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Efficacy of SMS Text Message Interventions for Smoking Cessation: A Meta-Analysis

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ABSTRACT

Background: Mobile technology provides new opportunities for health promotion communication. The purpose of this study was to conduct a current and extensive meta-analytic review of SMS (short message service) text message-based interventions for individual smoking cessation.
Methods: Academic Search Complete, PsycINFO, PubMed, and Scopus were reviewed for articles meeting selection criteria: 1) randomized controlled trials, 2) measured smoking cessation, and 3) intervention primarily delivered through SMS text messaging. Three and 6 month follow-up of 7-day point prevalence or continuous abstinence was considered from studies meeting criteria. All analyses were conducted with intention-to-treat. Both fixed and random effects models were used to calculate the global outcome measure and confidence intervals.
Results: Thirteen studies were identified that met inclusion criteria. The studies were found to be homogeneous [$Q_{12} = 12.47$, $p = 0.14$]. Odds ratios based on the random effects models suggested that interventions generally increased quit rates compared to controls, 1.36 [95% CI = 1.23, 1.51]. Intervention efficacy was higher in studies with a 3 month follow-up compared to 6 month follow-up. Text plus programs (e.g., text messaging plus Web or in-person intervention modalities) performed only slightly better than text only programs. Pooled results also indicate message frequency schedule can affect quit rates, in which fixed schedules performed better than decreasing or variable schedules. The use of quit status assessment messages was not related to intervention efficacy.
Conclusion: Smoking quit rates for the text messaging intervention group were 36% higher compared to the control group quit rates. Results suggest that SMS text messaging may be a promising way to improve smoking cessation outcomes. This is significant given the relatively wide reach and low cost of text message interventions. Identifying the components that make interventions efficacious will help to increase the effectiveness of such interventions.

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1. Introduction

Mobile phone technology for health promotion and disease prevention is a rapidly growing area of research. The development of mobile phone interventions (e.g., short-message service [SMS], multimedia message service [MMS], Internet, applications) is increasing with the widespread acceptance of cell phones. In 2014, an estimated 4.55 billion people worldwide will use a mobile phone, and 1.75 billion will use a smartphone (eMarketer, 2014). The growth and acceptance of mobile communication provides researchers with opportunities for delivering innovative health behavior change interventions.

Mobile phones have been utilized in numerous capacities in health research. They can be used to collect data or help people self-monitor (e.g., diet/exercise tracking), provide behavioral reminders (e.g., health service appointments, medication compliance), deliver medical test results, serve as boosters for in-person or Web applications, or as stand-alone behavior change programs (e.g., smoking cessation, decreasing alcohol consumption) (Cadmus-Bertram et al., 2013; Foreman et al., 2012; Free et al., 2011; Walters et al., 2014). Mobile technology also provides researchers with the versatility to target multiple behaviors for health promotion and disease prevention.

There are numerous benefits of mobile technologies for both researchers and mobile phone users who are interested in improving

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their health. For instance, mobile technology allows for direct interaction between practitioners and clients without the need for face-to-face contact (Fjeldsoe, Marhsall, & Miller, 2009). Researchers benefit from the use of mobile phone interventions because of their capability to collect and process large amounts of data efficiently, tailor messages based on user characteristics, and send time-sensitive information (Fjeldsoe et al., 2009; Whittaker et al., 2012). Mobile technology is also cost effective and easily scalable to large populations (Irvine et al., 2012; Whittaker et al., 2012). Mobile phone users benefit from the use of health technologies primarily because they are convenient and easy to use. Mobile technology can easily provide health information, distractions, triggers, and social support for behavior change. In addition, mobile communication provides a certain amount of anonymity and unobtrusive assessment regarding sensitive behaviors/attitudes (Fogg, 2003; Irvine et al., 2012).

Behavioral interventions delivered by mobile phone have targeted a broad array of health behaviors (e.g., diet, weight loss, smoking cessation, medication adherence, diabetes management) (Cole-Lewis & Kershaw, 2010). However, health promotion interventions delivered specifically through SMS text messaging have mostly targeted smoking cessation. For instance, Whittaker et al. (2012) conducted a meta-analytic review of mobile phone interventions (i.e., using any function or application sent via mobile phone) for smoking cessation. The review included five studies (N = 9,109) with 6 month follow-up data. Pooled results indicated that mobile phone interventions increased quit rates by 71% as compared to controls (RR = 1.71, 95% CI 1.47, 1.99). However, the authors indicated that future research is needed to identify specific intervention moderators that are associated with improved user outcomes. Another meta-analytic review conducted by Head, Noar, Iannarino, and Grant Harrington (2013) reviewed 19 SMS text message interventions (N = 5,137) for a variety of health promotion areas, including smoking cessation, diet, and weight loss. Pooled results of smoking cessation programs indicated that text messaging interventions were moderately effective, $d = .447$, at increasing quitting compared to control groups. Text message interventions for health promotion were generally more effective when they were tailored, personalized, and/or used a decreasing schedule of message frequency. These results suggest that it may be important to consider intervention moderators when delivering services in an efficient and cost-effective manner. Overall, these meta-analyses suggest that mobile phone interventions can be an effective option for individuals who are seeking to quit smoking; however additional research needs to be conducted to identify the most efficacious intervention moderators or components that lead to improved outcomes for smokers.

