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Participant-Level Meta-Analysis of Mobile Phone-Based Interventions for Smoking Cessation across Different Countries

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Abstract

With meta-analysis, participant-level data from five text messaging-based smoking cessation intervention studies were pooled to investigate cessation patterns across studies and participants. Individual participant data ($N = 8,315$) collected in New Zealand (2001-2003; $n = 1,705$), U.K. (2008-2009; $n = 5,792$), U.S. (2012; $n = 503$; $n = 164$) and Turkey (2012; $n = 151$) were collectively analyzed in 2014. The primary outcome was self-reported 7-day continuous abstinence at 4 weeks post-quit day. Secondary outcomes were: (1) self-reported 7-day continuous abstinence at 3 months and (2) self-reported continuous abstinence at 6 months post-quit day. Generalized linear mixed models were fit to estimate the overall treatment effect, while accounting for clustering within individual studies. Estimates were adjusted for age, sex, socioeconomic status, previous quit attempts, and baseline Fagerstrom score. Analyses were intention to treat. Participants lost to follow-up were treated as smokers. Twenty-nine percent of intervention participants and 12% of control participants quit smoking at 4 weeks (adjusted odds ratio [aOR] = 2.89, 95% CI [2.57, 3.26], $p < .0001$). An attenuated but significant effect for cessation for those in the intervention versus control groups was observed at 3 months (aOR = 1.88, 95% CI [1.53, 2.31]) and 6 months (aOR = 2.24, 95% CI [1.90, 2.64]). Subgroup analyses were conducted but few significant findings were noted. Text messaging-based smoking cessation programs increase self-reported quitting rates across a diversity of countries and cultures. Efforts to expand these low-cost and scalable programs, along with ongoing evaluation, appear warranted.

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Conflicts of interest: Dr. Ybarra reports that the SMS USA program is publicly available at StopMySmoking.com. Dr. Lorien Abroms receives royalties for the licensing of Text2Quit from Voxiva Inc. Dr. Whittaker reports that Auckland Uniservices Ltd received a small amount of royalties from the licensing of STOMP program. Drs. Free and Jiang have no conflicts to declare.

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Introduction

Cigarette smoking continues to be a significant contributor to morbidity and mortality across the world¹⁻⁵ and accounts for 12% of all deaths among adults ages 30 years and older.⁶ In the United States (U.S.), despite notable declines in smoking rates since 1965, almost one in five adults (19.3%), aged 18 years and older, were current smokers in 2010.⁷ Among young adults, the rate was slightly higher at 20.1%.⁸ Rates in other English-speaking developed countries and cultures are comparable: Although smoking prevalence rates have decreased over the last fifty years in Great Britain, rates have remained stable at 20% of adults 16 years of age and older over the past several years.⁹ Rates among younger smokers are higher in Great Britain: More than one in four (29%) adults, aged 20 to 24 years, are smokers.⁹ Rates in New Zealand are slightly lower: Recent studies suggest that 17.2% of adults, aged 15 years and older, are current smokers.¹ In contrast, rates of cigarette smoking in Middle Eastern countries, such as Turkey, are higher. Almost one in three (31%) adults were current smokers in Turkey in 2008, although recent tobacco control efforts decreased prevalence to 27%.¹⁰

Across countries and settings, smokers express a desire to quit smoking.¹¹⁻¹⁷ Mobile phone-based smoking cessation programs that use text messaging to deliver content have emerged as an important tool in the arsenal of tobacco control efforts.¹⁸⁻³³ Text messaging overcomes structural issues (e.g., lack of services, transportation) of face-to-face programs. They are cost-effective and easy to scale up with the ever-increasing use of text messaging across the world. Reviews and meta-analyses suggest that text messaging-based programs are effective in affecting cessation and other health behaviors.³⁴⁻³⁹

Despite the growing evidence that text messaging-based smoking cessation programs can positively affect quitting rates, gaps in our knowledge remain. Firstly, our understanding is limited about for whom these programs work best, for example, whether these programs work better for heavier smokers than for lighter smokers. Second, while previous meta-analyses were based on analyses of overall effect sizes for each study and did not include analyses at the participant level,^{34,35,40} there is a dearth of meta-analyses that analyze data at the individual participant level. This methodology, sometimes referred to as “integrative data analysis” has several advantages, including the ability to better study the effects of participant subgroups and characteristics on outcomes, and is considered the gold standard of meta-analyses.^{41,42} As such, the purpose of this study was to pool data at the individual level across five text messaging for smoking cessation studies^{21,28,32,33,43} conducted in four different countries (U.S., United Kingdom [U.K.], New Zealand, and Turkey). Once pooled, data were analyzed for overall predictors of smoking cessation, the effects of subgroups on quitting, and the effects of specific text messaging-based interventions on quitting.

