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Motivational Interviewing for Smoking Cessation: A Meta-Analytic Review

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Objective: Motivational interviewing (MI) is a treatment approach that has been widely examined as an intervention for tobacco dependence and is recommended in clinical practice guidelines. Previous reviews evaluating the efficacy of MI for smoking cessation noted effects that were modest in magnitude but included few studies. The current study is a comprehensive meta-analysis of MI for smoking cessation. ***Method:*** The meta-analysis included 31 controlled trials with an abstinence outcome variable. Studies with nonpregnant ($N = 23$) and pregnant samples ($N = 8$) were analyzed separately. ***Results:*** For nonpregnant samples, combined results suggest that MI significantly outperformed comparison conditions at long-term follow-up points ($d_c = .17$). The magnitudes of this result represented a 2.3% difference in abstinence rates between MI and comparison groups. All analyses investigating the impact of moderating participant, intervention, and study design characteristics on outcome were nonsignificant, with the exception of studies including international, non-U.S. samples, which had larger effects overall. Several subgroups of studies had significant combined effect sizes, pointing to potentially promising applications of MI, including studies that had participants with young age, medical comorbidities, low tobacco dependence, and, consistent with clinical practice guidelines, low motivation or intent to quit. Effects were smaller among pregnant samples. In addition, significant combined effect sizes were observed among subgroups of studies that administered less than 1 hr of MI and among studies that reported high levels of treatment fidelity. ***Conclusions:*** The results are interpreted in light of other behavioral approaches to smoking cessation, and the public health implications of the findings are discussed.

Keywords: motivational interviewing, meta-analysis, tobacco dependence, smoking cessation, behavioral treatments

Tobacco dependence is a global epidemic. It has been estimated that cigarette smoking will claim the lives of 500 million people alive today and as many as one billion people in the 21st century (World Health Organization, 2008). Although clinical interventions for smoking cessation have demonstrated efficacy, long-term abstinence rates remain low (Brandon, Vidrine, & Litvin, 2007). Thus, it is essential that researchers continue to investigate clinical treatments for tobacco dependence.

Motivational interviewing (MI) is an innovative therapeutic approach for promoting behavioral change that is being increasingly applied to smoking cessation. The first published trial of MI for tobacco dependence appeared in 1998 (Colby et al., 1998), with the vast majority of trials being published since 2004. The approach is unique in its departure from more traditional behavioral interventions for smoking, which typically rely heavily on advice giving, information provision, and skills building (Fiore et al., 2008). Instead of trying to convince individuals of the need to change or insert motivation or skills, MI holds the implicit assumption that clients have inherent motivation and ability to engage in positive change and consequently discourages the use of direct persuasion and unsolicited advice (Rollnick & Miller, 1995). However, MI is unique in its combination of both client-centered and directive strategies (Miller & Rollnick, 2002), and it encourages the active and strategic elicitation of intrinsic motivations to change (Amrhein, Miller, Yahne, Palmer, & Fulcher, 2003; Moyers, Miller, & Hendrickson, 2005).

Early conceptual models and evidence regarding mechanisms of action of MI have been developing (Miller & Rollnick, 2009; Miller & Rose, 2009; Moyers et al., 2007; Moyers, Martin, Houck, Christopher, & Tonigan, 2009). In a broad sense, MI is intended to target the construct of motivation, which is seen as both a precursor to the initiation of behavioral change and a causal agent in the progression of change (Miller & Rollnick, 2002). However, despite the centrality of the construct of motivation to MI, there is generally a lack of clear evidence regarding the nature and impact of this construct on client behavior and outcome (Hettema, Steele, & Miller, 2005). While some studies have found a relationship between baseline readiness and outcome (Strang & McCambridge, 2004), a recent review of mechanisms of action of MI did not identify any studies that directly examined the relationship between changes in readiness and outcome and found that most studies investigating a link between MI and measures of motivation have not supported the existence of a relationship (Apodaca & Longabaugh, 2009). In addition, although the conceptual model of MI might predict that individuals with low levels of motivation

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would differentially benefit from MI, evidence is mixed, with some studies revealing an interaction between low levels of motivation and positive outcome (Project MATCH Research Group, 1997) and other studies finding the opposite (Stein et al., 2009). In addition to motivation, problem severity has been hypothesized to be an important moderating factor in MI. While some have asserted that MI may be most appropriate for those with less severe dependence or problem behavior, reviews have failed to support the impact of this factor on the effectiveness of MI (Burke, Arkowitz, & Menchola, 2003; Hettema et al., 2005). The field would benefit from increased clarity regarding the potential role of moderating factors such as motivation and problem severity, and meta-analysis may be a valuable tool for providing such evidence.

While broad assumptions about the conceptual role of motivation within MI remain largely unsupported, some insight into the potential mechanisms of action of MI comes from recent research on the relationship between verbalization of motivation to change within sessions and outcome. Early evidence suggests that interventionists who are rated as being highly consistent with MI tend to elicit talk about change from clients, which in turn increases the likelihood that change will occur (Moyers et al., 2007, 2009).

While the development of a validated conceptual understanding of MI is in its early stages, the intervention has been widely applied to a range of problem behaviors and has demonstrated efficacy in treating alcoholism, substance abuse, medication compliance, diet and exercise, safe sex practices, and treatment engagement (Hettema et al., 2005). In addition, several recent reviews and meta-analyses have addressed the issues of MI as a treatment for smoking cessation. An early review by Dunn, Deroo, and Rivara (2001) examined the efficacy of MI across behavioral domains, including two smoking cessation trials. Dunn et al. reported that one of the two trials produced a significant effect size and concluded that, at that time, data were inadequate to judge the effect of MI for smoking. A later meta-analysis conducted by Burke et al. (2003) also included two smoking studies in their broad meta-analysis of MI and concluded that these preliminary results did not support the efficacy of MI for smoking. A more recent meta-analysis, which also investigated the effects of the intervention across a range of behavior domains, included six smoking cessation studies (Hettema et al., 2005). The results of this meta-analysis generally supported the short-term effectiveness of MI, though results for long-term effects were much lower. However, unlike the effects observed in other substance-related and chronic health conditions in this meta-analysis, the combined effect size of smoking studies was reported to be low (d_c = .14). Last, a recent review of MI for smoking cessation was conducted as part of the Cochrane Collaboration (Lai, Cahill, Qin, & Tang, 2010). This study included 14 controlled trials with nonpregnant adults. Studies with a no-treatment comparison condition design or that included outcome variables other than abstinence were excluded. The review found modest but significant between-group effects on cessation that favored MI over brief advice or usual care (relative risk = 1.27). Moderator analyses suggested that MI may show slightly higher effects for low-motivation samples, as measured by whether intention to quit was required for participation (relative risk = 1.37).

Despite early data that provide mixed evidence, the U.S. Department of Health and Human Services clinical practice guidelines for treating tobacco use and dependence (Fiore et al., 2008) recommend the use of MI strategies, particularly among those who are not currently motivated to quit. Research on the efficacy of MI for smoking cessation has increased dramatically in recent years, and a comprehensive review that focuses solely on smoking cessation and examines potential moderating factors is needed to inform clinical practice guidelines. The present meta-analysis examined the efficacy of MI for smoking cessation using 31 controlled trials of MI. The current meta-analysis significantly adds to the evidence base in several ways: (a) It adds to earlier studies (Burke et al., 2003; Dunn et al., 2001; Hettema et al., 2005) by focusing solely on smoking behavior, allowing for a more comprehensive analysis; (b) it adds to the recent smoking-focused meta-analysis (Lai et al., 2010) by expanding inclusion criteria to include adolescent and pregnant samples and studies with a no-treatment comparison condition; and (c) it adds to all of these previous reviews by more than doubling the number of included studies and conducting in-depth moderator analyses on an array of previously uninvestigated treatment, participant, and study design characteristics.

Method

Study Selection

For the present meta-analysis, a comprehensive literature search of PubMed and PsycINFO was conducted using the key terms *motivational interviewing, smoking, smoking cessation, nicotine dependence,* and *tobacco dependence* for studies published or available electronically before June 2008. Bibliographies of included studies and previously conducted meta-analyses were also hand searched. Studies were required to (a) examine at least one intervention condition that included the administration of MI, (b) examine at least one comparison condition that did not include the administration of MI, (c) indicate use of a procedure to ensure the equivalence of groups, and (d) report an abstinence-related outcome measure.