1.1. Intervention moderators

Despite the growing body of literature on text message-based interventions for smoking cessation, relatively little is known about which intervention moderators are most important in helping people quit smoking (Ybarra, Summers, Bagci, & Emri, 2012). Drawing from the broader literature, there are several possible moderators of text message interventions, including variations in content, scheduling, and the availability of other on-demand features. Each of these moderators may contribute to intervention efficacy (Head et al., 2013; Ybarra, Summers, et al., 2012).

Smoking cessation programs vary by intervention type (i.e., SMS only or SMS plus). Some programs only include messages sent via SMS, while others combine SMS with in-person or Web support programs. For example, Free et al. (2011) utilized an SMS text message only program, while Bock et al. (2013) gave smokers a 30-minute individual smoking cessation counseling session prior to randomizing participants to receive the text message intervention or non-smoking related messages. Head et al. (2013) found no difference in intervention efficacy between SMS only and SMS plus programs for health promotion behaviors. However, intervention type should be assessed individually for different behaviors that may require different levels of support for change to occur.

Smoking cessation programs vary by message frequency. For instance, many interventions adapt message frequency based on the quitting curve (i.e., high intensity messages at quit attempts, followed by a gradual reduction) (Free et al., 2011; Naughton, Prevost, Gilbert, & Sutton, 2012; Rodgers et al., 2005). For example, Naughton et al. (2012) utilized a decreasing message frequency schedule with the highest messages occurring around the person's quit date. Other programs utilized a fixed message schedule which delivered a relatively consistent number of messages per day across the intervention duration (Haug et al., 2013; Naughton et al., 2014; Shi, Jiang, Yu, & Zhang, 2013). Still other interventions use a dynamic message track depending on which stage the client is in currently (Bock et al., 2013; Borland, Balmford, & Benda, 2012; Haug et al., 2013). In sum, message frequency should be assessed to determine which schedule is most appropriate for smokers who want to quit.

Smoking cessation interventions vary by message direction and initiation. Some programs use only unidirectional messaging initiated by the researcher while others use bidirectional messaging to assess real-time quit status from smokers. This serves as a data collection tool that can be used to provide tailored messages based on a person's current stage of change (e.g., contemplation, action, maintenance) (Prochaska & DiClemente, 1982) or other factor. Individualized message tracks (i.e., tailoring message content based on smoking status or stage of change) are a particular strength of technology-based interventions; therefore, the majority of smoking cessation interventions utilize bidirectional messaging. For example, Haug et al. (2013) utilized weekly assessment messages such as “Have you recently smoked cigarettes?” and “How many cigarettes did you smoke this week?” as a way to tailor messages and gauge participant progress. Smoking cessation programs also vary based on who can initiate messages. Researcher-initiated messages often contain program intervention messages and assessment questions. User-initiated messages might contain requests for additional support or services (e.g., crave functions). Thus, it is important to assess message direction and initiation to determine their impact on overall intervention efficacy.

Smoking cessation interventions also vary depending on the format of message tracks. Fixed message tracks have one track for participants to follow; users cannot change the course of the intervention. Dynamic message tracks can change messages based on user assessments such as quit status or stage of change. For example, Free et al. (2011) utilized a fixed intervention track while Naughton et al. (2012) provided different message tracks to those in the smoking or non-smoking groups. Bock et al. (2013) created four message tracks based on the participant's stage of change, “not ready”, “prepare”, “quit”, and “relapse”. Thus, the use of fixed vs. dynamic message tracks may be an important predictor of intervention efficacy as dynamic tracks inherently provide more tailoring than fixed tracks.

Smoking cessation programs vary on the extent of message tailoring. Message tailoring utilizes personal characteristics (e.g., stage of change, coping, self-efficacy) to customize message content to a specific individual (Head et al., 2013; Petty, Barden, & Wheeler, 2009). It is generally accepted that message tailoring increases the relevance and salience of message content (Petty et al., 2009). For instance, Ybarra, Bagci, Korchmaros, and Emri (2012) created different content paths based on the participant's quit status. Likewise, Haug et al. (2013) tailored messages to participant demographic and smoking-related variables. Relatedly, targeted messages are customized based on shared characteristics of a population subgroup, such as gender, ethnicity, or location but not specific to one individual (Head et al., 2013; Petty et al., 2009). Message targeting increases the relevance of messages when content is specific to a certain population. For example,

Whittaker et al. (2011) provided indigenous Maori smokers with population-relevant messages, although the messages were not tailored to individuals. Thus, the extent of message tailoring is important to assess for program efficacy.

Finally, some smoking cessation SMS text message interventions provide on-demand messaging that allows participants to text a keyword (e.g., crave, help) in emergency situations to receive additional support (Bock et al., 2013; Borland et al., 2012; Haug et al., 2013; Naughton et al., 2012; Ybarra, Summers Holtrop, Prescott, Rahbar, & Strong, 2013). Participants receive immediate motivational support messages to help them cope with the craving or relapse. Some text message interventions also allow participants to connect with others for social support and encouragement (Bock et al., 2013; Free et al., 2009, 2011; Rodgers et al., 2005; Ybarra et al., 2013). For example, Rodgers et al. (2005) designed a "quit buddy" component that connected participants with other people who had similar characteristics and quit days.