Methods

Five text messaging-based smoking cessation programs were included in the meta-analysis: STOMP in New Zealand,²⁸ txt2stop in the U.K.,²¹ Text2Quit⁴³ and Stop My Smoking (SMS) USA³³ in the U.S., and SMS Turkey in Ankara, Turkey.³² All studies were randomized controlled trials of interventions delivered primarily by text messages and

compared with respective standard care. Outcomes included point prevalence and continuous abstinence at approximately 4 weeks and 3 months post-quit day, depending on when the participant responded to the assessment. Individual study results have been previously published.^{21,28,32,33,43} Studies were included by convenience: All authors agreed to share their respective entire data sets with the current study's biostatistician. Moreover, at the time of that request, there were no other published studies of RCTs of stand-alone SMS interventions with similar cessation outcome measures. Thus, these five studies were the most similar in terms of design, outcomes, and intervention and therefore most amenable to inclusion in the integrative data analysis.

Table 1 provides an overview of each cessation program and its evaluation. Text2Quit was developed independently, txt2stop was adapted from the original STOMP program, and SMS USA and SMS Turkey were developed by the same research team. Inclusion criteria were similar across the five trials. Control programs varied (e.g., pamphlets, referral to existing services, unrelated and/or infrequent messages) but intent was similar (i.e., to provide an inactive representation of standard care). Participants received program messages most frequently during the first four weeks following the quit day, which then reduced in frequency and intensity for the rest of the intervention period. All were based on known effective cessation techniques (e.g., setting a quit day) and, to some degree, behavior change theories, including cognitive behavioral therapy.⁴⁴⁻⁴⁹ Points of difference include: the degree and methods for personalization and tailoring of the interventions, with Text2Quit being the most highly personalized program (e.g., messages include participant's first name, quit date, their top three reasons for quitting, money saved by quitting⁴⁰); the frequency and scheduling of messages, although all start prior to the scheduled quit day; and the inclusion of a relapse program, with the exception of STOMP.

Fidelity of Implementation

As reported previously,³³ allocation concealment was broken for the last 8 participants enrolled in SMS USA because of an imbalance in the arm allocations. Otherwise, the RCT was implemented as intended. In SMS Turkey, two serious issues with the software program were noted during the RCT³²: The software program failed to send at least one program message to 58% ($n = 44$) of intervention group participants; duplicate text messages were sent to 66% ($n = 50$) of intervention participants. Neither appeared to affect cessation rates. In the Text2Quit trial,⁴³ a significant proportion of those randomized were later excluded ($n = 1242$) because they did not provide handset verification via SMS, did not have a valid cell phone number, or the cell phone number given was a wrong number. Additionally, the control material was changed during the trial when the source of the control material (Smokefree.gov) began offering an SMS-based smoking cessation program. After this point, control group participants received an electronic brochure. There were no reported issues with the fidelity of implementing the STOMP and txt2stop interventions.

Measures

Smoking outcomes—The primary outcome was self-reported 7-day continuous abstinence at 4 weeks post-quit day. In each study, participants were asked whether he/she had ever smoked in the last seven days. Self-reported 7-day continuous abstinence at 3

months was also queried in four trials and is therefore a secondary outcome. Self-reported continuous abstinence at 6 months (i.e., whether a participant has smoked no more than five cigarettes since their quit day⁵⁰) was measured in two trials and is a secondary outcome. As described above, the actual timing of data collection for these measures are approximate and depend on when the participant responded to the survey request. For simplicity, we will refer to these measures by their main timeframe (e.g., 4 weeks post-quit).

Quit day was defined as the day after the participant's last cigarette or the nominated quit day.

Fagerstrom score—All studies included the 6-item Fagerstrom test⁵¹ for nicotine dependence, which is a standard instrument for assessing the intensity of physical nicotine addiction. Scores ranged from 0 to 10, with a score of 5 or more indicating a high level of nicotine dependence.