Selection of Outcome Variables

For the present meta-analysis, two single effect-size estimates of outcome were selected for each study. For each study, the most rigorous outcome variable was selected, and the effect size of that variable at the shortest and longest follow-up periods available for that study was calculated. For studies in which only one follow-up period was available, follow-up periods of less than 6 months were considered short follow-up periods, and those equal to or greater than 6 months were considered long follow-up periods. For studies in which the follow-up period was considered the end of pregnancy and no specific duration could be determined, the short-term follow-up category was used. Selection of rigorous outcome variables is consistent with several previous reviews of smoking cessation treatments (Mottillo et al., 2009; Silagy, Lancaster, Stead, Mant, & Fowler, 2004). The most rigorous outcome variable type was selected based on the following hierarchical criteria: (a) biochemically verified continuous abstinence, (b) biochemically verified point prevalence abstinence, (c) self-reported continuous abstinence, and (d) self-reported point prevalence abstinence. For studies in which there was more than one MI or comparison condition, the most conservative outcome variable was

selected for each relevant comparison group and statistically combined using a fixed-effects model to give a conservative estimate for the study overall.

Study Characteristics

All included articles were independently coded by two reviewers (the authors) to extract information regarding characteristics of the interventions, participants, and study design. A detailed coding manual, which is available from Jennifer E. Hettema, was modified from previous reviews and meta-analyses (Hettema et al., 2005; Miller & Wilbourne, 2002) and used to assist reviewers. After coding articles, reviewers resolved discrepancies via discussion, with referral to the coding manual and manuscript. Rates of interrater reliability were recorded.

Coded intervention characteristics included the modalities implemented in the MI and comparison conditions and the setting (e.g., primary care, inpatient psychiatry), format (e.g., individual, group), and agent (e.g., physician, health educator) associated with each intervention. MI concentration within studies was categorized according to the implementation of MI alone versus MI in combination with some other active treatment. Studies that combined MI with feedback (as in motivational enhancement therapy) or literature were still considered to be MI alone. Studies were also divided into categories based on whether MI was combined with pharmacotherapy or not and whether MI was combined with a skills-based behavioral intervention, such as cognitive behavioral therapy (CBT) or relapse prevention, or not. In addition, the duration of treatment, including weeks in treatment, number of treatment sessions, and average treatment session length, was recorded. Total number of hours in treatment in the MI condition was calculated, and studies were categorized as being 1 hr or less, 1 to 2 hr, or more than 2 hr. MI training characteristics were recorded, and mentioning training in the text of the manuscript was used as a rough proxy of interventionist training. In addition, several treatment fidelity constructs were measured, including whether the authors reported engaging in some type of posttraining competency assessment, providing ongoing fidelity checks by coding session tapes, or providing ongoing support to therapists in the form of supervision. Studies were categorized as meeting zero to three of these criteria.

Several participant characteristics were coded for each study, including demographic characteristics such as ethnoracial constitution, gender, age, presence of comorbid medical or psychiatric disorders, pregnancy status, tobacco dependence, and motivation to quit. The percentage of participants belonging to different ethnoracial groups was documented, and studies were categorized as having a majority of minority participants (>50% African American, Hispanic, Asian and Pacific Islander, Native American, or other), having a majority of White participants (>50% White), or being an international sample (study conducted with participants from outside the United States). Reviewers recorded the percentage of males and females reported, and each study was categorized as being composed of a majority of male or majority of female participants. The mean age of participants was recorded, and studies were categorized as working with adult (mean age > 18 years) or adolescent samples (mean age < 18 years). Studies were categorized as having or not having a majority of patients with comorbid psychiatric or medical conditions. The pregnancy status of participants was also recorded, and studies with pregnant samples were analyzed separately from the main analyses. To assess tobacco dependence, provided measures of tobacco dependence and smoking-related inclusion criteria were gathered. Because a uniform method of assessing dependence was not available across all studies, rating assignments were made based on the following hierarchical criteria: baseline Fagerström Test of Nicotine Dependence (<4 = low, 4–6 = moderate, >6 = high), baseline smoking rate (<10/day = low, 10–20/day = moderate, >20/day = high), and inclusion criteria smoking rate (no smoking necessary, former smoker, or any smoking in the past 30 days = low, 1–20/day = moderate, >20/day = high). Motivation to quit was also not consistently measured across studies. However, given the importance of this construct in the proposed mechanisms of action of MI, attempts were made to quantify the motivation of study populations. The first method involved calculating a standardized mean score on a 0–10 scale for all studies. Several studies reported a mean score of motivation on a 10-point scale, with scores ranging from 0 (*low in motivation*) to 10 (*high in motivation*; e.g., the Contemplation Ladder; Biener & Abrams, 1991), and thus, no transformation was performed for these values. If studies provided the mean value of a continuous measure of motivation that did not use a 0–10 scale, this score was transformed to a 0–10 value. If percentages of participants within each stage of change were provided, the mean 0–10 Contemplation Ladder score corresponding to that stage of change (Herzog & Blagg, 2007) was weighted by the percentage of participants within that given category, and these scores were summed to calculate a weighted average score on a 0–10 scale. Motivation to quit was also measured by classifying studies as requiring or not requiring an intention to quit as a condition of enrollment.

Finally, several study design characteristics were coded for, including comparison type, follow-up length, and type of outcome variable. Each study was categorized as belonging to one of the following six comparison types: (a) MI versus another intensive active individual, computer, or telephone intervention totaling more than 10 min or any treatment incorporating pharmacotherapy; (b) MI versus another minimal active individual, computer, or telephone intervention totaling less than 10 min; (c) additive design in which MI was added to another intensive treatment and compared to that treatment alone; (d) additive design in which MI was added to literature, written referrals, or written advice and compared to that treatment alone; (e) MI versus literature, written referrals, or video; or (f) MI versus no treatment or an attentional or placebo control.

Methodological Quality

To assess quality and internal validity, all studies were double coded using the Methodological Quality Scale (MQS), a 12-item instrument used in several previous reviews and meta-analyses (Dunn et al., 2001; Hettema et al., 2005; Miller & Wilbourne, 2002). The instrument assigns point values for methodological quality characteristics, including method of group allocation strategy, treatment quality control, follow-up rate and length, use of collaterals and objective verification of assessment data, in-person assessment, consideration of individuals who drop out of treatment and are lost to follow-up in outcome analyses, masked assessments, acceptable statistical analyses, and multisite methodology.

All studies were independently rated by the two reviewers who then met and reconciled differences by referring to the manuscript.

Calculation of Effect Size

For each study, effect sizes and 95% confidence intervals (CIs) were computed for abstinence-related outcome variables. Two single effect-size estimates were extracted from each study using the decision rules described in the section on selection of outcome variables to represent the effect size associated with the most rigorous outcome variable at the shortest and longest follow-ups available for each study. Comprehensive Meta-Analysis (Version 2) software was used for all meta-analytic statistical procedures (Borenstein, Hedges, Higgins, & Rothstein, 2005). Between-group unbiased estimators of effect size (*d*) and 95% CIs were calculated. These effect sizes represent MI versus comparison condition differences in posttreatment scores or differences in changes between pre- and posttreatment between groups. Proportions and sample sizes or odds ratios (ORs) were used (Chinn, 2000). When the above information was not available, effect sizes were computed using *F, t,* chi-square, or *p* statistics (Rosenthal, 1991). When insufficient information was provided to calculate effect sizes and statistical tests were reported to be nonsignificant, zero effect sizes were assigned. When available, abstinence rates corresponding to the two single effect-size estimates were extracted for MI and comparison conditions. Cohen's (1988) criteria for identifying the magnitude of an effect size were used, where $d = .20$ is a small effect, $d = .50$ is a medium effect, and $d = .80$ is a large effect.

