from smoking cigarettes, mindfulness participants had significantly lower levels of craving for cigarette smoking at the beginning of the day after the lab session compared to participants who received no intervention; and significantly lower levels of craving after 10-hrs awake compared to participants who received standard psychoeducation and no intervention. The levels of craving among mindfulness participants presents an inverted U-shaped trajectory during the day after the lab session.	Relied on self-report measures.	10
Price et al. (2012)	Baseline, posttx (3-mo post-baseline), 6- & 9-mo follow-up assessments	MABT: 8 weekly, 1.5-hr individual sessions, in addition to TAU.	TAU: 3–5 wk inpatient program, 12–24 wk outpatient program, and 12-wk continuing care.	46 adult women (MABT: $n = 31$; TAU: $n = 15$) with substance misuse problems who were enrolled in an outpatient program. Of MABT participants, *Mage* = 40; 94.0% White. Of TAU participants, *Mage* = 38; 93.0% White. 63% reported sexual or physical trauma. 30% had comorbid eating disorder. There were no significant differences between MABT and TAU groups in baseline demographic or outcome variables.	Substance misuse was measured with the TFBL, urinalysis, and breathalyzer. Reasons for relapse was measured with the RDQ. Distress was measured with the MSC, BSI, and PDS. Eating disorder was measured with the EDEQ. Stress and coping were measured with the PSS, PANAS, DES, and DERS. Body awareness was measured with the SBC and BIS. Mindfulness was measured with the FFMQ.	MABT participants had a significant higher % of abstinent days in the past 90 days at posttx, were significantly more likely to maintain abstinence, and were significantly less likely to have a relapse due to craving or social pressure compared to TAU participants at posttx, 6-, and 9-mo follow-ups. Compared to TAU participants, MABT participants had significantly lower levels of dissociation experiences at posttx, 6-, and 9-mo follow-up assessments; significantly lower levels of eating disorder, depression, and limited strategies at 6- and 9-mo follow-up assessments; significantly lower levels of anxiety and control difficulties at 6-mo follow-up; and significantly lower levels of perceived stress and less frequent physical sxs at 9-mo follow-	Small sample size.	11

						up. Completion rates: 58% of participants completed at least 6 of 8 sessions; 52% completed all 8 sessions.		
Rogojanski et al. (2011)	Baseline, during cue exposure procedure (3 assessments), posttx, 7-day follow-up	Mindfulness: provide mindfulness instructions that teach "urge surfing" strategy during the 20-min smoking cue exposure procedure	Suppression: provided instructions that asked participants to avoid thoughts and feelings related to craving during the 20-min smoking cue exposure procedure	61adults who smoked ≥10 cigarettes/day (mindfulness condition: $n = 31$; suppression condition: $n = 30$): *Mage* = 40.3 (*SD* = 12.4); 59.0% men; 72.0% Caucasian. 80.3% of participants completed follow-up assessments. There were no significant differences between conditions in baseline demographic or outcome variables; no significant differences between participants who completed follow-up assessment and participants who did not complete follow-up assessment in baseline demographic or outcome variables.	Cigarette smoking was measured with the TLFB; nicotine dependence was measured with the FTND; negative affect was measured with the PANAS; self-efficacy was measured with the RSEQ; depression was measured with the DASS; mindfulness was measured with the CAMS-R; craving during the cue exposure procedure was measured with the VAS.	Participants in the mindfulness condition had significantly greater decreases in negative affect and depression, and a marginally significantly greater decrease in nicotine dependence at 7-day follow-up assessment compared to participants in the suppression condition. All participants had a significant increase in self-efficacy to refrain from cigarette smoking and a significant decrease in # of cigarettes smoked in the past week at 7-day follow-up assessment; however, no significant differences were found between the two conditions.	Relied on self-report measures.	9
Ruscio et al. (2015)	Assessment on PDA immediately after each tx session; baseline, 1- & 2-wk post-baseline for assessment in the lab	Brief mindfulness practice implemented on PDA: 5 daily, 20-min guided meditation sessions.	Guided sham-meditation track on PDA: 5 daily, 20-min guided sessions.	44 participants (tx condition: $n = 24$; control condition, $n = 21$) who reported smoking ≥10 cigarettes per day: ages = 18–65; 50% men. There were no significant differences between tx and control groups in demographics, # of cigarettes/day, age when starting daily smoking, # of quit attempts, or intention to quit at baseline. There were no significant differences in baseline demographics or levels of cigarette use between study completers and non-completers.	Cigarette smoking was measured with participants' self-reports, CO levels, and salivary cotinine. Craving for cigarette was measured with a single item on a 7-point Likert-type scale. Affect was measured with the PANAS.	Participants in the tx condition had a significantly greater reduction in # of cigarettes smoked per day over the 2-wk intervention compared to participants in the control condition. Participants in the tx condition had significantly greater reductions in craving immediately after meditation than their craving at other random time during the day. Participants in the tx condition had significantly lower levels of overall negative affect compared to participants in the control condition at 2-wks post-baseline. Completion rate was 72.7% for both tx and control participants.	Small sample size. Study had high attrition rates and ITT analyses were not used. No follow-up assessments posttx.	11
Schuman-Olivier, Hoeppner, Evins, and Brewer (2014) Secondary data analysis of Brewer et al. (2011)	Baseline, posttx (4-wk), & 6-, 12-, & 17-wk follow-up assessments	MTS: 4-wks, twice-a-wk, 1.5-hr group sessions.	FFS: 4-wks, twice a wk, 1.5-hr group sessions.	Same as Brewer et al. (2011).	Cigarette smoking was measured with the TLFB. Mindfulness was measured with the FFMQ.	MTS participants smoked significantly fewer cigarettes per day at posttx and 12-wk follow-up, and had a significantly higher 7-day point prevalence abstinence rate at posttx compared to FFS participants. Non-judgment	No information regarding tx fidelity assessment.	10

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
						moderated the tx effects of smoking cessation at 12-wks follow-up: among participants with high levels of non-judgment, those in the MTS condition smoked significantly fewer cigarettes per day over the follow-up period compared to FFS participants; among participants in the MTS condition, those with high levels of non-judgment smoked significantly fewer cigarettes per day over the follow-up period compared to participants with low levels of non-judgment. MTS participants with high levels of non-judgment had the highest 7-day point prevalence abstinence rate at 17-wk follow-up compared to other participants. MT participants who initiated tx ($n = 33$) attended an average of 6.7 ($SD = 1.7$) of 8 sessions vs. FFS participants who initiated tx ($n = 38$) attended an average of 6.2 ($SD = 2.2$) of 8 sessions.		
Tang et al. (2013)	Baseline & posttx (2-wk)	IBMT: 30-min IBMT practice training every night for 10 consecutive nights.	RT; 30-min RT practice training every night for 10 consecutive nights.	60 college students including 27 cigarette smokers and 33 nonsmokers (IBMT: $n = 33$ including 15 smokers and 11 of them were men; RT: $n = 27$ including 12 smokers and 8 of them were men): *Mage* = 21.5 ($SD = 3.1$). There were no significant differences between tx and control groups in levels of cigarette use and craving at baseline.	Cigarette smoking was measured with exhaled Carbon monoxide and the FTND. Craving was assessed with a 5-point Likert scale. Intention to smoke was measured with a 10-point scale. Brain functions associated with self-control were measured with brain scans.	IBMT participants had a significantly greater reduction in cigarette smoking at posttx compared to RT participants: IBMT participants had a reduction in smoking of 60%, whereas participants in the control condition had no reduction at posttx. IBMT participants had significantly increased activity at ACC/medial PFC and inferior frontal gyrus/ventrolateral PFC, compared to no significant changes among RT participants. Compared to RT participants, IBMT participants had significantly greater decreased activity at posterior cingulate	Small sample size. No information regarding tx fidelity assessment. No follow-up assessments posttx (authors mentioned in Discussion that 5 smokers in IMBT were assessed at 2- and 4-wk follow-ups using CO monitor and FTND, and theses participants maintained reduced smoking).	11

