Effect of a mobile phone intervention on quitting smoking in a young adult population of smokers: results from a randomized controlled trial

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Abstract

Background: Digital mobile technology presents a promising medium for reaching young adults with smoking cessation interventions because they are the heaviest users of this technology.

Objectives: The primary aim of this trial was to determine the efficacy of an evidence-informed smartphone app for smoking cessation, Crush the Crave (CTC), on reducing smoking prevalence among young adult smokers in comparison to an evidence-informed self-help guide On the Road to Quitting (OnRQ).

Methods: A parallel, double-blind randomized controlled trial (RCT) with two arms was conducted in Canada to evaluate CTC. In total, 1599 young adult smokers (19 to 29 years old) intending to quit smoking in the next 30 days were randomized to receive CTC or the control condition OnRQ for a period of 6 months. The primary outcome measure was self-reported continuous abstinence at the 6 month follow-up.

Results: Overall follow-up rates were 55.5% and 58.3% at 3 and 6 months respectively. Forty-five percent of participants (n=725) completed baseline, 3 and 6 month follow-up. Intention-to-treat (last observation carried forward) continuous abstinence (n=1,599) at 6 months was not significantly different at 7.8% for CTC vs. 9.2% for OnRQ (OR = 0.83, 95% CI = 0.59-1.18). Similarly, 30-day point prevalence abstinence at 6 months was not significantly different at 14.4% and 16.9% for CTC and OnRQ respectively (OR = 0.82, 95% CI = 0.63-1.08); however, these rates of abstinence are favourable compared to unassisted 30-day quit rates of 11.5% among young adults. Secondary measures of quit attempts and the number of cigarettes smoked per day at 6 month follow-up did not reveal any significant differences between groups. For those who completed 6 month follow-up, 85.1% of young adult smokers downloaded CTC as
comparing to 81.8% of OnRQ, \( \chi^2 (1, N = 845) = 1.64, p = .23 \). Further, OnRQ participants reported significantly higher levels of overall satisfaction (M=3.3, SD=1.1 versus M=2.6, SD=1.3, \( t(644)=6.87, p < .0001 \)) and perceived helpfulness (M=5.8, SD = 2.4 versus M=4.3, SD = 2.6, \( t(657)=8.0, p < .0001 \)) as compared to CTC participants.

**Conclusions:** CTC was feasible for delivering cessation support but was not superior to a self-help guide in helping motivated young adults to quit smoking. CTC will benefit from further formative research. Digital mobile technology smoking cessation interventions may serve as useful alternatives to traditional self-care guides due to the widespread availability of mobile technology.
Background

Tobacco use among young adults remains a global public health issue as young adults continue to maintain high prevalence rates [1]. For example, compared to the national average of 13%, prevalence of smoking among young adults in Canada was 18.5% among those aged 20-24 in 2015[2]. Globally, smoking is responsible for taking approximately 6 million lives and costing about $500 billion per year[3]. However, quitting before the age of 40 significantly reduces the morbidity and mortality rates related to smoking[4], making young adults a priority for smoking cessation efforts.

Younger age groups have the highest quit attempt rates, which decline with age [2], indicating that young adults are a ripe audience for assisting smoking cessation. Compared to their older counterparts, however, young adults are reported to not use cessation interventions, including pharmacological or psychological treatments [5–7]. The lack of tailored cessation interventions for this age demographic has been cited as a major reason for this underutilization [7]. In addition, personal and societal values of independence and autonomy may influence the general trend of unassisted smoking cessation among young adults [2,8,9].

A promising new direction for reaching and engaging young adults in smoking cessation interventions is the use of mobile phones, particularly smartphone apps. Smartphone ownership among young adults aged 18 to 34 in both the U.S. and Canada is almost ubiquitous at 92% and 94% respectively [10]. It is not surprising then that young adults lead the way in downloading and using health apps [11], and are the most frequent users of health-related apps [12]. The advanced processing capabilities, global reach, and unmatched accessibility of smartphones render them ideal channels for delivering health-related interventions [13]. In addition, the
complex functionalities enabled in smartphone apps facilitates high user engagement, which is a strong predictor of smoking cessation [14]. Encouragingly, smartphone apps have shown to be particularly appealing to young adults for receiving cessation support [15]. In light of their growing popularity, many cessation apps are now available [14,16,17]. However, very few are based on evidence or theory or have been rigorously evaluated [18,19].

While there is a growing body of evaluative evidence on the efficacy and effectiveness of smartphone-based technologies for smoking cessation, this has largely been through small pilot studies. While most evaluative evidence consists of studies of text-messaging-based interventions for quitting smoking [20,21], the body of evidence in relation to apps specifically is nascent. Two recent systematic reviews focused on smartphone apps for smoking cessation. Haskins et al. identified 7 studies of smoking cessation apps and searched a 177 unique smoking cessation apps on the iTunes app store and 139 unique smoking cessation apps on Google Play. They concluded that of the top 50 apps from these leading app stores, only 2 had any published scientific support.[22].