After calculating effect sizes for each included study, we conducted homogeneity analyses using Q and I^2 tests. A significant Q statistic indicates the presence of heterogeneity across studies that is not solely attributable to sampling error (Hunter, Schmidt, & Jackson, 1982). I^2 is the percentage of variation in treatment effect that is due to heterogeneity (Higgins & Thompson, 2002). This statistic can be quantified as representing low ($I^2 = 25\%$), moderate ($I^2 = 50\%$), or high ($I^2 = 75\%$) levels of heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003). Because the degree of homogeneity was not known in advance, combined effect sizes were calculated for the sample of studies using both fixed- and random-effects models. A fixed-effects model assumes that all studies represent a common effect and weights combined studies by the inverse of their variance. A random-effects model weights studies differently because it allows for variability between studies that may arise from differences in the intervention, study participants, or study design and assumes that the true effects of each study are not identical but lie within a distribution of effects (Hedges & Olkin, 1985). When a significant amount of heterogeneity is present and cannot be explained by moderator analyses, a random-effects model is generally agreed upon to be the more conservative estimate of effect (Hedges & Vevea, 1998).

Publication Bias

One concern of meta-analysis is the file-drawer problem, or the exclusion of nonsignificant studies that might nullify an observed effect. In the present meta-analysis, a funnel plot, in which the standard error of studies is displayed as a function of effect, was created to estimate such publication bias. In these plots, symmetrical distribution around the combined effect size indicates the absence of publication bias (Egger, Gavey, Schneider, & Minder, 1997). In addition, a classic fail-safe *N* was calculated to determine the number of missing studies with no effect that would be needed to nullify the effect (Hedges & Olkin, 1985; Rosenthal, 1979).

Subgroup Analyses

For the main subgroup analysis, which included nonpregnant samples and long- and short-term follow-up, rigorous variable effect sizes for each potential moderator were calculated using random-effects models. Significant between-group differences in effect were identified when subgroups did not have overlapping 95% CIs.

Several moderator analyses were conducted, including the following:

1. Intervention characteristics—MI concentration (MI condition included only MI alone or MI plus feedback or literature, MI condition included other treatment modalities);
2. Intervention characteristics—combination with pharmacotherapy or skills-based treatment (MI condition included pharmacotherapy or did not include pharmacotherapy, MI condition included skills-based treatment or did not include skills-based treatment);
3. Intervention characteristics—MI total duration (less than 1 hr, 1 hr to 2 hr, more than 2 hr);
4. Intervention characteristics—MI training (training of MI therapists mentioned in study; training of MI therapists not mentioned in study);
5. Intervention characteristics—MI fidelity (number of fidelity procedures used, including posttraining competency assessment, ongoing fidelity check [e.g., rating of tapes], ongoing support offered [e.g., supervision], ranging from zero to three);
6. Participant characteristics—ethnoracial constitution (minority majority, White majority, international [non-U.S.] sample);
7. Participant characteristics—gender (majority male, majority female);
8. Participant characteristics—comorbidity (no majority comorbid diagnosis, majority had medical comorbidity, majority had psychiatric comorbidity [includes alcohol dependence]);
9. Participant characteristics—tobacco dependence (low, medium, high);
10. Participant characteristics—motivation (above or below median split on 0–10 scale and intention to quit required for participation or not); and

11. Study design characteristics—comparison type (MI vs. intensive active treatment; MI vs. minimal active treatment; MI added to intensive active treatment; MI added to minimal active treatment; MI vs. literature, referral, or video; MI versus no treatment or attentional or placebo control).

Results

Study Coding

The meta-analysis included 23 studies with nonpregnant samples and eight with pregnant samples. Main analyses are reported for the 23 nonpregnant-sample studies, with pregnant-sample studies analyzed separately at the end of the results. Raters coded 66 variables for each study, which measured intervention, participant, study design, and methodological quality characteristics. Rates of interrater reliability were high, with 95.5% initial agreement between the two raters on a subsample of over 50% of studies. Disagreement seemed well distributed across coded characteristics. All disagreements were able to be conclusively resolved with agreement by both raters.

Description of Intervention Characteristics

Overall, there was wide variability in the administration of MI across the 23 main studies. MI was combined with a variety of other intensive and minimal active treatments in the majority (74%) of trials. Of the included studies, 30% combined MI with some form of pharmacotherapy, and 13% combined MI with a skills-based behavioral intervention such as CBT or relapse prevention. MI conditions were administered in a variety of settings, including specialty and primary care medical settings, emergency departments, residential treatment programs, schools, patients' homes, and research clinics. Overall, medical settings were the most common site of implementation. MI was delivered by range of providers, including physicians, psychologists, master's level counselors and social workers, nurses, and health educators. All included studies used human interventionists to administer MI, although several studies conducted the intervention via telephone or computer. Of the studies that reported intervention agents, mental health and medical providers were fairly evenly represented. MI was also conducted in a variety of formats, including individual and group, and several studies had some telephone-based component. The duration of the MI treatment condition also varied widely across studies, with participants assigned to this condition attending a mean of 5.50 (range = 1–24, SD = 5.21) treatment sessions, across 12.72 weeks (range = 1–72, SD = 18.52). Average session duration was 29.93 min (range = 10–60, SD = 29.93), with MI participants spending a total of 188.11 min (range = 10–635, SD = 195.30) in treatment on average. Average number of minutes in comparison condition treatments was much shorter (M = 11.10 min, range = 0–62.5, SD = 16.71).

Assessing fidelity to the MI intervention model was difficult to accomplish. Studies varied widely in their description of the intervention, with some giving a comprehensive theoretical background and step-by-step components of the intervention and others simply mentioning that MI strategies were used. In general, accessing companion articles did not provide additional treatment fidelity information, but this was done when possible. As a proxy to intervention training, studies were coded as mentioning or not mentioning the training of MI interventionists, and 16 out of 23 studies (70%) made such mention. Duration of training was reported in seven studies and ranged from 2 to 75 hr (M = 28.14, SD = 25.89). In addition, five studies reported conducting a posttraining competency assessment, three reported engaging in monitoring treatment sessions in some way to ensure fidelity, and 11 reported providing posttraining support or supervision.

Description of Participant Characteristics

The included studies represented 8, l65 participants. Brief descriptions of each sample can be found in Table 1. Male participants made up 43% of the sample. Mean participant age ranged from 15 to 61 years (M = 35.88, SD = 16.09). Several studies were conducted internationally, including studies in Australia (N = 3), Northern Ireland (N = 1), Sweden (N = 1), and Spain (N = 1). For studies conducted in the United States, participants represented a range of ethnicities, including White (61%), African American (22%), Hispanic (8%), Asian/Pacific Islander (1%), Native American (1%), and other or unspecified ethnicities (6%). Three studies recruited patients with psychiatric comorbidities, including psychotic disorders and alcohol dependence, and five recruited participants with medical disorders, including HIV, cancer, diabetes, hypertension, and chronic obstructive pulmonary disease.

Using the procedure described in the Method section, study participants were rated as low (N = 7), moderate (N = 12), or high (N = 4) in tobacco dependence based on baseline measures and inclusion criteria. The hierarchical procedure used to rate dependence seemed acceptable as there was agreement between categorizations in a majority of cases in which more than one rating criterion was available. Scores of motivation were provided for 16 studies, and these ranged from five to nine with a mean of 6.62 (SD = 1.01). These scores were divided at the median of 6.5 into high and low groups. In addition, 19 studies reported whether intention to quit was a requirement of enrollment, and of these, six (32.0%) required that participants have a desire to quit. Of the 12 studies with both types of motivation data available, discrepancies in categorization occurred in only two cases (16.7%).

Description of Study Design Characteristics

Several comparison types were used in the sample of studies. Of the tested comparisons, eight tested MI versus another intensive active treatment; eight compared MI to another minimal active treatment; one used an additive design in which MI was added to another intensive treatment; none used an additive design in which MI was added to another minimal treatment; two tested MI versus literature, written referrals, or video; and six compared MI to a no-treatment or an attentional or placebo control.