In sum, text message interventions provide numerous benefits to researchers and participants. Previous review articles and meta-analyses suggest that text message interventions can be an effective behavioral change intervention for a variety of behaviors, and in particular smoking cessation. Yet relatively little is known about which program components are most useful in an SMS text message intervention for smoking cessation. Given the accelerated advancements in technology, it is important to assess the efficacy of text message interventions for smoking cessation and their intervention components as technology changes and opportunities grow. This study provides the most extensive review of text message interventions for smoking cessation to date. This meta-analysis extends previous reviews with broad inclusion criteria to capture additional relevant studies compared to previous reviews that used more stringent inclusion criteria. We also extend the literature by examining the impact of intervention moderators specific to smoking cessation programs. This meta-analysis assesses the efficacy of smoking cessation text message interventions, with specific attention to intervention moderators that may affect quit rates.

2. Materials and methods

2.1. Search strategy

The search strategy consisted of three steps. First, a comprehensive search of electronic article databases was conducted; databases included Academic Search Complete, PsycINFO, Health Source, Psychology and Behavioral Sciences Collection, PubMed, Scopus, and Web of Knowledge. The key search words utilized were smok* (e.g., smoke, smoking, smoker), tobacco, and SMS, text messaging, texting, *m*health, phone, mobile, or text messag*, and randomized/randomised controlled trial, controlled trial, or RCT. No date limit was included on the electronic search; all articles identified by October 2014 were considered for inclusion. Second, a review of the reference sections of previous reviews (Head et al., 2013; Whittaker et al., 2012) and included articles was conducted to identify articles that might have been missed in the database search. Third, a review of the grey literature was conducted searching several Web sites and publically available databases, RAND Publications, the Grey Literature Report of the New York Academy of Medicine, The Community Guide, the National Association of County and City Health Officials (NACCHO) Model Practices Database, and WorldCAT Dissertations and Theses.

Studies were included in the meta-analytic review if they met the following conditions: 1) targeted smoking cessation; 2) randomized participants to intervention and control/comparison groups; 3) delivered the main intervention primarily through text messaging; 4) included a follow-up measure of smoking abstinence, and 5) published in English in a scientific peer-reviewed journal. This search strategy resulted in 377 unique articles. The first and fourth authors reviewed all studies for inclusion criteria separately. The first round of coding resulted in a reliability of $\alpha = 0.86$. Authors then met to resolve any discrepancies until total agreement was reached. After careful examination of article titles and abstracts, 36 articles were downloaded and fully reviewed for inclusionary criteria. The resulting review revealed 13 articles that met inclusionary criteria.[1]

2.2. Article coding

The first author extracted information about study population characteristics (e.g., age, gender) and location. Potential intervention moderators were coded by the first and fifth authors separately. The first round of coding resulted in a reliability of $\alpha = 0.87$. Authors then met to clarify intervention moderator definitions and discussed discrepancies until total agreement was reached. Potential moderators included intervention type (i.e., text only or text plus additional intervention), message frequency (i.e., decreasing schedule, fixed schedule, and variable schedule), message direction and initiation, assessment of quit status messages, message track (i.e., fixed or dynamic), message content tailoring (i.e., targeted, tailored), availability of on-demand messages (i.e., help or crave functions for immediate messages), inclusion of social or peer-to-peer support functions, and the provision of nicotine replacement therapy.

2.3. Outcome measure

Smoking cessation studies typically utilize outcome measures such as 7-day point prevalence, continuous 6-month abstinence, and biologically verified saliva cotinine levels. In order to maintain consistency in the effect size calculations, 7-day point prevalence was selected as the primary outcome measure as 11 out of 13 studies reported these results. Two studies only reported continuous 6-month abstinence. Seven-day point prevalence abstinence was collected at multiple follow-up periods for many of the studies, for instance at 3 and 6 months. The primary model and moderator analysis included the longest follow-up period available. Four studies reported 3-month follow-up data (Naughton et al., 2012; Shi et al., 2013; Ybarra, Bagci, et al, 2012; Ybarra et al., 2013) and nine studies reported 6-month follow-up data (Abroms, Boal, Simmens, Mendel, & Windsor, 2014; Bock et al., 2013; Borland et al., 2012; Free et al., 2009, 2011; Haug et al., 2013; Naughton et al., 2014; Rodgers et al., 2005; Whittaker et al., 2011).

2.4. Effect size extraction and calculation

Odds ratios (OR) and log-OR with 95% confidence intervals were calculated to determine the efficacy of text message interventions for smoking cessation, as well as potential intervention moderators. Effect sizes were calculated with intention-to-treat analyses. When more

[1] Articles were discarded for various reasons: One hundred thirty-two (35.0%) articles did not target smoking cessation; 124 (32.9%) articles did not utilize a text message-based intervention for smoking cessation; 45 (11.9%) articles were systematic reviews or meta-analyses; 28 (7.9%) articles did not include randomization and/or a control group; 14 (3.7%) articles were duplicate trial data reported elsewhere; 10 (2.7%) articles were smoking cessation interventions not delivered primarily through text messaging or were multi-media interventions in which the effect of text messaging could not be isolated; 9 (6.3%) articles were commentaries or theoretical articles; 1 (0.3%) article provided smoking cessation messages to both the experimental and control groups; and 1 (0.3%) article did not report follow-up smoking abstinence rates.

than one intervention existed in the same study, the most potent text messaging intervention was utilized for analyses. Effect sizes were also calculated for each reported follow-up period to determine intervention efficacy over time.