						cortex/precuneus and cerebellum. Results of brain scans suggested that improved self-control capacity in the IBMT group compared to RT group at posttx. Completion rates were 100% for both conditions.		
Tuab et al. (1994)	Baseline 6-, 12-, & 18-mo post-leaving the tx institution	TM: 7 group and individual sessions	BF: 20 daily, 1-hr sessions; NT: 5 daily 30-min sessions, 5 days a wk for 3 wks; RT: Alcohol Anonymous meetings and counseling services	250 adult men (TM: $n = 35$; BF: $n = 24$; NT: $n = 28$; RT: $n = 31$) with alcohol abuse problem were recruited: 80% African American. Of participants in TM group, *Mage* = 44.3. Of participants in BF group, *Mage* = 44.3. Of participants in NT group, *Mage* = 44.4. Of participants in RT group, *Mage* = 44.4.	Alcohol use was measured with social questionnaire including information about amount and pattern of drinking. Psychological state was measured with the PMS.	Participants in TM and BF groups had a significantly greater % of abstinent days compared to participants in RT group at 6-, 12-, and 18-mo follow-up assessments; however, there were no significant differences in % of abstinent days between TM and BF participants. Participants in TM and BF groups combined had a significantly greater % of participants who were completely abstinent at 6-, 12-, and 18-mo follow-ups compared to NT and RT participants combined. Participants in TM group had significant improvements on psychological states when they were discharged from the tx institution compared to baseline assessment. Completion rates were 100% for all tx conditions.	Relied on self-report measures. No information regarding tx fidelity assessment. Study had high attrition rates at follow-up assessments and ITT analyses were not used.	14
Ussher et al. (2009)	Pre-lab session, post-lab session, 5-min, 10-min, & 30-min after lab session; pre-session in normal environment, post-session in normal environment, 5-min & 30-min post-session in normal environment	BS: 10-min guided mindful body scan	IE: 10-min guided isometric exercise and muscle relaxation; control: 10-min audio-recording of a natural history text	48 adults who smoked ≥10 cigarettes/day (BS: $n = 18$; IE: $n = 14$; control: $n = 16$). Of BS participants, *Mage* = 29.7 (*SD* = 10.1); 83.3% men. Of IE participants, *Mage* = 28.4 (*SD* = 8.9); 42.9% men. Of control participants, *Mage* = 25.2 (*SD* = 5.2); 72.5% men. There were no significant differences between conditions in baseline demographic or outcome variables.	Nicotine dependence was measured with the FTND; mindfulness was measured with the MAAS; withdrawal symptoms and desire to smoke cigarette were assessed with the adapted MPSS.	During the lab session, BS and IE participants had significantly lower levels of desire to smoke immediately at post-session, and at 5-min, 10-min, and 30-min post-session compared to control participants. BS and IE participants had significantly lower levels of withdrawal at post-lab session compared to control participants. No significant differences between BS and IE participants in levels of desire to smoke and withdrawal at post-lab session. During the session in normal environment, BS and IE participants had significantly lower levels of desire to smoke	Relied on self-report measures.	9

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
						immediately post-session, and at 5-min post-session compared to control participants. BS and IE participants had significantly lower levels of withdrawal at post-session compared to control participants. No significant differences between BS and IE participants in levels of desire to smoke and withdrawal at post-session in normal environment.		
Vinci et al. (2014)	Baseline, post-intervention, post-affect induction procedure	Mindfulness: 10-min guided meditation instruction	Relaxation: 10-min guided passive progressive muscle relaxation; control: no intervention	207 college students who were at-risk drinkers (Mindfulness: $n = 67$; Relaxation: $n = 74$; control: $n = 66$): *Mage* = 20.1 ($SD = 1.9$); 76.3% women; 85.5% Caucasian, 6.3% African American, 3.5% Hispanic. There were no significant differences between conditions in baseline demographic or outcome variables.	Urge to drink was measured with a single item rated on a 10-point scale; tension/relaxation was measured with a single item rated on a 10-point scale; affect was measured with the PANAS; mindfulness was measured with the FFMQ and TMS; willingness to continue watching negative affect images was measured with a single item rated on a 10-point scale.	Both mindfulness and relaxation interventions significantly reduced negative affect to a greater level at post-intervention compared to control condition. However, all participants who were exposed under negative affect induction procedure had a significant *increase* in their negative affect at post-affect induction procedure. Both mindfulness and relaxation interventions significantly *increased* urge to drink at post-affect induction procedure. Mindfulness participants had a significantly greater increase in their mindfulness (i.e., curiosity and decentering) than relaxation and control participants at post-intervention. Both mindfulness and relaxation intervention participants had a significantly greater increase in relaxation compared to control participants at post-intervention.	Relied on self-report measures.	9
Witkiewitz and Bowen (2010) Secondary data analysis of Bowen et al. (2009)	Baseline, posttx (8-wk), 2- & 4-mo follow-up assessments.	MBRP as an adjunct to TAU: 8 weekly, 2-hr group sessions.	TAU: standard outpatient aftercare groups designed to maintain abstinence through a 12-step process-oriented format: 1.5-h group sessions, 1–2 times weekly.	Same as Bowen et al. (2009)	Substance use was measured with the TLFB. Craving was measured with the PACS. Depression was measured with the BDI.	61.4% of MBRP participants and 60.9% of TAU participants were abstinent during the study. Participation in MBRP was significantly negatively associated with craving at 2-mo follow-up. Tx	Relied on self-report measures.	9

						condition moderated the mediating effects of craving. Craving partially mediated the relation between depressive sxs and substance use for TAU participants, but not for MBRP participants. MBRP participants were less likely to experience craving in response to depression, and the attenuated reactivity to depressed mood and reduced craving also predicted fewer days of substance use at 4-mo follow-up. Craving at 2-mo follow-up partially mediated the relationship between depressive sxs at posttx and substance use at 4-mo follow-up among TAU participants, not among MBRP participants.		
Witkiewitz, Bowen et al. (2013) Secondary data analysis of Bowen et al. (2009)	Baseline, posttx (8-wk), 2- & 4-mo follow-up assessments	MBRP as an adjunct to standard outpatient aftercare: 8 weekly, 2-hr group sessions.	TAU: standard outpatient aftercare groups designed to maintain abstinence through a 12-step process-oriented format: 1.5-h group sessions, 1–2 times weekly.	Same as Bowen et al. (2009).	Craving was measured with the PACS. Mindfulness was measured with the FFMQ. Acceptance of negative experiences was measured with the AAQ.	MBRP participants had a significantly greater reduction in craving at 4-mo follow-up compared to TAU participants. The tx gain on craving decreased for MBRP participants posttx, whereas TAU participants had slight increases in craving at posttx. A latent factor representing acceptance, awareness, and nonjudgment mediated the effects of MBRP participation on craving at posttx.	Relied on self-report measures.	10
Witkiewitz, Greenfield et al. (2013) Secondary data analysis of Witkiewitz, Warner et al. (2014)	Baseline, mid-tx, posttx (8-wk), & 15-wk follow-up	Modified MBRP: 16, twice-a-wk, 50-min group sessions for 8 wks.	Relapse prevention tx (RP): matched MBRP in time, format, and group size.	70 women who had complete data on race/ethnicity in Witkiewitz, Bowen et al. (2014). There were no significant differences in demographic variables between White and Non-white participants at baseline. There were no significant differences in	Substance misuse was measured with the TLFB and ASI.	MBRP participants had significantly fewer drug use days over the 15-wk follow-up period compared to RP participants. Race/ethnicity moderated tx effects on drug use: Racial minority women in MBRP reported the lowest # of days of drug use at 15-wk follow-up compared to all	Relied on self-report measures. No information regarding tx fidelity assessment.	9