Description of Methodological Quality

The average methodological quality score for included studies was 10.56 (range = 5–14, SD = 2.60) out of a possible score of 16. This level is similar to levels of methodological quality that have been observed in other large reviews of addiction treatment

Table 1
Effect Sizes and Key Study Characteristics

Study	Sample (number of participants)	MI condition	Comparison condition	Most rigorous outcome variable (shortest follow-up/longest follow-up)	Most rigorous outcome variable/shortest follow-up, *d* [95% confidence interval], *p* value	Most rigorous outcome variable/longest follow-up, *d* [95% confidence interval], *p* value
			Nonpregnant			
Ahluwalia et al. (2006)	African American light smokers ($N = 755$)	LIT + MI + RX (nicotine gum)	LIT + BAD + ED + RX (placebo nicotine gum)	Bio. Ver. PP Abst. (PT/6)	−0.29 [−0.44, −0.15], $p < .00$	−0.36 [−0.50, −0.22], $p < .00$
Baker et al. (2006)	Psychotic smokers ($N = 298$)	MI + FB + CBT + RX (nicotine patch) + LIT	ST + LIT	Bio. Ver. Cont. Abst. (3/12)	0.59 [0.06, 1.13], $p < .00$	0.89 [−0.28, 2.05], $p < .14$
Borrelli et al. (2005)	Medically ill smokers ($N = 273$)	LIT + MI + FB	LIT + 5A	Bio. Ver. Cont. Abst. (PT/12)	0.53 [−0.85, 1.90], $p < .45$	0.49 [−0.14, 1.12], $p < .13$
Brown et al. (2003)	Adolescents smokers with psychiatric disorders ($N = 191$)	MI + FB + RX (nicotine patch) + LIT	BAD + RX (nicotine patch) + LIT	Bio. Ver. PP Abst. (1/12)	0.00 [−0.53, 0.53], $p < 1.00$	0.22 [−0.30, 0.73], $p < .41$
Butler et al. (1999)	Smokers in general practice ($N = 536$)	MI	BAD	Self-reported PP Abst. (NA/6)		0.39 [−0.28, 1.06], $p < .25$
Colby et al. (1998)	Adolescent smokers in medical settings ($N = 40$)	MI + FB + LIT	BAD + LIT + RF	Bio. Ver. PP Abst. (3/NA)	0.45 [−0.56, 1.45], $p < .38$	
Colby et al. (2005)	Adolescent smokers in hospital ($N = 85$)	MI + FB + VID + LIT	BAD + LIT	Bio. Ver. PP Abst. (1/6)	0.55 [−1.25, 2.35], $p < .55$	0.87 [−0.45, 2.19], $p < .20$
Emmons et al. (2001)	Smokers with young children ($N = 291$)	MI + FB + LIT	LIT + RF	Self-reported PP Abst. (3/6)	0.00 [−0.25, 0.25], $p < 1.00$	0.00 [−0.25, 0.25], $p < 1.00$
Hokanson, Anderson, Hennrikus, Lando, & Kendall (2006)	Diabetes mellitus patient smokers ($N = 114$)	MI + RX (nicotine patch/ bupropion)	RF	Self-reported PP Abst. (3/6)	0.64 [−0.13, 1.41], $p < .10$	−0.04 [−0.72, 0.65], $p < .91$
Hollis et al. (2005)	Adolescents in primary medical care settings ($N = 2,526$)	BAD + ES + MI + LIT	ATPL	Self-reported PP Abst. (12/24)	0.13 [0.03, 0.23], $p < .01$	0.11 [0.02, 0.21], $p < .02$
Horn, Dino, Hamilton, & Noerachmanto (2007)	Adolescent emergency patient smokers ($N = 75$)	MI + FB + LIT	BAD + RF	Self-reported PP Abst. (NA/6)		−0.08 [−1.60, 1.47], $p < .92$
Hyman, Pavlik, Taylor, Goodrick, & Moye (2007)	African-American, hypertensive primary care smokers ($N = 289$)	LIT + VID + MI + RX (bupropion)	LIT + VID + MI + RX (bupropion)or LIT + VID + RF	Bio. Ver. PP Abst. (6/18)	0.23 [−0.20, 0.65], $p < .29$	0.39 [−0.08, 0.86], $p < .10$
Ingersoll, Cropsey, & Heckman (2009)	HIV-positive smokers ($N = 40$)	MI + FB + RX (nicotine patch)	LIT + RX (nicotine patch)	Bio. Ver. PP Abst. (3/NA)	0.00 [−0.67, 0.67], $p < 1.00$	
Lipkus et al. (2004)	Adolescent smokers ($N = 402$)	LIT + VID + MI	LIT + VID	Self-reported PP Abst./ Self-reported Cont. Abst. (4/8)	0.24 [−0.08, 0.56], $p < .15$	0.15 [−0.25, 0.55], $p < .46$
Persson & Hjalmarson (2006)	Smokers with diabetes mellitus in primary care ($N = 412$)	MI	BAD	Self-reported PP Abst. (NA/12)		0.66 [0.26, 1.07], $p < .00$
Prochaska et al. (2008)	Medical university employees ($N = 136$)	FB + BAD + MI	FB + BAD + TTM or FB + BAD	Self-reported PP Abst. (NA/6)		0.45 [0.01, 0.89], $p < .05$

(*table continues*)

Table 1 (*continued*)

Study	Sample (number of participants)	MI condition	Comparison condition	Most rigorous outcome variable (shortest follow-up/longest follow-up)	Most rigorous outcome variable/shortest follow-up, *d* [95% confidence interval], *p* value	Most rigorous outcome variable/longest follow-up, *d* [95% confidence interval], *p* value
Prokhorov et al. (2008)	Community college smokers ($N = 426$)	MI + FB + ES	BAD + LIT + ED	Bio. Ver. PP Abst. (NA/10)		0.32 [−0.05, 0.68], $p < .09$
Rohsenow, Monti, Colby, & Martin (2002)	Alcoholic smokers in residential treatment ($N = 120$)	MI + FB + RX (unspecified) + LIT + RF + ST	BAD (one session) + FB + RX (unspecified) + LIT + RF + ST or BAD (three sessions) + FB + RX (unspecified) + LIT + RF + ST	Bio. Ver. PP Abst. (1/6)	−0.71 [−1.21, −0.20], $p < .01$	−1.10 [−2.37, 0.18], $p < .09$
Smith et al. (2001)	Community smokers ($N = 677$)	LIT + MI + ST + RX (nicotine patch)	LIT + CBT + ST + RX (nicotine patch) or ST + LIT + RX (nicotine patch)	Bio. Ver. PP Abst. (1/12)	0.00 [−0.20, 0.20], $p < 1.00$	−0.07 [−0.33, 0.18], $p < .58$
Soria, Legido, Escolano, López Yeste, & Montoya (2006)	Smokers in primary care ($N = 200$)	MI + RX (bupropion)	BAD + RX (bupropion)	Bio. Ver. PP Abst. (6/12)	1.01 [0.31, 1.71], $p < .01$	1.01 [0.31, 1.71], $p < .00$
Wakefield, Olver, Whitford, & Rosenfeld (2004)	Smokers with cancer ($N = 137$)	MI + RX (bupropion) + BAD + LIT + SO	BAD + LIT + RF	Biol. Ver PP Abst. (NA/6)		−0.11 [−0.92, 0.71], $p < .80$
Wilson, Fitzsimmons, Bradbury, & Elborn (2008)	Smokers with COPD ($N = 91$)	MI + BAD + LIT + RX (nicotine patch) + ED + RPT + CBT	MI + BAD + LIT + RX (nicotine patch) + ED + RPT + CBT or BAD + LIT	Bio. Ver. Cont. Abst. (NA/12)		0.00 [−0.58, 0.58], $p < 1.00$
Woodruff, Conway, Edwards, Elliott, & Crittenden (2007)	Adolescent smokers ($N = 136$)	MI + CBT + RPT	NT	Self-reported PP Abst. (PT/12)	0.36 [−0.13, 0.84], $p < .15$	−0.02 [−0.47, 0.43], $p < .92$
			Pregnant			
Ershoff et al. (1999)	Prenatal patient smokers ($N = 390$)	LIT + MI	LIT + ITL or LIT	Bio. Ver. PP Abst. (EOP/NA)	0.04 [−0.22, 0.30], $p < .75$	
Rigotti et al. (2006)	Pregnant smokers ($N = 442$)	LIT + PR + ST + CBT + RPT + MI	LIT + PR + ST	Bio. Ver. PP Abst/Bio. Ver. Cont. Abst. (EOP/EOP + 3)	0.17 [−0.20, 0.55], $p < .37$	0.22 [−0.33, 0.76], $p < .44$
Ruger, Weinstein, Hammond, Kearney, & Emmons (2008)	Low-income pregnant current or recent smokers ($N = 302$)	ED + MI + FB + LIT	ST + ED + LIT	Bio. Ver. PP Abst. (NA/EOP + 6)		0.11 [−0.32, 0.54], $p < .61$