2.5. Meta-analytic approach

A fixed effects model with inverse-variance weighting scheme was used to obtain an overall effect size. In this approach, it is assumed that all studies share a true effect size with minimal variation. A random effects model was also used, incorporating both between-study and within-study variability. Compared to fixed effects models, confidence intervals for random effects models tend to be wider, making them a more conservative estimate. The criterion for utilizing a fixed or random effects model can be determined based on the test of heterogeneity. If the heterogeneity between studies is not statistically significant, then the fixed effects model is a statistically valid model, but the conclusions from the meta-analysis should not be extended beyond the set of studies in consideration. Therefore, both fixed and random effects models are presented given that either of the two models is appropriate in this analysis. A publication bias analysis was conducted by generating and evaluating the symmetry of included studies in a funnel plot. A statistical test for publication bias was also performed as described by Egger, Davey Smith, Schneider, and Minder (1997). The Q statistic was calculated to determine the statistical significance of heterogeneity between studies. Natural log odds ratio was utilized to calculate the Q_B statistic for determining the statistical difference between effect sizes of intervention moderators. All analyses were conducted using packages “RMeta” and “Meta” in R-Studio with R version 3.0.1.

3. Results

3.1. Characteristics of individual studies

The search strategy resulted in 13 articles for inclusion in the meta-analysis. Text message interventions for smoking cessation were conducted in seven countries: four in the United Kingdom, three in the United States, two in New Zealand, and one each in Australia, China, Switzerland, and Turkey. The 13 articles resulted in a cumulative sample of N = 13,626. Participants were primarily adult smokers interested in quitting, six studies only recruited participants 18 and over, four studies recruited participants 15 and over, and three studies targeted adolescents and young adults (range 16–25). Mean participant ages ranged from 15 to 93 years with a mean weighted average of 35.1 years. Gender was evenly distributed among most studies; however, five studies reported disproportionate rates (Abroms et al., 2014; Borland et al., 2012; Free et al., 2009; Naughton et al., 2012; Shi et al., 2013).

Studies utilized various types of control conditions with varying intensities for comparison to text messaging-based interventions for smoking cessation. Only one study utilized an assessment only control group (Haug et al., 2013). Three studies only provided the control group with a self-help pamphlet for smoking cessation (Naughton et al., 2012; Shi et al., 2013; Ybarra, Bagci, et al., 2012; Ybarra, Summers, et al., 2012) while one study provided brief information on publicly available Web- and phone-based assistance for smoking cessation available in Australia (Borland et al., 2012). Three studies only provided control participants with biweekly generic study text messages describing the importance of participation and reminders for follow-up appointments (Free et al., 2009, 2011; Whittaker et al., 2011). Two studies provided control group participants with general information regarding publically available quitlines or Web sites for smoking cessation followed by generic study text messages regarding participation and follow-up appointments (Abroms et al., 2014; Rodgers et al., 2005). All participants in the Bock et al. (2013) study received a 30-minute counseling session and a quit smoking guide prior to randomization, the control group then received 8 weeks of daily motivational text messages not related to smoking cessation. Ybarra et al. (2013) also provided control participants with general health text messages but in a frequency similar to that received by the intervention group. Finally, Naughton et al. (2014) provided all participants regardless of randomization with routine smoking cessation advice by a healthcare provider and options for pharmacotherapy with the option for follow-up visits, but the control group did not receive any additional assistance.

A summary of the included studies and intervention moderator coding is provided in Table A.1. Approximately half ($k = 7$) of the text message interventions were SMS text plus programs combining text messaging with additional intervention modalities (e.g., individual counseling session, tailored self-help pamphlet, and video messaging), while 46% ($k = 6$) of programs reported using an SMS text only intervention. All text messaging interventions were automatically initiated by the researcher (with the exception of on-demand crave messages). All but one study ($k = 12$) offered bidirectional messaging that allowed for participants to respond to assessment messages and request craving support.

Sixty-two percent of studies ($k = 8$) utilized a tailored decreasing message frequency distribution based on the quitting curve, in which participants received the greatest number of messages around the quit attempt followed by a gradual reduction until the end of the program. Most of these programs ($k = 5$) also offered a preparatory phase of messages leading up to a quit attempt. Twenty-three percent ($k = 3$) of studies reported utilizing a fixed message frequency schedule which remained relatively constant across the intervention duration. The final 15% ($k = 2$) of studies reported a variable message frequency schedule, where participants could change between message tracks at any time.

Approximately half of studies ($k = 7$) included some sort of assessment messaging to evaluate quit status. The majority of studies ($k = 8$) utilized a dynamic message track that adjusted to an individual's quit status or current stage of change, while 38% percent of studies ($k = 5$) utilized a fixed message track in which participants were on the same fixed schedule of messaging. All studies implemented some sort of message tailoring or targeting; 62% ($k = 8$) used tailored messages only, 8% ($k = 1$) used targeted messages only, and 30% ($k = 4$) used both tailoring and targeting. The majority of studies ($k = 11$) provided participants with on-demand messaging for craving or relapse support. Thirty-eight percent of studies ($k = 5$) included a social or peer-to-peer support function for participants to communicate with each other. Finally, half of studies ($k = 7$) promoted the use of nicotine replacement therapy.