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Table 3 (*continued*)

Study	Data collection time points	Tx condition	Control condition	Sample	Outcome measures	Results	Limitations	MQRS score
				baseline demographic and outcome variables between study completers and non-completers.		other groups, while racial minority women in RP reported the highest # of days of drug use at 15-wk follow-up compared to other groups. MBRP participants had significantly lower levels of ASI-assessed addiction-related problems at 15-wk follow-up compared to RP participants. Race/ethnicity moderated the addiction-related problems: Racial minority women in MBRP had the lowest levels of addiction-related problems and medical problems at 15-wk follow-up compared to all other groups, while racial minority women in RP had the highest levels of addiction-related problems and medical problems at 15-wk follow-up.		
Witkiewitz, Warner et al. (2014)	Baseline, mid-tx, posttx (8-wk), & 15-wk follow-up	Modified MBRP: 16, twice-a-wk, 50-min group sessions for 8 wks.	Relapse prevention program (RP): matched MBRP in time, format, and group size.	105 women (MBRP: $n = 55$; RP: $n = 50$) who were referred by criminal-justice system to a residential addiction tx program. Of MBRP participants, *Mage* = 35.8 (*SD* = 9.5); 34.5% White, 12.7% African American, 7.3% Native American, and 40% unknown. Of RP participants, *Mage* = 32.4 (*SD* = 8.9); 51.0% White, 10.2% African American, 10.2% Native American, and 26.5% unknown. There were no significant differences between MBRP and RP groups in baseline demographics or outcome variables. Attrition was not significantly associated with any baseline demographic or substance use variables.	Substance misuse was measured with the TLFB, ASI, and SIP.	MBRP participants had significantly (96%) fewer drug use days over the 15-wk follow-up period compared to RP participants. MBRP participants had significantly lower (39%) levels of drug use-related consequences over the 15-wk follow-up period compared to RP participants. MBRP participants had significantly lower levels of ASI-assessed addiction-related legal and medical problems at the 15-wk follow-up compared to participants in the RP condition. Completion rates were 63.6% for MBRP group and 72% for RP group.	Relied on self-report measures. No information regarding tx fidelity assessment.	9

conditions. The sample sizes of the 5 studies varied from 46 to 135 ($M = 93.4$, $SD = 40.9$), and the number of participants who completed posttreatment/follow-up assessment ranged from 35 to 80 ($M = 59.9$, $SD = 42.8$). All 5 studies included middle-aged adults ($M = 42.1$, $SD = 4.3$). One study examined effects of mindfulness treatment among only women (Price et al., 2012); one study focused only on men (Garland et al., 2016), and the rest of the studies used samples of women and men. Three studies used the Perceived Stress Scale to measure stress and had an average effect size of −0.46 (95% CI [−0.81, −0.11]). One study assessed participants' stress using the PTSD CheckList-Civilian Version, and had an effect size of −3.77 (95% CI [−4.38, −3.15]). One study measured participants' stress using the Calgary Symptoms of Stress Scale and had an effect size of −0.41 (95% CI [−0.60, −0.22]). Overall, the synthesized effect size of mindfulness treatment on reducing stress at posttreatment relative to comparison conditions was statistically significant and large ($d = -1.12$, 95% CI [−2.24, −0.01]).

Fig. 6 presents the pooled Cohen's *d*s and associated 95% CIs of 8 RCTs that provided means and standard deviations for the measure of mindfulness at posttreatment, and sample sizes per treatment and comparison conditions. The sample sizes of the 8 studies varied from 38 to 198 ($M = 108.9$, $SD = 59.0$), and the number of participants who completed posttreatment/follow-up assessment ranged from 31 to 96 ($M = 61.0$, $SD = 24.5$). Ages of participants ranged between 33 and 48 ($M = 40.7$, $SD = 4.6$). Two studies examined effects of mindfulness treatment among only women (Nakamura et al., 2015; Price et al., 2012); one study focused only on men (Garland et al., 2016), and the remainder used samples of women and men. Mindfulness at posttreatment across the 8 RCTs was measured with the Five Facet Mindfulness Questionnaire. Results revealed a medium effect size ($d = 0.61$, 95% CI [−0.02, 1.24]) of mindfulness treatment on enhancing mindfulness at posttreatment, relative to comparison conditions. The effect size approaches the significance level at 0.05 ($p = 0.059$). Table 4 presents synthesized effect sizes of mindfulness treatment on each outcome variable.

Results of the meta-analyses showed large between-study heterogeneity across studies that were included in the meta-analyses of craving, stress, and mindfulness outcomes ($I^2 > 0.85$). To explore between-study heterogeneity, subgroup meta-analyses were conducted on each outcome variable (i.e., substance misuse, abstinence, craving, stress, and mindfulness) by measurement instruments of outcome variable, type of mindfulness treatment, type of substance misuse, and gender because studies were varied largely on these factors according to the systematic review. Table 4 presents detailed results of the subgroup meta-analyses. Results of the subgroup meta-analyses suggested that studies of MORE and brief mindfulness intervention in a laboratory setting had larger effects on reducing craving for substance use at posttreatment/post-cue-exposure induction compared to other types of mindfulness treatment. Similarly, studies of MORE had larger effects on reducing stress and increasing mindfulness at posttreatment compared to other types of mindfulness treatment. In addition, mindfulness treatment had larger effects on reducing craving and stress, and increasing mindfulness at posttreatment among men than other samples. Finally, mindfulness treatment had larger effects on reducing craving and stress, and increasing mindfulness at posttreatment for polysubstance-misusing participants than participants misusing a specific category of substance. Random effects meta-regression analyses were performed to examine whether the effect of mindfulness treatment on each outcome variable was affected by study characteristics, including participants' age and gender, sample size of the study, type of mindfulness treatment, type of substance misused, type of control condition (TAU vs. alternative treatments), treatment dosage (i.e., number of hours of the mindfulness treatment), and study methodological quality (i.e., MQRS scores). Results showed that gender was significantly associated with the effects of mindfulness treatment on reducing craving ($\beta = -1.56$, $SE = 0.31$, $p = 0.001$) and stress ($\beta = -3.33$, $SE = 0.34$, $p = 0.002$), and increasing mindfulness ($\beta = 2.68$, $SE = 0.45$, $p = 0.001$). Specifically, mindfulness treatment had significantly larger effects on reducing carving and stress, and increasing mindfulness among men compared to other samples.

The potential effect of publication bias was assessed by analyzing funnel plot asymmetries using Egger's test (Harbord, Harris, & Sterne, 2009). Funnel plots (Figs. 1–5 in Appendix) were generated for all meta-analyses outcomes. Funnel plots of substance misuse, craving, and mindfulness did not show major asymmetries, and Egger's tests ($p < 0.05$) provided weak evidence for the presence of publication bias. Funnel plots of point-prevalence abstinence and stress showed some asymmetries. The asymmetries of the funnel plots suggested that studies with small sample sizes showing nonsignificant effect of mindfulness treatment were missing from the meta-analyses, and that the synthesized effect sizes of mindfulness treatment on abstinence and stress might be overestimated. The asymmetries of the funnel plots may also be attributable to the large between-study heterogeneity. However, Egger's tests ($p < 0.05$) did not provide strong evidence for the presence of publication bias of funnel plots for abstinence and stress. Overall, funnel plots and Egger's tests together suggested that results of meta-analyses were not likely to be affected by publication bias. However, the funnel plots need to be interpreted cautiously due to small sample sizes, particularly for funnel plots for abstinence ($n = 4$) and stress ($n = 5$).