Table 1 (*continued*)

Study	Sample (number of participants)	MI condition	Comparison condition	Most rigorous outcome variable (shortest follow-up/longest follow-up)	Most rigorous outcome variable/shortest follow-up, *d* [95% confidence interval], *p* value	Most rigorous outcome variable/longest follow-up, *d* [95% confidence interval], *p* value
Stotts, DeLaune, Schmitz, & Grbaowski (2004)	Low-income pregnant smokers ($N = 54$)	MI + FB	BAD	Bio. Ver. PP Abst. (0/NA)	−0.15 [−1.12, 0.82], $p < .76$	
Stotts, Diclemente, & Dolan-Mullen (2002)	Brief smoking treatment failure smokers ($N = 269$)	MI + LIT + VID + TTMFB	NT	Bio. Ver. PP Abst. (34th week of pregnancy/NA)	−0.07 [−0.37, 0.23], $p < .63$	
Suplee (2005)	Pregnant recent smokers ($N = 62$)	MI + RPT + ED + LIT	NT	Bio. Ver. PP Abst. (2/NA)	0.31 [−0.29, 0.91], $p < .31$	
Tappin et al., 2005	Pregnant smokers ($N = 762$)	ST + MI + ED + LIT	ST + LIT	Bio. Ver. PP Abst. (36th week of pregnancy/NA)	−0.10 [−0.39, 0.19], $p < .48$	
Tappin et al. (2000)	Pregnant smokers ($N = 100$)	MI	NT	Bio. Ver. PP Abst. (36th week of pregnancy/NA)	−0.41 [−1.37, 0.56], $p < .41$	

Note. 5A = the five As (ask, advise, assess, assist, arrange); ATPL = attentional placebo; BAD = brief advice; Bio. Ver. Cont. Abst. = biochemically verified continuous abstinence; Bio. Ver. PP Abst. = biochemically verified point prevalence abstinence; CBT = cognitive behavioral therapy; ED = education; EOP = end of pregnancy; ES = expert system; FB = feedback; ITL = interactive telephone treatment; LIT = literature, brochures, or pamphlets; MI = motivational interviewing; NA = not applicable; NT = no treatment; PR = provider reminder; PT = posttreatment; RF = referral; RPT = relapse prevention treatment; RX = pharmacotherapy (type); Self-reported Cont. Abst. = self-reported continuous abstinence; Self-reported PP Abst. = self-reported point prevalence abstinence; SO = involvement of significant other; ST = unspecified standard treatment; TTM = transtheoretical model treatment; TTMFB = transtheoretical model–based feedback; VID = video.

(Hettema et al., 2005; Miller & Wilbourne, 2002). This suggests that most of the studies were of medium to high methodological quality and did not represent a significant probability of bias.

Effect Outcomes: All Outcome Estimates

Most rigorous variable short- and long-term follow-up effect sizes for all included studies can be seen in Table 1. Forest plots of effect-size estimates for short- and long-term follow-ups are available in Figures 1 and 2. Effect-size estimates ranged from $d = -.71$ to 1.01 for short-term follow-up and $d = -1.10$ to 1.01 for long-term follow-up. Among calculated effect sizes for short- and long-term follow-up periods, eight out of 14 (57.1%) and 11 out of 19 (57.8%) were greater than zero, respectively. Similarly, for short- and long-term follow-ups, seven out of 14 (50%) and nine out of 19 (47.4%) studies yielded effect sizes that were greater than the small range using Cohen's estimates of effect-size magnitude (Cohen, 1988). Using short-term follow-up estimates of effect, three studies had effect sizes that were statistically significant ($p < .05$) in favor of MI, and two significantly favored the comparison condition, while the remaining studies did not yield significant differences between groups. For long-term follow-up estimates, most studies yielded nonsignificant results, but four studies significantly favored MI, while one favored the comparison condition.

Q tests for heterogeneity were significant, and I^2 values suggested that high levels of effect variance were due to heterogeneity between studies (see Table 2). This level of heterogeneity suggests that random-effects models of analyses are the most conservative approach to analyzing the data, and this strategy was used for all future analyses.

As can be seen in Table 2, the random-effects model combined effect size for short-term follow-up periods was $d_c = .12$ [−.05, .28] (*ns*), and for long-term follow-up periods, it was $d_c = .17$ ([.01, .32] ($p < .05$). These combined effect sizes are below Cohen's criteria for a small effect (Cohen, 1988). These

Figure 1. Meta-analytic forest plot of combined effects sizes and 95% confidence intervals for short-term follow-up. Arrows indicate that the 95% confidence interval exceeds the range of possible values shown. The diamond indicates the overall meta-analytic effect and 95% confidence interval.

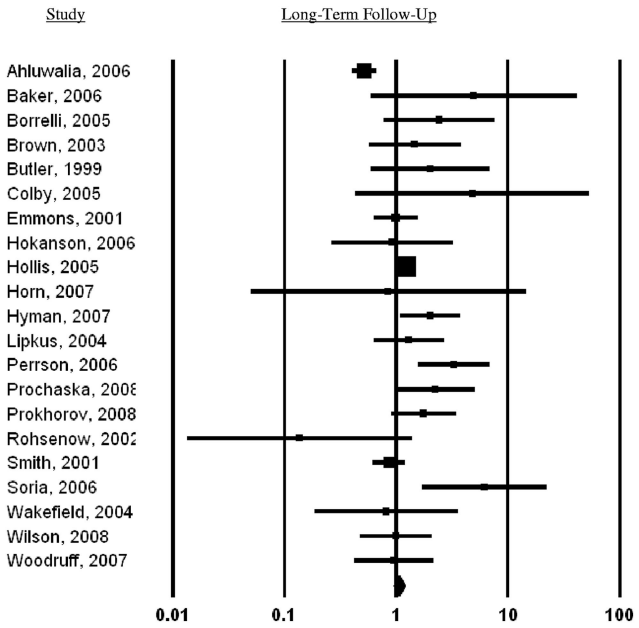

Figure 2. Meta-analytic forest plot of combined effects sizes and 95% confidence intervals for long-term follow-up. Arrows indicate that the 95% confidence interval exceeds the range of possible values shown. The diamond indicates the overall meta-analytic effect and 95% confidence interval.

effect sizes correspond to ORs of OR = 1.07 [0.96, 1.19] and OR = 1.35 [1.02, 1.78], respectively. In addition, data on the abstinence rates of MI versus comparison samples is available in Table 3. For short-term follow-up periods, the mean abstinence rate for the MI conditions was 13.8% (*SD* = 9.10) compared to a mean abstinence rate of 11.2% (*SD* = 10.01) for the comparison conditions. For long-term follow-up periods, the mean abstinence rate for the MI conditions was 12.8% (*SD* = 10.50) compared to a mean abstinence rate of 10.5% (*SD* = 9.10) for the comparison conditions. Studies for which abstinence data included samples that were currently nonsmokers were excluded from these analyses.

Effect Outcomes: Publication Bias

Analysis of generated funnel plots revealed a high level of symmetry around the combined effect for both short- and long-term effect estimates. For long-term effects, the fail-safe *N* for the combined two-tailed *p* value to exceed .05 is 25. Both tests suggest that there are low levels of publication bias in the current meta-analysis.