3.2. Intervention efficacy

Studies were not significantly heterogeneous ($Q_{12} = 12.47, p = .41$). Therefore, we report results for both fixed and random effects models. The fixed effects model indicated that smoking quit rates for the text messaging intervention groups were 37% higher compared to the quit rates for controls (OR = 1.37, 95% CI = 1.25, 1.50) (Fig. A.1.). The random effects model similarly reported a 36% increase in smoking cessation rates for text message interventions when compared to control (OR = 1.36, 95% CI = 1.23, 1.51). These effect sizes suggest that text messaging interventions are an effective means for reducing smoking. Due to the similarity in results between models, only the random effects model will be discussed in text (see Table A.2. for all results). An informal assessment of the funnel plot indicates that the included studies were symmetrical and the test assessing funnel plot symmetry was not significant ($p = .12$) also

indicating that there was no statistically significant publication bias in our meta-analysis.

3.3. Intervention moderators' efficacy

Intervention moderators were analyzed to identify differences between group effect sizes (see Table A.2.). First, we assessed the efficacy of text message interventions at 3 and 6 month follow-up. There were no significant differences between intervention efficacy over time ($Q_B = 0.46$, df = 1, $p = .49$); however, studies with a 3 month follow-up period showed a slightly higher efficacy compared to studies with 6 month follow-up data. These results indicate that intervention efficacy is consistent across 3 and 6 month follow-up periods but short-term intervention efficacy is slightly better.

Second, we compared smoking cessation interventions that provided only text messages ($k = 6$) to those that provided text messaging plus additional modalities ($k = 7$). There were no significant differences between intervention types ($Q_B = 1.66$, df = 1, $p = .20$), but text plus programs indicated a slightly higher pooled effect size. These results indicate that smoking cessation programs that include additional intervention modalities (i.e., individual counseling session, tailored self-help pamphlet, and video messaging) were not significantly more effective than those that only utilized text messaging.

Third, we examined the differences between messaging frequencies. There was no statistically significant difference between the three message frequencies: decreasing schedule ($k = 8$), fixed schedule ($k = 3$), and a variable schedule ($k = 2$), ($Q_B = 0.86$, df = 2, $p = .65$). However, interventions that utilized a fixed message schedule had the highest significant effect size (OR = 1.57, 95% CI = 1.14, 2.17) compared to a decreasing (OR = 1.34, 95% CI = 1.17, 1.54) or varied schedule (OR = 2.13, 95% CI = 0.44, 10.26). These results may suggest that using a consistent number of daily messages throughout the intervention period may increase intervention efficacy and prove to be the most effective messaging strategy.

Fourth, we compared text message interventions that implemented a fixed message track ($k = 5$) to those that used a dynamic message track ($k = 8$). We found no significant difference based on choice of message track ($Q_B = 1.03$, df = 1, $p = .31$). These results indicate that there is no particular benefit of utilizing a fixed or dynamic message track in terms of intervention efficacy.

Fifth, we examined the difference in effect sizes between studies that used message tailoring ($k = 8$), targeting ($k = 1$), or the use of both techniques ($k = 4$). While there was no significant difference between message content tailoring and targeting, ($Q_B = 1.15$, df = 2, $p = .56$), all studies utilized some type of message content tailoring. Pooled results indicated the use of message tailoring (OR = 1.51, 95% CI =1.17, 1.94) and the combined use of message targeting and tailoring (OR = 1.39, 95% CI = 1.25, 1.56) techniques were equally effective for increasing smoking cessation when compared to control groups. As only one study included only message targeting, there are no pooled results for this group, and it is difficult to determine the isolated effect of message targeting on smoking cessation.

Sixth, we compared programs that offered on-demand messaging services for additional support ($k = 11$) to those that did not provide crave/relapse support ($k = 2$). There was no significant difference between programs that offered on-demand messages and those that did not ($Q_B = 0.11$, df = 1, $p = .74$). While pooled results of studies not offering on demand messaging had a higher efficacy than studies that offered on demand messaging, this result was not statistically significant (OR = 1.50, 95% CI = 0.91, 1.55). These results may indicate that offering on-demand support messages can increase the intervention efficacy. However, information was not available regarding the actual use of the on-demand service from the included studies.

Seventh, we compared interventions that included assessment messages ($k = 7$) to those that did not assess for quit status or stage of change ($k = 6$). There was no statistically significant difference between interventions that utilized assessment messages versus those that did not ($Q_B = 0.69$, df = 1, $p = .41$). These results indicate that the use of assessment messages did not affect intervention efficacy.

Eighth, we compared text message interventions that provided a peer-to-peer support component ($k = 5$) to those that did not ($k = 8$). We did not find a statistically significant difference between studies that included a social support component and those that did not ($Q_B = 0.31$, df = 1, $p = .58$). These results suggest that a social support function does not significantly increase intervention efficacy. However, data regarding the actual use of the social support function was not available from all included studies.

Finally, we compared studies that promoted the use of NRT ($k = 7$) to those that did not ($k = 6$). While we did not find a significant difference between programs that allowed the use of NRT, ($Q_B = 0.75$, df = 1, $p = .39$), programs that did not utilize NRT (OR = 1.57, 95% CI = 1.14, 2.16) displayed a slightly higher effect size than those that allowed NRT use (OR = 1.34, 95% CI = 1.16, 1.53). These results indicate that text message interventions may be more effective without the use of NRT; however, information regarding the actual use of NRT is not available from all of the included studies.