4. Discussion

This systematic review and meta-analysis examined 42 studies published by December 2015. The number and variety of studies and the use of meta-analysis allowed us to evaluate the therapeutic benefits of

Notes to Table 3:
Acronyms/abbreviations: AAQ = Acceptance and Action Questionnaire; ACQ = Appraisal of Craving Questionnaire; ACS = Attentional Control Scale; ASI = Addiction Severity Index; ASI-R = Anxiety Sensitivity Index-Revised; ATD = Attitude Toward Drugs; AUQ = Alcohol Urge Questionnaire; BDI = Beck Depression Inventory; BF = (EMG) Biofeedback; BIS = Body Investment Scale; BPI = Brief Pain Inventory; BS = Body Scan; BSI = Brief Symptom Inventory; CAMS-R = Cognitive Affective Mindfulness Scale-Revised; CDS = Cigarette Dependence Scale; CES-D = Center for Epidemiologic Studies-Depression; CERQ = Cognitive Emotion Regulation Questionnaire; COMM = Current Opioid Misuse Measure; C-SOSI = Calgary Sxs of Stress Inventory; CSQ = Coping Strategies Questionnaire; DASES = Drug Avoidance Self-Efficacy Scale; DASS = Depression Anxiety and Stress Scale; DDQ = Daily Drinking Questionnaire; DES = Differential Emotion Scale; DES = Dissociation Experiences Scale; DERS = Difficulty in Emotion Regulation Scale; DMS = Decision-making Skills; DRSEQ = Drinking Refusal Self-Efficacy Questionnaire; DTS = Distress Tolerance Scale; DUDIT = Drug Use Identification Disorders Test-Extended; EDEQ = Eating Disorder Examination Questionnaire; EMA = ecological momentary assessment; FFS = Freedom from Smoking program; FTND = Fagerstrom Test for Nicotine Dependence; HR = heart rate; hr = hour; IARIS = Impaired Alcohol Response Inhibition Scale; IBMT = Integrative Body-Mind Training; IE = Isometric Exercise; IES-R = Impact of Event Scale-Revised; ILS = Interactive Learning Smokers program; IOP = Intensive Outpatient Program; ITT = intent-to-treat; LAP-R = Life Attitude Profile-Revised; LOT = Life Orientation Test; MAAS = Mindful Attention Awareness Scale; MABT = Mindful Awareness in Body-Oriented Therapy; MBI = Mind-Body Intervention; MBRP = Mindfulness-Based Relapse Prevention; MC = Manipulation Checks; MI = Motivational interviewing; min = minute; MJ = Marijuana; MM = Mindfulness Meditation; mo = month; MORE = Mindfulness-Oriented Recovery Enhancement; MOS-SS = Medical Outcomes-Study Sleep Scale; MPSS = Mood and Physical Symptoms Scale; MQRS = Methodological Quality Rating Scale; MSC = Medical Sxs Checklist; MT = Mindfulness training; MTS = Mindfulness Training for Smoking Cessation; NT = Neurotherapy; PACS = Penn Alcohol Craving Scale; PANAS = Positive and Negative Affect Schedule; PCL-C = PTSD Checklist-Civilian Version; PDA = Personal Digital Assistant; PDS = Post-Traumatic Stress Disorder Scale; PDSQ-GAD = Psychiatric Diagnostic Screening Questionnaire-Generalized Anxiety Disorder; PLCS = Prison Locus of Control Scale; PMS = Profile of Mood States; PSS = Perceived Stress Scale; QL = (Tobacco) Quit Line; RAPI = Rutgers Alcohol Problem Index; RDQ = Reasons for Drinking Questionnaire; RP = relapse prevention; RSEQ = Relapse Situation Efficacy Questionnaire; RSES = Rosenberg Self-Esteem Scale; RT = Relaxation Training; RT = Routine Therapy; SAS = Spirituality Assessment Scale; SBC = Scale of Body Connection; SCS = Self-Compassion Scale; SF-36 = SF-36 Health Survey Questionnaire; SG = Support group; SIP = Short Inventory of Problems; SQHQ = Smoking and Quitting History questionnaire; SUQ-B = Smoking Urges Questionnaire-Brief; sxs = symptoms; TAU = Treatment as usual; TC = Therapeutic Community; TLFB = Timeline Followback; TM = Transcendental Meditation; TMC = Toronto Mindfulness Scale; tx = treatment; VAS = Visual Analog Scale; WBSI = White Bear Suppression Inventory; WHO-5 = World Health Organization Well-Being Index; wk = week; yr = year; # = number; % = percent/percentage.

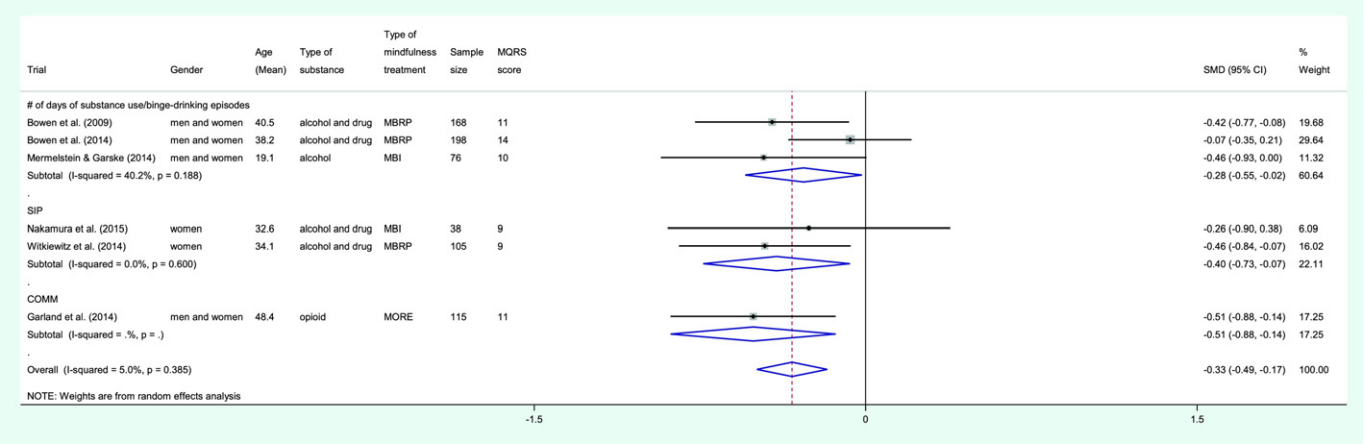

Fig. 2. Forest plot displaying random effects meta-analysis for the effect of mindfulness treatment on substance use at posttreatment relative to a comparison condition by measurement instruments. Note: COMM = Current Opioid Misuse Measure; MBI = other type of mindfulness-based intervention; MBRP = Mindfulness-Based Relapse Prevention; MORE = Mindfulness-Oriented Recovery Enhancement; MQRS = Methodological Quality Rating Scale; SIP = Short Inventory or Problem Drug/Alcohol Use.

mindfulness treatment in diverse substance misusing client populations. The promising effects of mindfulness treatment are supported by the consistency of positive findings across studies using different designs and evaluating different mindfulness treatment modalities in diverse populations with a variety of substance misuse problems. Further, results of meta-analyses revealed small-to-large effects of mindfulness treatment on reducing substance misuse, craving for substance misuse, and stress compared to alternative treatments (e.g., TAU, CBT, and support group).