Moderator Outcomes: Intervention Characteristics

Subgroup analyses were conducted to test for the moderating effects of MI duration, concentration, combination of MI with pharmacotherapy, combination of MI with skills-based behavioral treatments, mention of MI training in the study, and number of MI fidelity practices endorsed. None of the analyses revealed significant differences between subgroups. However, the combined effect size of some subgroups did reach statistical significance. For example, short MI duration (1 hr or less) resulted in significant combined effect sizes for long-term follow-up effect estimates (d_c = .33, $p < .05$) suggesting that briefer administrations of MI may be more effective. Furthermore, trials that did not combine MI with pharmacotherapy resulted in significant combined effect sizes among long-term follow-up rigorous variables (d_c = .21, $p < .01$). For short-term follow-up estimates, the combination of MI with a skills-based intervention yielded a significant combined effect size (d_c = .46, $p < .01$), but at long-term follow-up points, studies that did not include a skills-based component showed significant effects (d_c = .18, $p < .05$). Finally, both mentioning training in the study and engaging in all three of the measured treatment fidelity practices resulted in significant long- and short-term combined effect sizes (d_c = .26, $p < .01$, and d_c = .13, $p < .01$, respectively). Table 4 lists the random-effects model combined

Table 2
Combined Study Effect Sizes and Heterogeneity Results

Type of analysis	d_c	95% confidence interval	*Z*	Number of studies	*Q*	I^2 (%)
		Nonpregnant				
Rigorous variable shortest follow-up						
Fixed	0.04	[−0.03, 0.10]	1.08	16	50.10**	70.06
Random	0.12	[−0.05, 0.28]	1.36	16		
Rigorous variable longest follow-up						
Fixed	0.04	[−0.02, 0.10]	1.19	21	72.33**	72.35
Random	0.17*	[0.01, 0.32]	2.11*	21		
		Pregnant				
Rigorous variable shortest follow-up						
Fixed	−0.01	[−0.17, 0.15]	0.13	7	3.36	0
Random	−0.01	[−0.17, 0.15]	0.13	7		
Rigorous variable longest follow-up						
Fixed	0.15	[−0.19, 0.49]	0.88	2	0.09	0
Random	0.15	[−0.19, 0.49]	0.88	2		

Note. d_c = combined effect size.
* $p < .05$. ** $p < .01$.

Table 3
Abstinence Rates

Study	Most rigorous outcome variable (shortest follow-up/longest follow-up)	MI abstinence rate/short-term follow-up	Comparison abstinence rate/short-term follow-up	MI abstinence rate/long-term follow-up	Comparison abstinence rate/long-term follow-up
Ahluwalia et al. (2006)	Biol. Ver. PP Abst. (PT/6)	.14	.22	.09	.17
Baker et al. (2006)	Biol. Ver. Cont. Abst. (3/12)	.11	.04	.03	.01
Borrelli et al. (2005)	Biol. Ver. Cont. Abst. (PT/12)	.02	.01	.12	.05
Brown et al. (2003)	Biol. Ver. PP Abst. (1/12)	.11	.11	.14	.10
Butler et al. (1999)	Self-reported PP Abst. (NA/6)	NA	NA	.03	.02
Colby et al. (1998)	Biol. Ver. PP Abst. (3/NA)	.20	.10	NA	NA
Colby et al. (2005)	Biol. Ver. PP Abst. (1/6)	.02	.00	.09	.02
Emmons et al. (2001)	Self-reported PP Abst. (3/6)	NA	NA	NA	NA
Hokanson, Anderson, Hennrikus, Lando, & Kendall (2006)	Self-reported PP Abst. (3/6)	.24	.09	.16	.17
Hollis et al. (2005)[a]	Self-reported PP Abst. (12/24)	.77	.73	.73	.69
Horn, Dino, Hamilton, & Noerachmanto (2007)	Self-reported PP Abst. (NA/6)	.05	NA	.03	.03
Hyman, Pavlik, Taylor, Goodrick, & Moye (2007)	Biol. Ver. PP Abst. (6/18)	.09	.06	.19	.10
Ingersoll, Cropsey, & Heckman (2009)	Biol. Ver. PP Abst. (3/NA)	NA	NA	NA	NA
Lipkus et al. (2004)	Self-reported PP Abst./Self-reported Cont. Abst. (4/8)	.16	.11	.09	.07
Persson & Hjalmarson (2006)	Self-reported PP Abst. (NA/12)	NA	NA	.20	.07
Prochaska et al. (2008)	Self-reported PP Abst. (NA/6)	NA	NA	.35	.19
Prokhorov et al. (2008)	Biol. Ver. PP Abst. (NA/10)	NA	NA	.16	.10
Rohsenow, Monti, Colby, & Martin (2002)	Biol. Ver. PP Abst. (1/6)	.13	.35	.02	.13
Smith et al. (2001)[a]	Biol. Ver. PP Abst. (1/12)	.45	.45	.19	.21
Soria, Legido, Escolano, López Yeste, & Montoya (2006)	Biol. Ver. PP Abst. (6/12)	.18	.04	.18	.04
Wakefield, Olver, Whitford, & Rosenfeld (2004)	Biol. Ver. PP Abst. (NA/6)	NA	NA	.05	.06
Wilson, Fitzsimmons, Bradbury, & Elborn (2008)	Biol. Ver. Cont. Abst. (NA/12)	NA	NA	.00	.00
Woodruff, Conway, Edwards, Elliott, & Crittenden (2007)	Self-reported PP Abst. (PT/12)	.35	.22	.37	.38

Note. Biol. Ver. Cont. Abst. = biochemically verified continuous abstinence; Biol. Ver. PP Abst. = biochemically verified point prevalence abstinence; MI = motivational interviewing; PT = posttreatment; Self-reported Cont. Abst. = self-reported continuous abstinence; Self-reported PP Abst. = self-reported point prevalence abstinence.
[a] Studies that included some nonsmokers in their sample. These studies were excluded from calculations of mean abstinence rates.

Table 4
Intervention Characteristics Subgroup Analyses

Moderator analysis	d_c	95% confidence interval	Z	Number of studies
MI duration				
1 hour or less				
Short follow-up	0.14	[−0.17, 0.45]	0.87	7
Long follow-up	0.33*	[0.02, 0.63]	2.10	8
1–2 hours				
Short follow-up	−0.01	[−0.35, 0.33]	−0.05	4
Long follow-up	0.06	[−0.29, 0.41]	0.32	5
More than 2 hours				
Short follow-up	0.17	[−0.04, 0.38]	1.57	5
Long follow-up	0.12	[−0.05, 0.30]	1.36	8
MI concentration				
Mixed				
Short follow-up	0.13	[−0.06, 0.31]	1.54	13
Long follow-up	0.15	[−0.02, 0.33]	1.69	16
MI alone				
Short follow-up	0.03	[−0.22, 0.27]	0.22	3
Long follow-up	0.14	[−0.10, 0.37]	1.15	5
MI includes pharmacotherapy				
No				
Short follow-up	0.09	[−0.09, 0.28]	1.01	10
Long follow-up	0.21**	[0.08, 0.35]	3.13	15
Yes				
Short follow-up	0.17	[−0.14, 0.49]	1.08	6
Long follow-up	0.07	[−0.22, 0.37]	0.48	6
MI includes skills				
No				
Short follow-up	0.07	[−0.11, 0.24]	0.74	14
Long follow-up	0.18*	[0.01, 0.35]	2.06	18
Yes				
Short follow-up	0.46**	[0.11, 0.82]	2.54	2
Long follow-up	0.05	[−0.26, 0.36]	0.33	3
MI training				
No				
Short follow-up	0.02	[−0.22, 0.26]	0.93	6
Long follow-up	−0.01	[−0.25, 0.23]	−0.08	6
Yes				
Short follow-up	0.18	[−0.04, 0.40]	1.59	10
Long follow-up	0.26**	[0.10, 0.43]	3.13	15
MI fidelity				
0				
Short follow-up	0.13	[−0.19, 0.45]	0.80	7
Long follow-up	0.20	[−0.04, 0.45]	1.63	10
1				
Short follow-up	0.09	[−0.21, 0.39]	0.57	3
Long follow-up	0.09	[−0.11, 0.28]	0.88	4
2				
Short follow-up	0.16	[−0.33, 0.65]	0.63	4
Long follow-up	0.23	[−0.27, 0.73]	0.89	5
3				
Short follow-up	0.13**	[0.03, 0.23]	2.60	2
Long follow-up	0.17	[−0.10, 0.44]	1.25	2

Note. d_c = combined effect size; MI = motivational interviewing.
* $p < .05$. ** $p < .01$.

effect sizes and 95% CIs for each tested moderator variable. Using this table, the reader can also make determinations regarding the magnitude of subgroup effects, which do not always overlap with statistical significance.