4. Discussion

The purpose of this meta-analysis was to examine the efficacy of text message interventions for smoking cessation. We were particularly interested whether different intervention moderators affected subsequent quit rates. The results of this meta-analysis indicate that text message interventions are an effective means for reducing smoking. The overall random effects model indicates that text message interventions for smoking cessation increase the odds of quitting by 1.36 compared to quitting in control groups. These findings are similar to results found in other meta-analytic reviews of text messaging and mobile technology for health behavior change and smoking cessation (Head et al., 2013; Whittaker et al., 2012). Text message interventions also display comparable quit rates with other types of smoking cessation interventions: telephone quitlines can increase the odds of quitting by 1.6, counseling and behavior therapies, such as social support and practical counseling, increases the odds of quitting by 1.3 and 1.5, respectively, while NRT and medications can increase the odds of smoking cessation by 1.5 to 3.1 over placebo (Fiore et al., 2008). Our results indicate that text message interventions are as effective as other smoking cessation interventions, with the added benefit of being delivered at a presumably lower cost.

Our moderator analyses provided important insights regarding text messaging program components and their effect on smoking cessation. It is important to note that moderators are not randomly distributed across studies and thus are always confounded by the presence or absence of other moderators. Our results indicate that smoking cessation rates were generally consistent at 3- and 6-month follow-ups. However, pooled results of studies with 3 month follow-up data indicate a slightly better efficacy of short-term smoking cessation. Our results are consistent with those of Head et al. (2013) in which text plus interventions were not significantly better than text only interventions. This is an important finding for the development of future text message interventions for smoking cessation. Researchers and program developers may not need to include additional intervention modalities in order to obtain the same efficacy from text messages alone.

Based on a limited number of studies, we found some evidence that message frequencies utilizing a fixed message frequency may be the most effective strategy for smoking cessation. While this result was not significantly greater than the decreasing or variable message frequencies, it does provide an opportunity for future investigation. Our results also suggest that there may not be a benefit of utilizing a fixed or dynamic message track. This is an interesting finding considering that dynamic message tracks inherently provide more tailored information by varying the participants' messaging based on quit status or stage of change. However, the tailored messaging tracks did not significantly improve intervention efficacy when compared to fixed messaging tracks in this sample of studies.

In this meta-analysis, all studies utilized some type of content tailoring or targeting making it difficult to determine an effect between message tailoring and no tailoring. However, studies that utilized tailoring or a combination of tailoring and targeting exhibited similar efficacy for smoking cessation. These results are similar to those found by Head et al. (2013) in which the combination of targeting and tailoring techniques were the most efficacious, followed by message tailoring, while message targeting was not found to be effective. This method of content tailoring is particularly beneficial for use in text message interventions because it has the ability to provide tailored information on multiple levels (e.g., demographics, psychosocial variables).

Our results found that on-demand support messages did not increase quit rates. However, information was not available regarding the actual use of these on-demand services in the included articles. Therefore, results should be interpreted with caution, and further research is necessary to determine the exact relationship between on-demand support and quit rates. We also found that the use of assessment messages did not affect intervention efficacy and appeared to be unobtrusive in the quitting process. Assessment messages are an important component of text message interventions in order to obtain real-time participant updates and assess treatment fidelity. While the use of assessment messages did not increase quit rates, they also did not appear to negatively impact intervention efficacy through increased participant burden. Irvine et al. (2012) also found process measures collected during a brief text message alcohol intervention, which were unobtrusive and cost-effective.

Our findings also suggest the inclusion of a social support communication function did not significantly increase quit rates. However, these results should be interpreted with caution given that data regarding the actual use of the social support function were not available in the included studies. Further research into the importance of social support communication between smokers may provide promising avenues for future interventions. Finally, our results indicate that the promotion of NRT use did not significantly increase the quit rates among smokers. This could present a potential confounding variable when assessing text message intervention efficacy, however studies that did not encourage the use of NRT actually had slightly higher effect sizes than those that encouraged its use. Again, however, data were not available regarding the actual use of NRT in all of the included studies. Further research is necessary to determine to effectiveness of text message programs with the use of NRT. Treatment combinations (e.g., behavioral interventions with medications) have generally been found to be more effective than with one alone (Fiore et al., 2008).

Our results provide additional support for this increasingly popular area of using technology to increase smoking cessation. Due to the growing capabilities of mobile technology, text message interventions have the capacity to provide users with numerous program options, such as social support from peers, tailored message tracks and content, and on-demand support. This analysis of intervention components will inform future intervention design regarding which components are most effective at increasing quit rates.

4.1. Future research

Future research should focus on adaptive, tailored programming for text message interventions. Ecological momentary assessment (EMA) may provide a promising avenue for assessing smoking relapse risk and priming a text message program to intervene with additional support at the most appropriate time. EMA can be particularly useful for assessing cue-induced craving (Watkins et al., 2014). When EMA is used in conjunction with a behavioral intervention, the craving or relapse can be intervened upon and prevented in real-time. Watkins et al. (2014) utilized EMA to assess smoking urges and geo-spatial location via smartphones. Their findings suggest that closer proximity to tobacco outlets increased urges to smoke. By utilizing this kind of information as well as various other triggers, location, and psychosocial characteristics, text message programs can provide increasingly tailored support for smoking cessation.