Socioeconomic status (SES)—SES was measured differently across studies. In each case, low/high SES was categorized using predefined cut-off points. Household income was collected in STOMP (<15,000 New Zealand dollar versus higher), SMS USA (<15,000 U.S. dollar versus higher), and SMS Turkey (<2,000 Turkish lira versus higher); education level was collected in Text2Quit (some high school/college versus higher); and age when the participant left full-time education in txt2stop (< 16 years versus older).

Statistical Analysis

Data analyses were performed on the principle of intention to treat using statistical software SAS version 9.3⁵² and R version 3.0.⁵³ Participants with missing smoking status were considered to be smokers in the analyses. First, descriptive summaries of baseline demographic and smoking characteristics were tabulated for each study as well as the combined sample. Heterogeneity across studies was tested in the fixed-effect model using the Mantel-Haenszel method⁵⁴ and in the random-effects mixed model using generalized linear regression with a binomial distribution. The overall treatment effect on primary and secondary smoking outcomes was evaluated using the multilevel mixed models, adjusting for predefined baseline confounding variables (i.e., age in years, biological sex, SES, previous quit attempts, and total Fagerstrom score). Individual studies were fitted as a random effect in the model to control for clustering of data. Adjusted odds ratios (aOR) and adjusted relative risks (aRR) were estimated using the logit and log links, respectively. The effects of intervention on specific subgroups of interest, sex, and level of nicotine dependence were estimated and tested using their interaction with the treatment groups in the main model (i.e., intervention × sex; intervention × nicotine dependence).

Results

A total of 8,315 randomized participants from the five individual trials were included in the meta-analysis: 4,202 participants in the treatment group and 4,113 participants in the control group. Participant characteristics within and across studies are shown in Table 2. The two groups were similar with respect to age, sex, SES, baseline number of previous quit attempts, and baseline nicotine dependence.

Descriptive Smoking Data

Compared to one in four participants in the treatment group ($n = 1,200$; 28.6%), one in ten in the control group ($n = 507$, 12.3%) reported smoking abstinence during the previous seven days at 4 weeks post-quit day (Table 2). The unadjusted relative risk (RR) was 2.32 ($p < 0.0001$). Among the four trials that measured 7-day continuous abstinence at 3 months post-quit, 29.4% of the participants in the treatment group ($n = 380/1,291$) reported not smoking, compared to 18.8% in the control group ($n = 231/1,232$) with an unadjusted RR of 1.57 ($p < 0.0001$). Based upon the two studies that measured continuous abstinence at 6 months post-quit, 13.1% of the participants in the treatment group ($n = 493/3,763$) versus 6.4% in the control group ($n = 237/3,734$) had quit smoking long-term with an unadjusted RR of 2.06 ($p < 0.0001$).

Smoking Cessation Outcomes

Heterogeneity of the treatment effect across studies was not supported by analyses: There was no significant interaction between treatment group and individual study in the random-effect mixed model using outcomes data at 4 weeks ($p = 0.32$), 3 months ($p = 0.34$), and 6 months ($p = 0.48$). Similar results were observed using the fixed-effect Mantel-Haenszel method for test of heterogeneity at 4 weeks (Chi-squared = 6.41, $p = 0.17$), 3 months (Chi-squared = 1.67, $p = 0.64$), and 6 months (Chi-squared = 0.28, $p = 0.60$). An overall treatment effect was therefore evaluated across all studies (i.e., the interaction term reflecting heterogeneity was therefore dropped from subsequent multivariate regression models).

Adjusting for age, sex, SES, previous quit attempts, and baseline Fagerstrom score, the odds ratio of 7-day continuous abstinence at 4 weeks was over 2.0 for four of the five studies included in the meta-analysis (Figure 1). Across studies, after adjusting for underlying differences in personal characteristics, those in the intervention groups were more than twice as likely as their control group peers (aOR = 2.89, 95% CI [2.57, 3.26]; aRR = 2.34, 95% CI [2.12, 2.58]) to report being abstinent in the past seven days at 4 weeks post-quit (Table 3). Although attenuated, the likelihood of cessation continued to be significantly higher for smokers with similar demographic and baseline smoking characteristics in the intervention versus control groups in the four studies that measured 7-day continuous abstinence at 3 months post-quit day (aOR = 1.88, 95% CI [1.53, 2.31]; aRR = 1.60, 95% CI [1.37, 1.87]). Findings persisted at 6 months post-quit in the two studies that measured long-term continuous abstinence (aOR = 2.24, 95% CI [1.90, 2.64]; aRR = 2.07, 95% CI [1.91, 2.40]).