A majority of studies in this review reported that mindfulness treatment was effective in reducing substance misuse and related medical, psychological, relationship, and legal problems, and in increasing abstinence at posttreatment and follow-ups ranging from 2-weeks to 12-months posttreatment. RCTs suggested that MBRP combined with TAU outperformed TAU alone (e.g., Alterman et al., 2004; Bowen et al., 2009, 2014) and relapse prevention treatment (e.g., Bowen et al., 2014; Witkiewitz, Warner et al., 2014) in reducing substance misuse at posttreatment and follow-ups. However, the treatment gains for MBRP participants diminished as time passed the initial treatment period in two studies (Bowen et al., 2009; Hsu et al., 2013). Mindfulness treatment for cigarette smoking based on MBSR was superior to alternative treatments adapted from the American Lung Association's Freedom from Smoking program (American Lung Association, 2010) and the Mayo Clinic's Nicotine Dependence Center program (Boardman, Catley, Mayo, & Ahluwalia, 2005), and Tobacco Quit Line in enhancing abstinence at follow-up periods ranging from 2- to 24-weeks post-quit day (e.g., Brewer et al., 2011; Davis et al., 2013; Davis, Goldberg et al., 2014). Further, MORE was significantly more effective than a support group based on the Matrix model treatment and CBT (e.g., Garland et al., 2010, 2016; Garland, Manusov et al., 2014) in populations with alcohol and prescription opioid misuse. In addition, quasi-experimental studies suggested that VM courses plus TAU outperformed TAU alone (e.g., Bowen et al., 2006) in substance misusing populations involved in the criminal justice system; and mindfulness treatment combined with therapeutic community usual care outperformed TAU (e.g., Marcus et al., 2009) in people enrolled at a therapeutic community for substance misuse problems. These positive findings were supported by meta-analyses of RCTs that revealed a small, though significant, effect of mindfulness treatment on severity of substance misuse at posttreatment compared to TAU or alternative treatments.

In contrast, a few RCTs in this review did not support a greater effect of mindfulness treatment in decreasing alcohol and cocaine use at posttreatment compared to a group-based cognitive-behavioral therapy (Brewer et al., 2009) and a running group (Murphy et al., 1986), or in

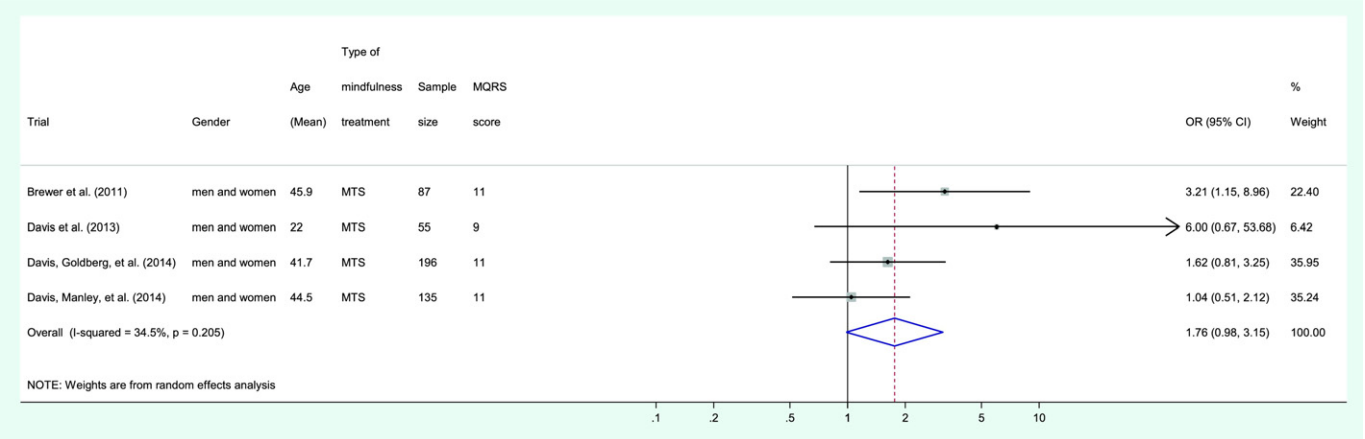

Fig. 3. Forest plot displaying random effects meta-analysis for the effect of mindfulness treatment on point-prevalence rates of abstinence from cigarette smoking at posttreatment relative to a comparison condition. Note: MQRS = Methodological Quality Rating Scale; MTS = Mindfulness Training for Smoking Cessation.

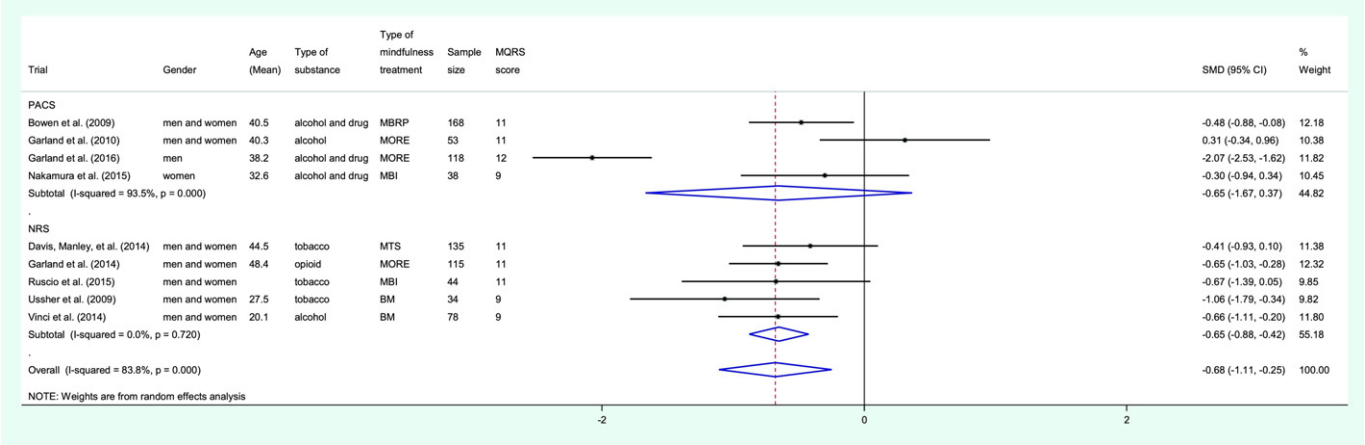

Fig. 4. Forest plot displaying random effects meta-analysis for the effect of mindfulness treatment on craving at posttreatment relative to a comparison condition by measurement instruments. Note: BM = brief mindfulness training in a lab session; MBRP = Mindfulness-Based Relapse Prevention; MORE = Mindfulness-Oriented Recovery Enhancement; MQRS = Methodological Quality Rating Scale; MTS = Mindfulness Training for Smoking Cessation; NRS = Numeric Rating Scale; PACS = Penn Alcohol/Drug Craving Scale.

increasing abstinence from cigarette smoking and alcohol use at follow-ups ranged from 1-month to 18-months compared to a Freedom from Smoking Program that was matched to the mindfulness treatment in terms of group structure and dosage (Davis, Manley et al., 2014) and an EMG biofeedback intervention (Tuab et al., 1994). Studies showing that mindfulness treatment was not superior in treating substance misuse shared common characteristics, including small sample sizes and high attrition rates that could lead to low statistical power to detect significant results. Further, these studies compared mindfulness treatment to alternative treatments that involved active intervention components (e.g., CBT and EMG biofeedback). In fact, participants who were assigned to CBT received more treatment sessions than participants assigned to mindfulness treatment in Brewer et al. (2009). The imbalanced treatment dosage might also have contributed to the finding that mindfulness treatment was less effective in treating substance misuse compared to CBT.

Further, this review indicated that mindfulness treatment could alter underlying risk mechanisms for addictive behaviors and relapse, particularly craving for substance use and stress-induced substance misuse behaviors. These findings are potentially important given that craving and substance use as a palliative coping response for stress are established as predictors of relapse (Hartz, Frederick-Osborne, & Galloway, 2001; Tiffany & Conklin, 2000). Mindfulness treatment may reduce craving by facilitating people's metacognitive awareness of their craving experience and the presence of urges, teaching people to disengage their attention from substance-related urges and distressing experiences that could trigger substance use and to reorient attention to health-promoting stimuli (Garland, 2014). Studies suggest that mindfulness training could reduce craving through cultivating awareness and acceptance of, and nonreactivity to, craving without engaging in addictive responses (Garland, Manusov et al., 2014; Witkiewitz, Bowen et al., 2013). This review also found that mindfulness treatment was effective in reducing stress (e.g., Davis et al., 2013; Garland et al., 2016), and might have reduced stress-induced substance misuse. Greater effects of mindfulness treatment compared to TAU or alternative treatments with regard to reducing craving and stress were also supported by meta-analytic findings. Results of meta-analyses revealed significant, moderate-to-large effects of mindfulness treatment on craving and stress reduction at posttreatment relative to a comparison condition.