4.2. Limitations

There were some limitations to this meta-analytic review. First, this review only included 13 studies, a small sample for a meta-analysis. For the moderator analyses, the sample sizes were even smaller when grouped by intervention moderator; hence it was difficult to detect some effects. It will be important to assess these intervention moderators again with a larger sample of text message interventions. Second, we mainly relied on information collected from the published article. This resulted in items being coded as not occurring if the component was not specifically mentioned in the article. For example, if NRT was not mentioned in the article it was coded as 'not promoting' the use of NRT. It is possible that some studies could have been misclassified if the article did not specifically reference the component. Data regarding the actual usage of the optional intervention components (e.g., crave messages, social support, NRT use) must be interpreted given that actual usage rates were not available for all of the included articles. Finally, it is further speculated that the explanation for non-significant results in the Q_B analysis was due to studies being too homogeneous. The test for heterogeneity as not significant and the similarity between studies could have led to non-significant results regarding the differences in effect sizes between moderator groups.

5. Conclusions

Our results add to a growing body of literature indicating that smoking cessation interventions via mobile phone are effective. The moderator analyses provide information for future research and text message intervention development. Moderators such as these will be important when developing new text message interventions that include the most efficacious design components. The benefits of mobile technology include the ease of use, cost-effective intervention delivery, the ability to tailor message content and timing to individual characteristics, and sending and receiving time-sensitive information. However, our results must be interpreted with caution given that the relatively small sample size and future research should assess a larger pool of text message interventions for smoking cessation.

Conflict of interest

None reported.

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Appendix A

Table A.1
Summary of SMS text messaging interventions.

Article	N	Outcome measure	Follow-up length	Intervention type	Message content type	Message track
Abroms et al. (2014)	503	7-day point prevalence	6 months	Text plus Emails and supporting Web site	Tailored Quit date, reasons for quitting, money saved, and use of NRT	Dynamic Messaging track dependent on quit success
Bock et al. (2013)	60	7-day point prevalence	6 months	Text plus 30 minute counseling session	Tailored Stage of change matched	Dynamic Messaging tracks dependent on current stage of change
Borland et al. (2012)	3530	7-day point prevalence	6 months	Text only	Both Stage of change matched and gender	Dynamic Messaging track dependent on current stage of change
Free et al. (2009)	200	7-day point prevalence	6 months	Text Only	Both Demographic information and concerns about quitting	Fixed
Free et al. (2011)	5800	7-day point prevalence	6 months	Text Only	Both Demographic information and concerns about quitting	Fixed
Haug et al. (2013)	755	7-day point prevalence	6 months	Text only	Both Demographic information and stage of change matched	Dynamic Messaging track dependent on current stage of change
Naughton et al. (2012)	207	7-day point prevalence	3 months	Text plus Tailored self-help pamphlet	Tailored 26 characteristics: motivation to quit, confidence, nicotine dependence, beliefs about harms	Dynamic Messaging track dependent on quit success
Naughton et al. (2014)	602	Continuous abstinence	6 months	Text plus Smoking cessation advice from primary care provider and tailored self-help pamphlet	Tailored 24 characteristics: motivation to quit, determination, nicotine dependence, reasons for quitting	Dynamic Messaging track dependent on quit success
Rodgers et al. (2005)	1705	7-day point prevalence	6 months	Text only	Tailored Preferences, smoking history, barriers to cessation	Fixed
Shi et al. (2013)	179	7-day point prevalence	3 months	Text plus Supporting Web site and online chatting	Tailored Stage of change matched	Fixed
Whittaker et al. (2011)	226	7-day point prevalence	6 months	Text plus Supporting Web site	Targeted Role model for video messages, message timing	Fixed
Ybarra, Bagci, et al. (2012)	151	7-day point prevalence	3 months	Text Only	Tailored Stage of change matched	Dynamic Messaging track dependent on quit success
Ybarra et al. (2013)	211	Continuous abstinence	3 months	Text plus Supporting Web site	Tailored Stage of change matched	Dynamic Messaging track dependent on quit success

(continued on next page)

Table A.1 *(continued)*

Article	Message frequency	Average number of messages sent	On demand messaging	Assessment messaging	Peer-to-peer support	Use of NRT
Abroms et al. (2014)	Decreasing schedule 5 on quit day 2 per day for 1 week 3 per week for 8 weeks 1 per week for 4 weeks	45 over 3 months	Yes	Yes	No	Yes
Bock et al. (2013)	Variable schedule Not ready —1 per day for 14 days Prepare—2 per day for 14 days Quit—4 per day for 2 weeks then 2 per day for 4 weeks	Unable to calculate Dependent on message track, variable over 8 weeks	Yes	Yes	Yes	No
Borland et al. (2012)	Variable schedule Participants could choose 3 different message frequencies	Unable to calculate Dependent on message track, variable over 6 months	Yes	Yes	No	Yes
Free et al. (2009)	Decreasing schedule 1 per day until quit 5 per day for 5 weeks 3 per week for 26 weeks	225 over 7–8 months	Yes	No	Yes	No
Free et al. (2011)	Decreasing schedule 5 per day for 5 weeks 3 per week for 26 weeks	225 over 7–8 months	Yes	No	Yes	Yes
Haug et al. (2013)	Fixed schedule 1–3 daily messages	58 over 3 months	No	Yes	No	No
Naughton et al. (2012)	Decreasing schedule 1–3 messages daily Highest during first 4 weeks then frequency reduced	80 over 11 weeks	Yes	Yes	No	Yes
Naughton et al. (2014)	Fixed schedule 0–2 daily messages	108 over 3 months	Yes	Yes	No	Yes
Rodgers et al. (2005)	Decreasing schedule 5 per day for 1 week pre-quit 5 per day for 4 weeks 3 per week for 4.5 months	199 over 6 months	Yes	No	Yes	Yes
Shi et al. (2013)	Fixed schedule 1 message per day	84 over 3 months	Yes	No	No	No
Whittaker et al. (2011)	Decreasing schedule 1 per day for 1 week pre-quit 3 per day for 5 weeks 3–4 per week for 2 weeks 1–2 per week for 20 weeks	136 over 6 months	Yes	No	No	Yes
Ybarra, Bagci, et al. (2012); Ybarra, Summers, et al. (2012)	Decreasing schedule 5 per day during 2 week pre-quit 9 quit day 1 less each day for the first week 2 per day for 2 weeks 1 per day for 1 week	119 over 6 weeks	No	No	No	No
Ybarra et al. (2013)	Decreasing schedule 4 per day during 2 week pre-quit 9 quit day 1 less each day for the first week 2 per day for 2 weeks 1 per day for 1 week	146 over 6 weeks	Yes	Yes	Yes	No