Investigation of Outcomes by Subpopulations

Subsequent analyses suggested that men in the intervention group (aOR = 2.95, 95% CI [2.50, 3.48]) were just as likely as women (aOR = 2.83, 95% CI [2.39, 3.36]) to quit at 4 weeks post-quit (p value for the interaction term = 0.73; data not shown). Similarly no difference was observed between men (aOR = 1.66, 95% CI [1.20, 2.30]) and women (aOR = 2.05, 95% CI [1.56, 2.68]) at 3 months post-quit among the four studies that collected these data (p value for interaction term = 0.33). In the two studies that collected continuous abstinence at 6 months post-quit day, however, data suggested that intervention group men (aOR = 2.86, 95% CI [2.26, 3.61]) were more likely than women (aOR = 1.70, 95% CI [1.34, 2.16]) to achieve long-term abstinence (p value for interaction term = 0.002).

Differences in cessation rates at 4 weeks post-quit were not apparent for intervention group smokers with high (aOR = 2.95, 95% CI [2.51, 3.47]) versus low (aOR = 2.82, 95% CI [2.37, 3.36]) levels of baseline nicotine dependence as measured on the Fagerstrom score (p value for the interaction term = 0.72; data not shown). The trend at 3 months post-quit suggested that intervention group smokers with high levels of nicotine dependence (aOR = 2.29, 95% CI [1.71, 3.06]) might be more likely to quit than intervention group smokers with lower levels of dependence (aOR = 1.53, 95% CI [1.13, 2.06]; p value for interaction term = 0.06). In the two studies that measured continuous abstinence at 6-months post-quit, however, those with low levels of addiction may have been more likely to quit (aOR = 2.52, 95% CI [1.98, 3.21]) than those with high levels of addiction (aOR = 2.0, 95% CI [1.59, 2.51]), although the interaction term was not significant ($p = 0.17$).

Additional Characteristics Predictive of Quitting

Beyond exposure to text messaging-based smoking cessation programs, increasing age was slightly but significantly associated with 7-day continuous abstinence at 4 weeks post-quit (aOR = 1.01, 95% CI [1.01, 1.02], $p < 0.0001$; Table 3). On the other hand, trends suggested that as Fagerstrom score increased, the relative odds of quitting at 4 weeks decreased (aOR = 0.98, 95% CI [0.96, 1.00], $p = 0.07$). Patterns persisted for age (aOR = 0.99, 95% CI [0.98, 1.00]) and Fagerstrom score (aOR = 0.96, 95% CI [0.92, 1.01]) at 3 months post-quit day, although neither was statistically significant ($p = 0.1$). Both were significantly associated with quitting in the two studies that reported continuous abstinence at 6 months post-quit day, however (age: aOR = 1.02, 95% CI [1.01, 1.02], $p < 0.0001$; Fagerstrom score: aOR = 0.95, 95% CI [0.92, 0.98], $p = 0.003$).

Discussion

In one of the first individual-level meta-analyses of smoking cessation outcomes associated with text messaging-based programming, findings across four countries suggest that text messaging-based programs are associated with a two-fold increased odds of quitting. This is true for both short-term and long-term cessation. Findings are also persistent after adjusting for participants' sex, age, SES, smoking dependence, and previous quit attempts at baseline. Using the gold standard of meta-analyses,^{41,42} this study therefore adds to literature reporting positive cessation outcomes associated with text messaging-based interventions.^{34,35}

It is intriguing that control group quit rates increase in the short-term from 4-week to 3-month post-quit day across studies (12% at 4 weeks versus 19% at 3 months post-quit; Table 2). This does not seem to persist through 6 months, however. Perhaps because these control participants are unable to quit in the short term (i.e., at 4 weeks) and try again. While some may be briefly successful (i.e., at 3-month follow-up) they appear to be unable to sustain cessation over time (i.e., by 6-month follow-up). This is purely speculative, but the pattern deserves greater attention in future research. Indeed, it may be that control content, which by its nature is less intense, may invigorate cessation behavior (e.g., by resulting in people seeking out other methods of quitting) that could, for some smokers, represent an important opportunity to engage them before they experience another relapse.