Some studies in this review examined changes in neuropsychological and psychophysiological functions associated with substance misuse as a result of mindfulness treatment (Alfonso et al., 2011; Brewer et al., 2009;

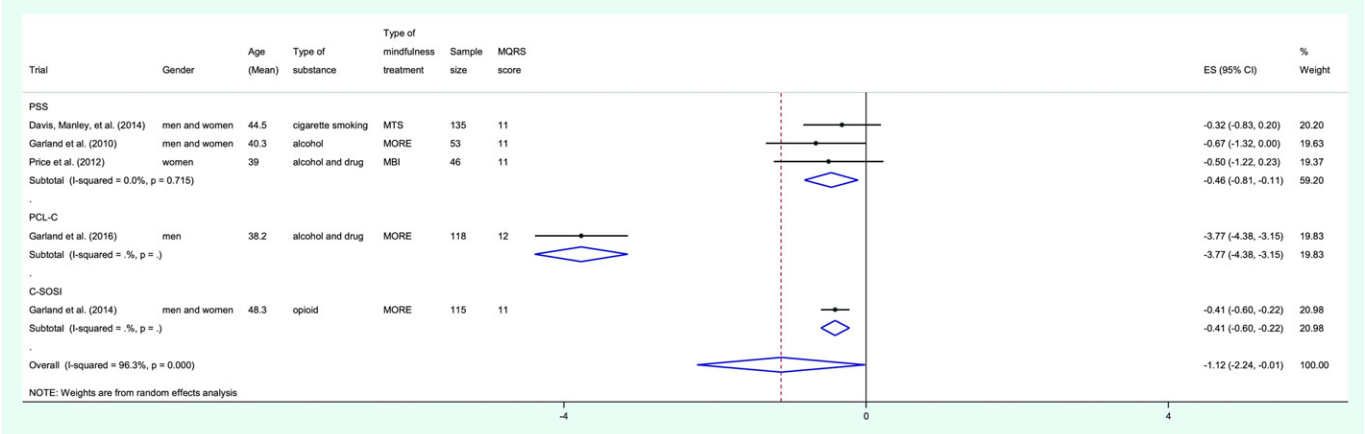

Fig. 5. Forest plot displaying random effects meta-analysis for the effect of mindfulness treatment on stress at posttreatment relative to a comparison condition by measurement instruments. Note: C-SOSI = Calgary Symptoms of Stress Inventory; MBI = other type of mindfulness-based intervention; MORE = Mindfulness-Oriented Recovery Enhancement; MTS = Mindfulness Training for Smoking Cessation; PCL-C = PTSD Checklist-Civilian Version; PSS = Perceived Stress Scale.

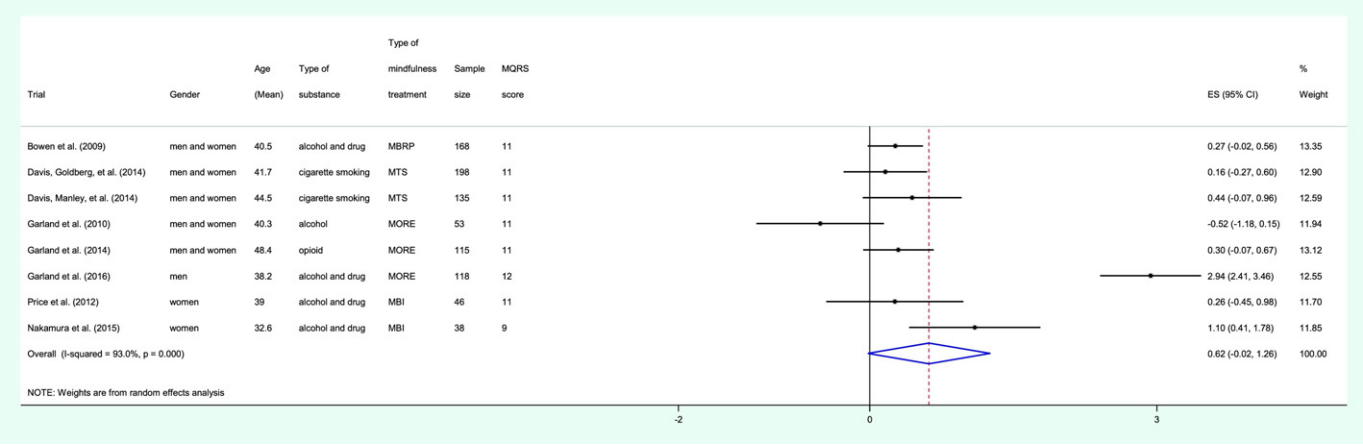

Fig. 6. Forest plot displaying random effects meta-analysis for the effect of mindfulness treatment on mindfulness at posttreatment relative to a comparison condition. Note: MBI = other type of mindfulness-based intervention; MBRP = Mindfulness-Based Relapse Prevention; MORE = Mindfulness-Oriented Recovery Enhancement; MTS = Mindfulness Training for Smoking Cessation. All studies used Five Facet Mindfulness Questionnaire to assess mindfulness.

Garland et al., 2010, 2014b; Tang et al., 2013). Findings suggested that mindfulness treatment was associated with greater decreases in substance-related cue reactivity (Garland et al., 2014b), attentional-bias toward substance-related cues (Garland et al., 2010), executive and decision-making deficits in people with substance misuse problems (Alfonso et al., 2011), enhancement of brain functions associated with self-control capacity in cigarette smokers (Tang et al., 2013), and enhancements in physiological recovery from stress and substance-related cues (Brewer et al., 2011; Garland et al., 2014b) compared to alternative treatments. Neurobiological findings suggest that mindfulness treatment could modify brain and psychophysiological functions associated with addiction, and thereby reduce risk of relapse to substance misuse.

Since treatment adherence appears to be a critical issue in populations with substance misuse problems, this review specifically examined treatment completion rates across studies. Findings suggested moderate-to-high treatment adherence (i.e., 40%–100%) for mindfulness treatment in samples with a variety of substance misuse problems. Treatment completion rates for mindfulness treatment across studies were not substantially different from TAU or alternative treatments (e.g., CBT and social support group). Moreover, the amount of mindfulness practice between sessions/at home was significantly positively associated with abstinence maintenance, and negatively associated with amount of substance use and likelihood of relapse (e.g., Brewer et al., 2011; de Dios et al., 2012).

Although a majority of studies in this review reported positive findings regarding effects of mindfulness treatment, several methodological limitations were noted. Many studies had small samples and limited statistical power to detect treatment effects. Further, methodological limitations such as nonprobability sampling, reliance on self-report measures, a lack of randomization to treatment conditions, and failure to use intent-to-treat analyses might have led to biased findings and limited generalizability. Although a few studies followed treatment participants for 12-month posttreatment, a majority of studies only assessed treatment outcomes at posttreatment or 3-month posttreatment. Importantly, although many mindfulness interventions were manualized, many did not report treatment fidelity assessment. Finally, less than half of the RCTs and only one quasi-experimental study in this review provided detailed statistical information (e.g., means and standard deviations) on a specific outcome variable (e.g., substance misuse, abstinence, craving, stress, and mindfulness) measured at posttreatment or follow-ups. Lacking detailed statistical results in published clinical trials limits the possibility for researchers to obtain accurate synthesized effects of an intervention from meta-analysis.