Table A.2
Effect sizes by categorical moderating variables.

		Fixed effects		Random effects			
	k	OR	95% CI	OR	95% CI	Q	Q_B
Combined	13	1.37	1.25–1.50	1.36	1.23–1.51	NS	
Follow-up period						NS	NS
3 month	4	1.58	1.06–2.36	1.57	1.05–2.35		
6 month	9	1.36	1.24–1.49	1.35	1.18–1.49		
Intervention						NS	NS
Text only	6	1.33	1.21–1.47	1.32	1.17–1.48		
Text plus	7	1.59	1.26–2.01	1.58	1.25–1.99		
Message frequency						NS	NS
Decreasing schedule	8	1.36	1.23–1.50	1.34	1.17–1.54		
Fixed schedule	3	1.57	1.14–2.17	1.57	1.14–2.17		
Variable schedule	2	1.32	0.99–1.76	2.13	0.44–10.26		
Message track						NS	NS
Fixed	5	1.33	1.19–1.48	1.28	1.08–1.52		
Dynamic	8	1.49	1.25–1.78	1.48	1.24–1.77		
Message type						NS	NS
Targeted	1	1.00	0.53–1.86	–	–		
Tailored	8	1.35	1.15–1.59	1.51	1.17–1.94		
Targeted/Tailored	4	1.39	1.25–1.56	1.39	1.25–1.56		
Messages on demand						NS	NS
Yes	11	1.37	1.24–1.50	1.36	1.21–1.52		
No	2	1.48	0.97–2.26	1.50	0.91–2.48		
Assessment messages						NS	NS
Yes	7	1.47	1.23–1.75	1.46	1.22–1.75		
No	6	1.34	1.20–1.49	1.30	1.09–1.55		
Social/Peer-to-Peer						NS	NS
Yes	5	1.35	1.21–1.50	1.32	1.07–1.63		
No	8	1.43	1.20–1.70	1.43	1.20–1.70		
NRT						NS	NS
Yes	7	1.35	1.23–1.49	1.34	1.16–1.53		
No	6	1.60	1.16–2.19	1.57	1.14–2.16		

k = number of studies, OR = odds ratio, CI = confidence interval, *Q* = measure of heterogeneity, *QB* = measure of effect size difference. NS = non-significant.

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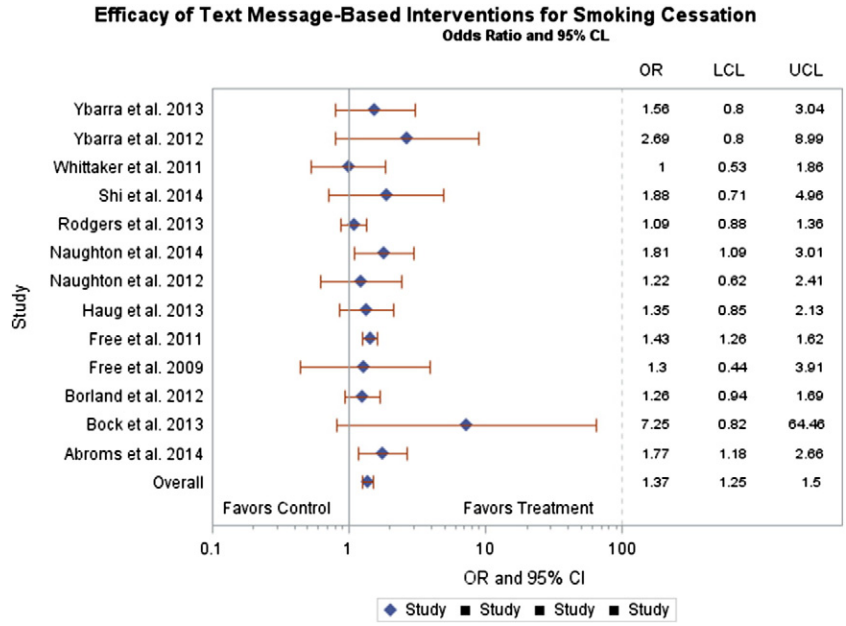

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