Although not entirely clear, the findings suggest that perhaps, among those exposed to the intervention, men compared to women may be more likely to benefit from text messaging-based interventions and sustain long-term abstinence. The findings are also unclear about how nicotine dependence may moderate the intervention effect: In the short term, there is some suggestion that highly dependent people were more likely to quit; in the long term, there is some suggestion that lesser dependent people were more likely to quit. Nonetheless, these data highlight the importance for future research to examine when and for whom different types of cessation programs have more potential to invigorate cessation rates, particularly among subpopulations with higher smoking rates.

Limitations

Findings should be interpreted within the study limitations. Although long-term effects would have been the optimal outcome, the main outcome was at 4-weeks post-quit because this time point was measured in all of the studies. Only studies to which the biostatistician had access to the full data set were included. It is possible that findings may have been different if a larger number of studies had been included. Given the statement released by the National Institutes of Health on sharing research data,⁵⁵ it may be feasible to conduct such a study in the future.

Also too, a potential time effect was not taken into account in the analyses: Studies ranged in field from 2001 to 2012. This is particularly important for Turkey, New Zealand, and U.K., which were each at varying stages of implementing the World Health Organization's Framework Convention on Tobacco Control⁵⁶ during their respective randomized controlled trials. That said, in the analysis, “study” was fit as a random cluster effect. There was no observed difference between studies when it was also considered as a fixed effect in the model. This could indicate that there was no time effect associated with individual studies.

It should also be noted that in countries where text message interventions have been studied, a national tobacco control program of some kind had been implemented to varying degrees. There are yet to be any published trials in developing countries that have little organized response, including mass media, promoting the harms of smoking and benefits of quitting. The generalizability of the current findings to these lesser resourced environments is unknown.

Sample sizes (Range: 151-5,792) greatly varied between the trials. Given that the analyses are at the individual level, this limitation might be considered similar to subgroup analyses with varying sample sizes. Thus, data in the larger samples may have overshadowed those in the smaller samples in the same way that subgroup analyses may be underpowered in analyses where the subgroups are limited in sample size.

Furthermore, although outcomes were adjusted for several important characteristics (e.g., number of quit attempts, sex), other characteristics were not measured in the same manner across all studies (e.g., SES) or were excluded because each study used a unique schedule of assessments.

Additionally, although we were lacking in power to examine it, differences in study components (Table 1) might have possibly helped contextualize the results.

Also, as noted above, the comparison groups differed across the studies. This may have introduced bias to the pooled effect sizes, although this bias is unlikely to be more than is introduced in all meta-analyses that include studies with different study populations, inclusion/exclusion criteria, and intervention/control strategies. Indeed, the individual patient data analysis used in the current study could potentially improve the efficiency and reduce some bias compared to the summary level meta-analysis. Further research work may still be needed to evaluate the potential impact of different intervention and standard care strategies implemented in different studies on the size of overall treatment effect before this could be said definitively.

Finally, not all studies included in the meta-analysis used biochemical verification.²⁸ To align the data across studies, only self-reported cessation was used in the current study. Although self-report is vulnerable to misreporting, review groups have advised that in population-based studies with limited contact face-to-face, biochemical verification should not necessarily be seen as required nor desirable.^{57,58}

Next Steps

Despite some crossover (e.g., txt2stop was developed from STOMP; SMS USA and SMS Turkey were developed by the same research team), each intervention was developed in a different context and included unique content. This leads to interesting questions about the efficacy of specific program components and mechanisms of text messaging that support behavior changes, including smoking cessation: Is the actual content of the messages less important than the inclusion of key smoking cessation techniques (e.g., setting a quit day, preparing to quit) and a strong behavior change model, such as cognitive behavioral therapy? This is an important point for further research to explore. That said, we do not believe that simply reminding people of the importance of quitting smoking is enough to significantly affect quitting rates. Ybarra's team tested this directly in the SMS USA study using a control group that received the same number of messages as the intervention group.³³ Content provided guidance on quitting smoking within the context of improving one's sleep and fitness. Control messages were not based upon a theoretical model and also lacked key components known to invigorate cessation (e.g, preparing to quit, etc.). There is still much to be learned from this very simple technology with its minimal content. We encourage future trials to collect data about the mechanisms of action so that these may be included in future meta-analyses.