Future research would benefit by addressing these methodological concerns. To establish empirical evidence for mindfulness treatment as an intervention for substance misuse problems, larger and more rigorous RCTs are needed to evaluate the efficacy and effectiveness of manualized mindfulness treatments in diverse populations and varied clinical settings. Detailed information is needed in future intervention studies regarding descriptions of treatment protocols/manuals, extent of adaptation/deviation from original treatment protocols/manuals, fidelity assessment, treatment adherence, randomization protocols, statistical analyses that could minimize biases due to missing data, and detailed statistical information (e.g., means and standard deviations) of outcome variables at posttreatment that could be used for meta-analysis. Longer-term follow-up assessments and the additional objective measures of substance use could strengthen study findings.

Moreover, many researchers have published conceptual models that elucidate therapeutic mechanisms of mindfulness treatment for substance misuse problems (Garland et al., 2014a; Marlatt & Chawla, 2007); however, few studies have tested treatment models using empirical data (e.g., Garland, Manusov et al., 2014; Witkiewitz & Bowen, 2010; Witkiewitz, Bowen et al., 2013). Future studies are needed to assess potential mechanisms of mindfulness treatment using longitudinal and experimental designs.

This review and meta-analysis has limitations. This review was limited to studies published in English-language and studies published in peer-reviewed journals. Focusing only on published studies could introduce publication bias in that studies included in this review might have overrepresented statistically significant effects of mindfulness treatment. Further, only a small proportion of studies were included in the meta-analyses because many studies did not provide adequate statistical information for effect size synthesizing. The small sample size for the meta-analyses might have made estimates of effect size less reflective of the true effects of mindfulness treatment. Additionally, the small sample size for the meta-analyses might have decreased the statistical power of the meta-regression and prevented the detection of effects of study characteristics on effect size of mindfulness treatment. Finally, synthesizing findings across studies that evaluated different modalities (e.g., group-based vs. individual therapy) and types of mindfulness treatment (e.g., MTS and MBRP) could have introduced bias to meta-analytic results due to the heterogeneity of included studies, although the heterogeneity was controlled for using a random effects model and explored through subgroup meta-analyses and meta-regression. Despite the limitations, this review suggests that mindfulness treatment is a promising intervention for substance misuse and relapse prevention.

Table 4
Synthesized effect sizes of mindfulness treatment on substance use, abstinence, craving, stress, and mindfulness.

Outcome variable	N	Cohen's *d*/OR	95% CI	z	*p*	I^2
Substance use	**6**	**−0.33**	**[−0.49, −0.17]**	**4.10**	**0.000**	**5.0%**
Measures						
# of days of substance use/binge-drinking episodes	3	−0.28	[−0.55, −0.02]	2.08	0.037	40.2%
Current Opioid Misuse Measure	1	−0.51	[−0.88, −0.14]	2.67	0.008	
Short Inventory of Problem Alcohol/Drug Use	2	−0.40	[−0.74, −0.07]	2.38	0.017	0%
Type of Mindfulness Treatment						
MBRP	3	−0.29	[−0.55, −0.03]	2.20	0.028	44.6%
MORE	1	−0.51	[−0.88, −0.14]	2.67	0.008	
Other types of mindfulness treatment	2	−0.39	[−0.77, −0.02]	2.04	0.042	0%
Gender						
Women and men	4	−0.33	[−0.56, −0.11]	2.91	0.004	36.8%
Women	2	−0.40	[−0.74, −0.07]	2.38	0.017	0%
Substance						
Alcohol and drugs	4	−0.28	[−0.48, −0.07]	2.65	0.008	16.9%
Alcohol	1	−0.46	[−0.93, −0.003]	1.95	0.052	
Opioid prescription drugs	1	−0.51	[−0.88, −0.14]	2.67	0.008	
Abstinence from cigarette smoking[a]	**4**	**1.76**	**[0.99, 0.3.15]**	**1.91**	**0.056**	**34.5%**
Craving	**9**	**−0.68**	**[−1.11, −0.25]**	**3.10**	**0.002**	**83.8%**
Measures						
Penn Alcohol/Drug Craving Scale	4	−0.65	[−1.67, 0.37]	1.25	0.21	93.5%
Numeric rating scale	5	−0.65	[−0.88, −0.42]	5.62	0.000	0%
Type of mindfulness treatment						
MBRP	1	−0.50	[−0.88, −0.08]	2.35	0.019	
MORE	3	−0.82	[−2.07, 0.42]	1.30	0.195	95.0%
MTS	2	−0.41	[−0.93, 0.11]	1.90	0.057	
Other types of mindfulness treatment	1	−0.47	[−0.94, 0.01]	1.56	0.118	0%
Brief mindfulness intervention in a lab setting	2	−0.77	[−1.16, −0.39]	3.93	0.000	0%
Gender						
Women and men	7	−0.52	[−0.77, −0.27]	4.12	0.000	38.0%
Women	1	−0.30	[−0.94, 0.34]	0.92	0.359	
Men	1	−2.07	[−2.53, −1.62]	8.94	0.000	
Substance						
Alcohol and drugs	3	−0.96	[−2.09. 0.17]	1.66	0.097	93.9%
Alcohol	2	−0.20	[−1.15, 0.07]	0.42	0.676	82.5%
Tobacco smoking	3	−0.65	[−1.02, −0.27]	3.41	0.001	3.9%
Opioid prescription drugs	1	−0.65	[−1.03, −0.28]	3.40	0.001	
Stress	**4**	**−1.12**	**[−2.24, −0.01]**	**1.98**	**0.048**	**96.3%**
Measures						
Perceived Stress Scale	3	−0.46	[−0.81, −0.11]	2.54	0.011	0%
PTSD CheckList – Civilian Version	1	−3.77	[−4.39, −3.16]	12.01	0.000	
Calgary Sxs of Stress	1	−0.41	[−0.60, −0.22]	4.29	0.000	
Type of mindfulness treatment						
MORE	3	−1.61	[−3.61, 0.40]	1.57	0.117	98.1%
MTS	1	−0.32	[−0.83, 0.20]	1.21	0.225	
Other types of mindfulness treatment	1	−0.50	[−1.22, 0.23]	1.34	0.180	
Gender						
Women and men	3	−0.42	[−0.59, −0.25]	4.80	0.000	0%
Women	1	−0.50	[−1.22, 0.23]	1.34	0.180	
Men	1	−3.78	[−4.39, −3.16]	12.01	0.000	
Substance						
Alcohol and drugs	2	−2.14	[−5.35, 1.07]	1.31	0.191	97.8%
Alcohol	1	−0.67	[−1.33, −0.002]	1.97	0.049	
Tobacco smoking	1	−0.32	[−0.83, 0.20]	1.21	0.225	
Opioid prescription drugs	1	−0.41	[−0.60, −0.22]	4.29	0.000	
Mindfulness[b]	**8**	**0.62**	**[−0.02, 1.26]**	**1.90**	**0.057**	**93.0%**
Type of mindfulness treatment						
MBRP	1	0.27	[−0.02, 0.56]	1.81	0.700	
MORE	3	0.28	[−0.05, 0.61]	0.93	0.351	97.6%
MTS	2	0.91	[−1.00, 2.82]	1.65	0.100	0%
Other types of mindfulness treatment	2	0.69	[−0.13, 1.51]	1.65	0.099	63.2%
Gender						
Women and men	5	0.20	[−0.02, 0.43]	1.75	0.079	30.8%
Women	2	0.69	[−0.13, 1.51]	1.65	0.099	63.2%
Men	1	2.94	[2.41, 3.47]	10.89	0.000	
Substance						
Alcohol and drugs	4	1.14	[−0.19, 2.47]	1.69	0.092	96.2%
Alcohol	1	−0.52	[−0.18, 0.15]	1.52	0.100	
Tobacco smoking	2	0.28	[−0.05, 0.61]	1.65	0.128	0%
Opioid prescription drugs	1	0.30	[−0.07, 0.67]	1.59	0.112	

N: # of studies that were included in the meta-analysis.
I^2: % of variation attributable to heterogeneity. A value of 0% indicates no observed heterogeneity, and larger % indicates increasing heterogeneity.
MBRP = Mindfulness-Based Relapse Prevention; MORE = Mindfulness-Oriented Recovery Enhancement; MTS = Mindfulness Training for Smoking Cessation; Sxs = Symptoms.
Overall effect size, 95% CI, and other statistics for each primary outcome (substance use, abstinence, craving, stress, mindfulness) are bold to distinguish from sub-group analyses
[a] Abstinence from cigarette smoking was measured using 7-day point-prevalence abstinence rates. The effect size was measured with pooled odds ratios.
[b] Mindfulness was measured using the Five Facet Mindfulness Questionnaire in all 8 studies.