Moderator Outcomes: Participant Characteristics

Several subgroup analyses were conducted to determine the moderating impact of enrolling participants with certain characteristics on outcome, including severity of tobacco dependence, analyses of ethnoracial constitution, gender, motivation, intention to quit, and the presence of comorbid diagnoses. Table 5 provides detailed descriptions for each subgroup analysis. Only one participant characteristic was found to significantly moderate effect. Studies with international, non-U.S. samples had significantly larger effects than U.S. White and minority sample studies at short-term follow-up. Studies with international samples had sig-

nificant combined effect sizes at both short- ($d_c = .75$, $p < .01$) and long-term follow-up ($d_c = .43$, $p < .05$). Other subgroups also yielded significant combined effect sizes when analyzed separately. Those studies that included samples with low levels of tobacco dependence had significant combined effect sizes at both short- and long-term follow-up points ($d_c = .15$, $p < .01$, and $d_c = .24$, $p < .01$, respectively). Studies with participants who had low levels of motivation had significant combined effect sizes at both short- and long-term follow-up points ($d_c = .39$, $p < .05$, and $d_c = .34$, $p < .01$, respectively), as did those that included participants who were not required to indicate an interest in quitting as a condition of study enrollment at long-term follow-up ($d_c = .26$, $p < .01$). Studies with adolescent samples (under 18 years old) also had significant combined effect sizes at both follow-up points ($d_c = .15$, $p < .01$, and $d_c = .11$, $p < .01$). Finally, studies that included participants with medical comorbidities had significant long-term effect sizes ($d_c = .29$, $p < .05$).

Moderator Outcomes: Study Characteristics

Subgroup analyses investigating the moderating effects of comparison type did not reveal significant differences in effects across groups. However, studies in which MI was compared to a minimal active treatment had a significant combined effect size at the long-term follow-up point ($d_c = .27$, $p < .01$), and studies in which MI was compared with no treatment or an attentional or placebo control condition had significant combined effect sizes at both follow-up points ($d_c = .14$, $p < .01$, and $d_c = .11$, $p < .05$). Table 6 describes the results in further detail.

Moderator Outcome Methodological Quality

To determine the impact of methodological quality on outcome, meta-regression tools were used to plot methodological quality against effect size, and no clear break point at which effect sizes differed markedly from the mean was identified. In addition, subgroup analyses were conducted with the studies that had exceptionally high levels of methodological rigor (MQS $\geq$ 13; Baker et al., 2006; Borrelli, Novak, et al., 2005; Colby et al., 1998, 2005; Hollis et al., 2005; Soria, Legido, Escolano, López Yeste, & Montoya, 2006), and these studies were not found to have significantly higher effects than those with lower methodological quality.

Pregnant-Sample Effects

Most rigorous variable short- and long-term follow-up effect sizes for pregnant-sample studies can be seen at the end of Table 1. As can be seen in Table 2, the random-effects model combined effect size for short-term follow-up periods was $d_c = -.01$ [$-.17$, .15] (*ns*), and for long-term follow-up periods, it was $d_c = .15$ [$-.19$, .49] (*ns*). Effect-size estimates ranged from $d = -.41$ to .31 for short-term follow-up and $d = .11$ to .27 for long-term follow-up. Q tests for heterogeneity were nonsignificant, and I^2 values were zero, suggesting low levels of heterogeneity between studies (see Table 2). Moderator analyses were not conducted due to the low levels of heterogeneity and the small sample size of studies.

Discussion

The current investigation demonstrates that MI generally outperforms or does as well as comparison conditions for the treatment of tobacco dependence among nonpregnant samples. Effects were smaller among pregnant samples. Overall, the magnitude of MI's effect was modest, particularly when compared to the observed effects of MI for other conditions (Hettema et al., 2005; alcohol $d_c = .26$, drugs $d_c = .26$). Estimates of the magnitude of effect of MI on smoking are consistent with previous meta-analyses of MI (Burke et al., 2003; Dunn et al., 2001; Hettema et al., 2005; Lai et al., 2010). Subgroup analyses revealed that MI may show particular promise as follows: for individuals living outside the United States, adolescents, and those with medical comorbidities; for individuals with low tobacco dependence and motivation to quit; and when it is applied for a total of less than 1 hr and when the MI protocol includes training or fidelity practices. When delivered in conjunction with skills-based treatments, MI may produce especially favorable short-term outcomes, although this effect may diminish or reverse with time. Overall, the effect of MI on cessation appears to be consistent with effects and estimated abstinence rates observed for other types of counseling and behavioral therapies reported in the clinical practice guidelines (Fiore et al., 2008, Table 6.18).

Evaluation of the effects of MI should also consider dose response. The duration of time used to implement the intervention was approximately 17 times longer than comparison conditions in the current review. However, it may be the case that implementation of MI in the included studies exceeded the amount that is clinically necessary, as studies with administrations of MI that were shorter than 1 hr revealed significant effects, while longer administrations did not. It is also notable that the effects of MI observed within the current meta-analysis are lower than treatments of equivalent duration reported in the clinical practice guidelines (Fiore et al., 2008, Table 6.9).

Although the effects of MI on smoking may be small in magnitude, the intervention may still have significant public health impacts if implemented at the population level. For instance, based on the abstinence rates extracted for the current meta-analysis, if MI were provided to each of the United States' current 45 million smokers (Fiore et al., 2008), approximately 5.8 million would be expected to achieve long-term abstinence, as compared to 4.7 million who would do so with the aid of a comparison treatment.

Although high levels of heterogeneity were present in the current investigation, moderator analyses only revealed one significant difference between subgroups on measures of intervention, participant, or study design characteristics. Despite efforts to test a wide and comprehensive range of potential moderators, unexplained variance within the sample cautions that there may be important differences between studies that impact effect that were not revealed in the current review. While no significant differences between subgroups were found, examining the significance of effects within subgroups may provide some preliminary evidence regarding potential moderators of MI effect and inform the developing conceptual model of MI.

First, the present meta-analysis seems to provide support for the assertion that MI may be relatively more efficacious for those with low levels of motivation. In fact, studies that included samples with low levels of motivation had significant effect sizes that were approximately 2 to 3 times the overall effect of MI that was observed in the meta-analysis. These findings are consistent with the conceptual understanding of MI, which highlights the idea that the intervention is designed specifically for people who are low in

Table 5
Participant Characteristics Subgroup Analyses

Moderator analysis	d_c	95% confidence interval	Z	Number of studies
Dependence				
Low				
Short follow-up	0.15**	[0.05, 0.24]	3.09	3
Long follow-up	0.24**	[0.06, 0.41]	2.67	7
Medium				
Short follow-up	0.07	[−0.15, 0.28]	0.62	10
Long follow-up	0.16	[−0.08, 0.39]	1.30	10
High				
Short follow-up	0.16	[−0.77, 1.08]	0.32	3
Long follow-up	−0.06	[−0.67, 0.55]	0.85	4
Ethnoracial				
Minority majority				
Short follow-up	0.01	[−0.26, 0.27]	0.06	5
Long follow-up	−0.02	[−0.36, 0.33]	−0.09	4
White majority				
Short follow-up	0.07	[−0.11, 0.25]	0.78	9
Long follow-up	0.13	[0.01, 0.26]	1.85	11
International (non-U.S.) sample				
Short follow-up	0.75**	[0.32, 1.17]	3.44	2
Long follow-up	0.43*	[0.07, 0.79]	2.32	6
Gender				
Female majority				
Short follow-up	0.09	[−0.08, 0.27]	1.05	11
Long follow-up	0.16	[−0.01, 0.33]	1.90	15
Male majority				
Short follow-up	0.16	[−0.36, 0.68]	0.61	5
Long follow-up	0.13	[−0.31, 0.57]	0.57	6
Motivation 0–10				
Low (<6.5)				
Short follow-up	0.39*	[0.08, 0.69]	2.51	6
Long follow-up	0.34**	[0.10, 0.58]	3.25	8
High (>6.5)				
Short follow-up	0.09	[−0.19, 0.38]	0.42	5
Long follow-up	0.06	[−0.21, 0.34]	0.45	6
Intent to quit				
No				
Short follow-up	0.12	[−0.05, 0.28]	1.36	16
Long follow-up	0.26**	[0.09, 0.43]	3.00	12
Yes				
Short follow-up				0
Long follow-up	−0.07	[−0.32, 0.18]	−0.57	5
Age				
18 years or younger				
Short follow-up	0.15**	[0.06, 0.24]	3.14	6
Long follow-up	0.11**	[0.03, 0.20]	2.53	6
Older than 18 years				
Short follow-up	0.09	[−0.15, 0.34]	0.74	10
Long follow-up	0.19	[−0.03, 0.41]	1.73	15
Comorbidity				
None				
Short follow-up	0.11	[−0.08, 0.30]	1.12	9
Long follow-up	0.12	[−0.07, 0.30]	1.23	12
Medical				
Short follow-up	0.26	[−0.05, 0.58]	1.63	4
Long follow-up	0.29*	[0.04, 0.54]	2.30	6
Psychiatric				
Short follow-up	−0.04	[−0.78, 0.70]	−0.11	3
Long follow-up	0.07	[−0.84, 0.97]	0.14	3

Note. d_c = combined effect size.
* $p < .05$. ** $p < .01$.