Aside from SMS USA, the studies used passive, low-contact control groups that may not have been blinded to their condition. Understanding how these programs compare to more active controls, including perhaps other smoking cessation programs (e.g., telephone quit lines), would help contextualize the relative impact of mobile health programming compared to other evidence-based smoking cessation options. Future research could also examine the potential impact of different frequencies and intensities of text messaging-based interventions on cessation rates.

Conclusion

In one of the first integrative data analyses of text messaging-based smoking cessation programming, multi-national data suggest that text messaging-based smoking cessation programs increase the chance of quitting. Efforts to expand these low-cost and scalable programs to other countries appear warranted, but should be combined with ongoing evaluation of impact. As the field of public health moves from proving the effectiveness of text messaging-based programs to exploring their optimization for specific population groups, an important next step will be to identify differences in effects. Such information could inform the development of interventions in different contexts and for priority groups, such as pregnant women, underserved populations, and individuals of low SES.

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Abbreviations

SMS	Stop My Smoking
SES	socioeconomic status
aRR	adjusted relative risk

Highlights

- This is the first multi-national, integrative data analysis of mHealth cessation programs.
- Cessation rates both short- and longer-term were higher for intervention than control.
- Increased short-term cessation in the control groups was noted across studies.
- Cessation rates were largely similar across subgroups suggesting similar effects.
- Efforts to expand mHealth cessation programs to additional countries appear warranted.

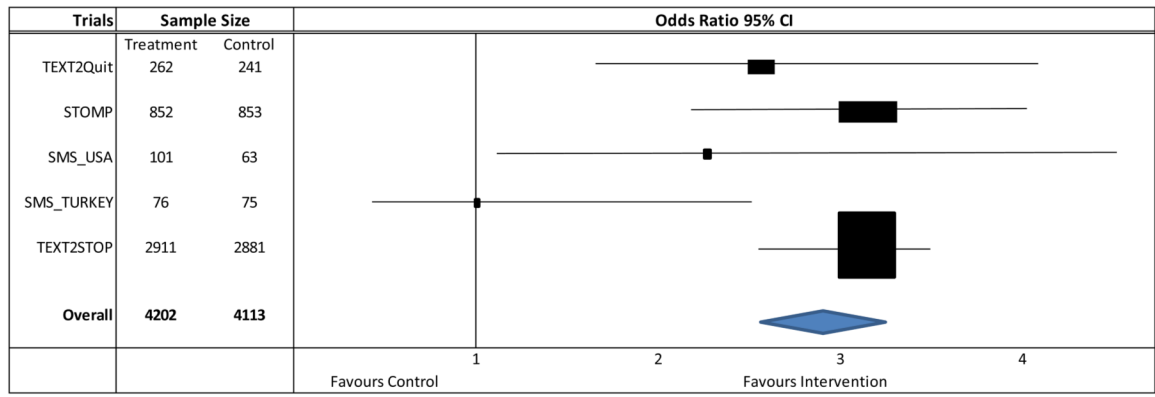


Figure 1. Forest plot of per-program adjusted odds ratios associated with 7-day continuous abstinence at 4 weeks post-quit

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Table 1

Description of Smoking Cessation Studies (n = 5)

	STOMP	SMS USA	SMS Turkey	txt2stop	Text2Quit
Year fielded	2001-2003	2012	2012	2008-2009	2012
4-week self-reported cessation					
Risk Ratio	2.23***	1.61*	1.07	2.43***	2.10***
Odds Ratio (95% CI)	2.72 (2.12, 3.50)	2.09 (1.06, 4.13)	1.08 (0.46, 2.56)	2.99 (2.60, 3.44)	2.59 (1.66, 4.03)
Participants	1,705 participants were randomized to the intervention (n = 853) or control group (n = 853)	164 young adults were randomized to the intervention (n = 101) or control group (n = 63)	151 participants were randomized to the intervention (n = 76) or control group (n = 75)	5,792 participants were randomized to the intervention (n = 2,911) or control group (n = 2,881)	503 participants were randomized to the intervention (n = 262) or control group (n = 241)
Inclusion criteria					
Age	Aged 16 years and older	Aged between 18 and 25 years	Aged 18 years or older	Aged 16 years or older	Aged 18 or older
Smoking frequency	Currently smoking cigarettes daily	Smoking 24 cigarettes or more per week (at least 4/day on at least 6 days/ week)	Daily smokers	Currently smoking cigarettes daily	Smoking five or more cigarettes a day
Quitting intention	Interested in quitting	Seriously thinking about quitting in the next 30 days	Seriously thinking about quitting in the next 15 days	Willing to make an attempt to quit smoking in the next month	Interested in quitting in the next month
Language/residency	English-speaking, living in New Zealand	English-speaking, living in the U.S.	Turkish-speaking, living in Ankara, Turkey	English-speaking, living in the U.K.	English-speaking, living in the U.S.
Text familiarity	Able to send and receive messages	Able to send and receive messages	Sent or received at least 1 text message in the past year		
Type of phone	Current owner of a Vodafone mobile phone	Owning a mobile phone	Owning a mobile phone	Owning a mobile phone	Owning a cell phone for personal use
Text plan		Currently or planning to enroll in an unlimited text messaging plan			Enrolled in an unlimited text messaging plan
Other		Agree to verification of smoking cessation status by a significant other	No chronic or serious illness		An email address for personal use
Other					Not being pregnant
Comparison/control group	One message every two weeks unrelated to quitting	Attention-matched on number and frequency of program messages. Content focused on the benefits of improving sleep and fitness to assist in quitting.	Quitting brochure	One message every two weeks unrelated to smoking	Occasional text messages encouraging user to visit http://smokefree.gov