Meta-analytic results reveal small-to-large effects of mindfulness treatment vis-a-vis reducing levels of substance misuse, craving for psychoactive substances, and stress at posttreatment compared to alternative treatments.

Conflict of interest

The authors report no financial or professional conflicts of interest with respect to the contents of this review.

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Appendix A. Funnel plots evaluating publication bias

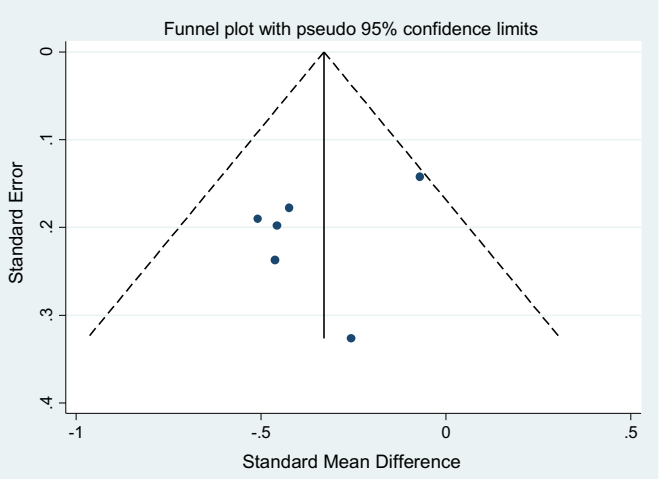

Fig. 1. Funnel plot to evaluate publication bias among studies included in the meta-analysis for the effect of mindfulness treatment on substance misuse. The outer dashed lines indicate the triangular region within which 95% of studies are expected to lie in the absence of both biases and heterogeneity.

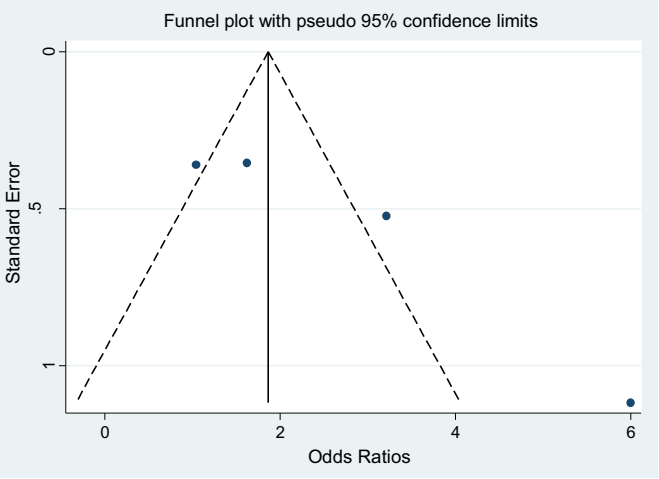

Fig. 2. Funnel plot to evaluate publication bias among studies included in the meta-analysis of the effect of mindfulness treatment on cigarette smoking point-prevalence abstinence rate. The outer dashed lines indicate the triangular region within which 95% of studies are expected to lie in the absence of both biases and heterogeneity.

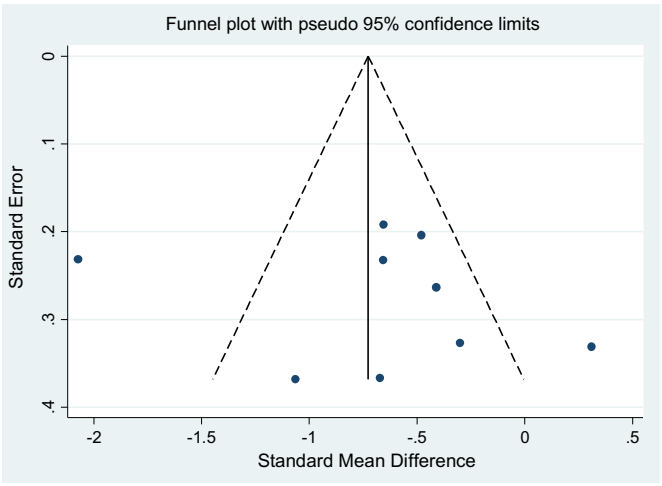

Fig. 3. Funnel plot to evaluate publication bias among studies included in the meta-analysis for the effect of mindfulness treatment on craving. The outer dashed lines indicate the triangular region within which 95% of studies are expected to lie in the absence of both biases and heterogeneity.

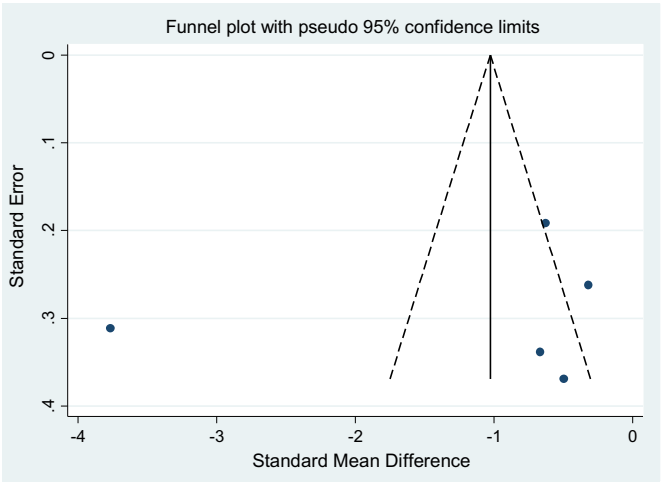

Fig. 4. Funnel plot to evaluate publication bias among studies included in the meta-analysis for the effect of mindfulness treatment on stress. The outer dashed lines indicate the triangular region within which 95% of studies are expected to lie in the absence of both biases and heterogeneity.

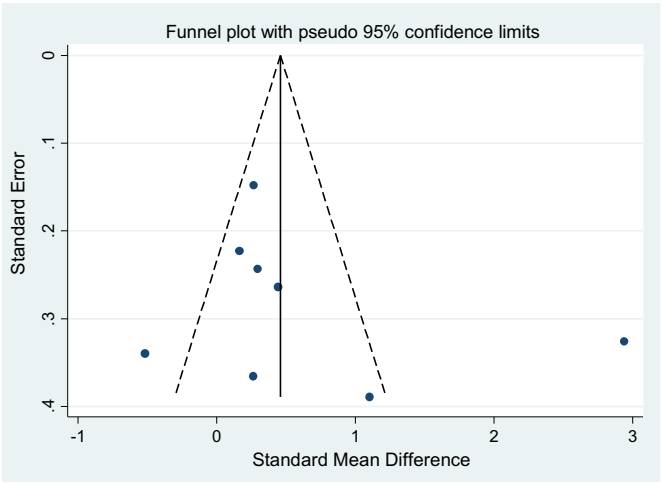

Fig. 5. Funnel plot to evaluate publication bias among studies included in the meta-analysis for the effect of mindfulness treatment on mindfulness. The outer dashed lines indicate the triangular region within which 95% of studies are expected to lie in the absence of both biases and heterogeneity.

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