Table 6
Study Design Characteristics Subgroup Analyses

Moderator analysis	d_c	95% confidence interval	Z	Number of studies
MI vs. intensive active treatment				
Short follow-up	−0.07	[−0.37, 0.23]	−0.47	6
Long follow-up	0.11	[−0.20, 0.43]	0.70	7
MI vs. minimal active treatment				
Short follow-up	0.29	[−0.08, 0.66]	1.55	4
Long follow-up	0.27**	[0.06, 0.48]	2.48	7
MI added to intensive active treatment				
Short follow-up	0.24	[−0.08, 0.56]	1.45	1
Long follow-up	0.15	[−0.25, 0.55]	0.74	1
MI added to minimal active treatment				
Short follow-up				0
Long follow-up				0
MI vs. literature, referral, or video				
Short follow-up	0.33	[−0.14, 0.81]	1.37	3
Long follow-up	0.30	[−0.15, 0.74]	1.29	4
MI vs. no treatment				
Short follow-up	0.14**	[0.04, 0.24]	2.79	2
Long follow-up	0.11*	[0.01, 0.20]	2.25	2

Note. d_c = combined effect size; MI = motivational interviewing.
* $p < .05$. ** $p < .01$.

readiness or ambivalent about making a change (Miller & Rollnick, 2002). Similarly, studies that did not require a desire to quit as a condition of enrollment revealed significant effects at long-term follow-up points. While the potential moderating effects of motivation within the current study are interesting, volunteers for smoking cessation studies may be more motivated to quit than the general population of smokers, which suggests that generalizing about the impact of motivation on the effect of MI in the population from the current meta-analysis may not be valid. In addition, subgroups were created based on characteristics that were measured at the study level, making assertions about the impact of individual characteristics prone to error.

Another factor that shows some early evidence of potentially moderating the effect of MI is the tobacco dependence of the sample. Several pieces of evidence suggest that those with lower levels of tobacco dependence may particularly benefit from MI. For example, studies that included participants with low levels of tobacco dependence and younger samples revealed significant effects of MI. Similarly, individuals who continue to smoke despite pregnancy may have higher levels of tobacco dependence, and the current meta-analysis revealed smaller effects among pregnant samples. Interestingly, effects of MI appeared to be slightly larger and more likely to be significant within subgroups at longer follow-up points, suggesting that the differential effects of MI may take some time to appear. This is inconsistent with the trend seen in previous reviews (Hettema et al., 2005). Finally, some subgroups that were found to have significant effects on outcome are difficult to explain using the developing conceptual model of MI and merit further investigation, including the significant effect sizes observed among studies that included international samples.

Another method of analyzing factors that may potentially moderate the impact of MI involves examining the characteristics of studies that found relatively small or large effects of MI. Several studies found particularly small or large effects; however, no clear participant, intervention, or study design characteristics stand out to us as potential explanations for these results, with the exceptions of general participant characteristics and outcome variable type. Rohsenow, Monti, Colby, and Martin (2002) demonstrated the largest negative effect sizes within the present analysis. This investigation was also the only study to examine the effect of MI among alcohol-dependent smokers. Ahluwalia et al. (2006) also exhibited a relatively large negative effect size. This study was conducted among light smokers who appeared especially motivated to quit smoking (means of approximately 9 on a 0–10 scale of motivation, compared to an average of 6.7). On the other hand, the effect size of Baker et al. (2006) was significant and relatively large. This examination used a sample of smokers with psychotic disorders. Finally, Soria et al. (2006) exhibited a significant and relatively large effect size. As noted by the authors, MI was implemented by the participants' usual medical care providers.

There are several limitations to the current meta-analysis that should be considered when interpreting results. First, the degree to which MI was administered as intended in this sample of studies is difficult to determine. Treatment fidelity is multidimensional (Borrelli, Sepinwall, et al., 2005), and authors of clinical outcome trials often fail to provide sufficient information to judge the type and quality of fidelity practices that were implemented. In fact, among the studies in the current meta-analysis, fewer than half reported engaging in any of the fidelity practices measured. In the area of MI, the limited research available on the topic of fidelity suggests that to achieve fidelity, providers need not only initial training but also posttraining competency assessments, ongoing fidelity checks, and ongoing support and corrective feedback (Miller, Yahne, Moyers, Martinez, & Pirritano, 2004). One recent analysis of treatment fidelity within an MI trial for smoking cessation revealed that, despite training efforts, levels of MI fidelity were low (Thyrian et al., 2010). However, interestingly, the same study found that proficiency in MI across providers was not predictive of outcome. Despite this evidence, fidelity to the MI approach is asserted to be an important factor within the literature. Only two

studies within the current meta-analysis reported engaging in the three suggested fidelity practices cited above, making the study prone to false interpretations regarding the significance of results.

Second, there are very few studies within the current meta-analysis that give a clear picture of the relative efficacy of MI by comparing it directly with another treatment approach. The presence of multiple treatment modalities, particularly pharmacotherapy, in both MI and comparison treatment conditions may lead to participant change, leaving little room for the impact of MI.

Third, several factors have been identified as potentially active components of MI, including eliciting and responding to change talk (Amrhein et al., 2003; Moyers et al., 2007, 2009). The current meta-analysis was unable to inform this literature as estimates of such behaviors or therapist behaviors thought be precursors of them within studies were not provided or readily extractable. It is possible that when applying MI to smoking cessation, providers are less likely to use those components of the intervention that are most active. It is also possible that providers giving brief advice or other forms of treatment that have been compared to MI in the current meta-analysis implemented some of the active components of MI.

A final limitation of the current study that warrants discussion is its ability to measure motivation or readiness to quit. Motivation is a construct that is central to the proposed mechanisms of action of MI, and the current clinical practice guidelines suggest that MI may be particularly appropriate for those with low motivation to quit. Unfortunately, there is a great deal of variability between studies in their use of instruments to measure motivation and reporting of motivation characteristics. We have attempted to characterize the average motivation level of study samples using a transformation procedure that has drawbacks, including concerns that reporting mean values of ordinal motivation scales ignores important heterogeneity within samples. Despite these limitations, such transformations commonly occur within the literature (e.g., Herzog, Abrams, Emmons, & Linnan, 2000; Herzog & Blagg, 2007; Nath, Herzog, & Brandon, 2002), and given the variability of measurement across studies, we feel it is the best available means of quantifying this important construct. To supplement these data, we also categorized studies based on intention-to-quit inclusion criteria, and subgroup analyses revealed similar findings across methods. This study did not include motivational constructs as outcomes in effect-size analyses, and future studies may wish to investigate whether MI acts on motivational constructs as its conceptual model might predict. However, the significance of such findings should be tempered by the impact of conceptually derived mediator variables on actual behavioral outcomes such as cessation.

Overall, MI appears to have some efficacy for smoking cessation across a diverse group of participants that is within the range of other behavioral interventions for tobacco dependence, though somewhat lower than expected given the duration of treatment. Subgroup analyses suggest that this finding generalizes across intervention administration styles, treatment populations, and research designs. Early evidence suggests that MI may be particularly efficacious for those low in motivation or with low levels of tobacco dependence, as predicted by some conceptual explanations of MI. Researchers are encouraged to continue to explore the efficacy of MI for smoking cessation, paying particular attention to potential moderating factors. In addition, researchers may wish to continue to investigate the importance of social or ecological models that place less emphasis on individual motivation or decision making and more emphasis on the role of the environmental or social context in promoting behavioral change.

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