Year fielded	STOMP	SMS USA	SMS Turkey	txt2stop	Text2Quit
	2001-2003	2012	2012	2008-2009	2012
Components					
Cessation support, motivation & tips	X	X	X	X	X
Smoking facts	X	X	X	X	X
On-demand tips to get through craving	X	X		X	X
Quit buddy	X (if requested)	X			
Polls & quizzes	X			X	X
Trivia messages for distraction	X				
Tailoring	Personalized to concerns at baseline (e.g., weight)	Type of message changes according to pre-quit, early quit, late quit, relapse, and post-quit	Type of message changes according to pre-quit, early quit, late quit, relapse, and post-quit	Personalized to concerns at baseline (e.g., weight)	Personalized to goals, reasons, triggers, social support, gender, money saved, medications used
Promotes use of helpline & nicotine replacement therapy	X	X	X	X	X
Relapse program					
Messages to check in on smoking status		Daily during quit week	2-day and 7-day post-quit		X
Schedule					
Pre-quit	1-2 weeks pre-quit: 1-2 text/day	2 weeks pre-quit: 3-5 texts/day	2 weeks pre-quit: 3-5 texts/day	1-2 weeks pre-quit: 1-2 text/day	2-4 weeks pre-quit: 8 texts/week. Week prior to quit day: 30/week
4 weeks post-quit	5/day	8/day on quit day, then reduced from 6/day to 1/day in the last week	8/day on quit day, then reduced from 6/day to 1/day in the last week	3-5/day	Week post-quit: 34, 2-3 weeks post-quit: 3/wk, 3+ weeks post-quit: 1/ wk
5+ weeks post-quit	5-24 weeks: 1 every 3 days 26 weeks			5-26 weeks: 1 every 3 days	4/month
Duration		6 weeks (depending on pathing)	6 weeks (depending on pathing)		3 months
Number of messages (core program)	Approximately 198	Approximately 140	Approximately 120	186	Approximately 120

Table 2

Participant characteristics within and across studies

	Overall (N = 8,315)		STOMP (N = 1,705)		Text2Quit (N = 503)		SMS USA (N = 164)		SMS Turkey (N = 151)		txt2stop (N = 5,792)	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Smoking behavior	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Age	33.6 (11.51)	33.66 (11.61)	24.86 (8.78)	24.64 (8.63)	35.85 (10.72)	35.53 (10.6)	21.63 (2.11)	21.56 (2.12)	36.13 (9.51)	35.64 (10.31)	36.31 (10.98)	36.38 (11.09)
Previous quit attempts	4.58 (8.17)	4.35 (7.86)	3.04 (2.55)	2.78 (2.42)	5.34 (7.07)	6.89 (16.14)	3.66 (1.61)	2.62 (1.69)	2.38 (1.51)	2.36 (1.53)	5.06 (9.42)	4.67 (7.94)
Fagerstrom score	4.63 (2.42)	4.62 (2.44)	4.6 (2.16)	4.52 (2.23)	5.36 (2.28)	5.3 (2.33)	3.92 (2.06)	3.83 (2.23)	1.87 (1.25)	1.96 (1.49)	4.67 (2.48)	4.68 (2.48)
Demographic characteristics	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Female	2062 (49.1)	1995 (48.5)	500 (58.7)	497 (58.3)	180 (68.7)	150 (62.8)	44 (43.6)	28 (44.4)	35 (46)	24 (32)	1303 (44.8)	1296 (45)
SES												
Low	1872 (44.6)	1830 (44.5)	364 (42.7)	349 (40.9)	165 (63)	152 (63.1)	46 (45.5)	32 (50.8)	23 (30.3)	37 (49.3)	1274 (43.8)	1260 (43.7)
High	2109 (50.2)	2068 (50.3)	267 (31.3)	289 (33.9)	97 (37)	89 (36.9)	55 (54.5)	31 (49.2)	53 (69.7)	38 (50.7)	1637 (56.2)	1621 (56.3)
Missing	221 (5.3)	215 (5.2)	221 (25.9)	215 (25.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Smoking outcomes	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
4 weeks (PP)												
Quit smoking	1200 (28.6)	507 (12.3)	243 (28.5)	109 (12.8)	80 (30.5)	35 (14.5)	44 (43.6)	17 (27)	13 (17.1)	12 (16)	820 (28.2)	334 (11.6)
Smoking	2794 (66.5)	3441 (83.7)	563 (66.1)	709 (83.1)	133 (50.8)	183 (75.9)	43 (42.6)	38 (60.3)	46 (60.5)	48 (64)	2009 (69)	2463 (85.5)
Missing	208 (5.0)	165 (4.0)	46 (5.4)	35 (4.1)	49 (18.7)	23 (9.5)	14 (13.9)	8 (12.7)	17 (22.3)	15 (20)	82 (2.8)	84 (2.9)
3 months (PP)	N = 1,291	N = 1,232										
Quit smoking	380 (29.4)	231 (18.8)	247 (29)	160 (18.8)	87 (33.2)	48 (19.9)	36 (35.6)	19 (30.2)	10 (13.2)	4 (5.3)	NA	NA
Smoking	691 (53.5)	842 (68.3)	499 (58.6)	628 (73.6)	123 (47.0)	159 (66.0)	45 (44.6)	32 (50.8)	24 (31.6)	23 (30.7)	NA	NA
Missing	220 (17.0)	159 (12.9)	106 (12.4)	65 (7.6)	52 (19.8)	34 (14.1)	20 (19.8)	12 (19)	42 (55.3)	48 (64)	NA	NA

NA = not applicable; measures are not available.

Table 3
Self-reported abstinence across studies

Timeframe	aOR (95% CI)	<i>p</i> value	aRR (95% CI)	<i>p</i> value
4-weeks post quit (<i>n</i> = 8,315)				
Intervention	2.89 (2.57, 3.26)	<0.0001	2.34 (2.12, 2.58)	<0.0001
Age (in years)	1.01 (1.01, 1.02)	<0.0001	1.01 (1.006, 1.014)	<0.0001
Female	0.99 (0.88, 1.11)	0.8124	0.99 (0.91, 1.08)	0.7904
High SES	0.94 (0.84, 1.06)	0.2971	0.96 (0.88, 1.04)	0.3064
Previous quit attempts	1.00 (0.99, 1.01)	0.7199	1.00 (0.99, 1.004)	0.7549
Fagerstrom score	0.98 (0.96, 1.00)	0.0748	0.98 (0.97, 1.00)	0.0640
3 months post-quit (<i>n</i> = 2,523)				
Intervention	1.88 (1.53, 2.31)	<0.0001	1.60 (1.37, 1.87)	< 0.0001
Age (in years)	0.99 (0.98, 1.00)	0.0862	0.99 (0.98, 1.00)	0.0715
Female	1.03 (0.83, 1.27)	0.8140	1.02 (0.87, 1.19)	0.8426
High SES	0.93 (0.75, 1.15)	0.4935	0.95 (0.81, 1.12)	0.5420
Previous quit attempts	1.00 (0.98, 1.02)	0.8292	1.00 (0.98, 1.01)	0.8523
Fagerstrom score	0.96 (0.92, 1.01)	0.0967	0.97 (0.94, 1.01)	0.1139

aOR = adjusted Odds Ratio; aRR = adjusted Risk Ratio. Six multivariate models are shown: two for each time point, one for odds and the other for risk ratio. Point estimates are adjusted for the five covariates included in the model

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