A systematic review of 8 studies found mixed evidence as to the effectiveness of smoking cessation apps and observed that user engagement and adherence to app features influenced quit rates and that larger sample size studies are needed.[23] Two of the apps examined were supported by small randomized controlled trials[14,24] and one was an observational study[25]. Only one small study specifically targeted young adults aged 18 to 30, and the authors found that the smartphone app did not move smokers to quit as quickly as text messaging [24]. Another pilot study with older adults tested the efficacy of a smoking cessation app based on acceptance and commitment therapy and found that it was feasible to deliver a theory-based smartphone app; however, the quit rates were not significantly different between conditions [14]. The third
A small observational study tested a smoking cessation app based on behaviour change theory and found that participants were more likely to be abstinent from smoking for 28 days or longer as compared with the general smoking population [25].

One recent randomized control trial examined the effect of an evidence-informed decision-aid app on continuous abstinence at 1, 3, and 6 months among adults aged 18 and over who were motivated to quit [26]. The authors found that the decision-aid app, based on the Ottawa Decision Support Framework, significantly predicted abstinence at all 3 time points compared to the control app, which did not provide any structured process for considering options, benefits and harms of quitting methods, nor did it provide ongoing support of a decision [26].

Our aim was to conduct a large and methodologically rigorous evaluation of smartphone cessation technology to address the identified gap in the published literature. We compared the effects of an evidence-informed smoking cessation mobile phone app known as Crush the Crave (CTC) with a self-help booklet on reducing smoking prevalence among young adult smokers after 6 months. The mobile phone app was hypothesized to yield higher rates of continuous abstinence, 30-day PPA, 7-day PPA, quit attempts, and reduction in consumption of cigarettes. The current trial is the first that we are aware of to assess the efficacy of a quit smoking app that specifically targets young adults in a full-scale, longer-term trial.

Methods

Study Design

The study was a 6 month, 2-arm, parallel, randomized controlled trial conducted in Canada with participants assigned with an equal probability to the mHealth intervention, CTC, or to the self-help booklet. Investigators, data collectors and participants were blinded as to the group
assignments. Follow-up was conducted at 3 and 6 months post randomization. A superiority trial design was used [27] and the protocol was in accord with the CONSORT-EHEALTH checklist [28]. See Figure 1 for a CONSORT diagram of the proposed study design. A complete description of the study protocol has been published elsewhere [29].

Participants and recruitment

Participants were eligible if they were between the ages of 19 and 29, smoked cigarettes daily, resided in Canada, were considering quitting smoking in the next 30 days, had an Android (Version 2.0 to 5.0) or iPhone (Version 4.0 to 7.0) smartphone, were able to provide informed consent, were able to comprehend English, and were not referred to the study by an existing study participant – a friend or family member already participating in the study – to avoid possible contamination bias.

Recruitment sources were primarily online media and included: 72% from Facebook ads, 24% Google ads, and 4% from other sources (an online classified message board and off-line recruitment through a commercial survey panel). Interested young adults were referred to a website describing the trial. Potential participants were screened at the entry web-page where their eligibility was determined, informed consent was sought, and registration for the trial took place. Participants who met the inclusion criteria and consented to participate completed the online baseline questionnaire and were then randomly allocated to either the control or
intervention arm and were sent a computer-generated email message confirming registration and instructions for downloading their randomly assigned quit smoking program. Participants were sent a reminder email at one month after completing the baseline questionnaire to download the assigned program, if they had not already done so. Participants were provided a $35 incentive for registering for the trial and a raffle of an iPad Air tablet was used as an incentive to complete 6 month follow-up.

Interventions

Crush the Crave

The intervention group received a comprehensive and evidence-informed smoking cessation smartphone app, Crush The Crave (CTC). CTC was developed in early 2012 by a team of population health researchers, social media experts and computer programmers as an evidence-informed quit smoking smartphone and social media app for young adults ages 19 to 29 [29]. CTC enabled users to customize a quit plan by choosing a quit date and then deciding whether to quit immediately or reduce the number of cigarettes they smoke every week up to their quit date. CTC then assisted smokers in staying on track by reminding them of how much money they had saved and how much their health had improved over time after quitting. Based on contingency reinforcement, milestones were tracked as rewards, which smokers could choose to share with their social network via Facebook and Twitter, and rally support from friends and family. Participants could also link to the CTC Facebook community for additional support for quitting. Users of the app received supportive text messages via the app tailored to their specific quit plan and where they were in the quitting experience. Participants could also record when, where and why they were smoking in order to understand the triggers and psychosocial factors related to smoking. The app provided both graphic and tabular performance feedback, online distractions
to help deal with cravings, evidence-informed information for assisting smokers on topics such as relapse and dealing with cravings, push notifications on rewards received and helpful reminders to continue to use the app, access to evidence-based cessation services such as smoking cessation quitlines and information on the use of nicotine replacement therapy.

Recently, Ubhi and colleagues conducted a review of 137 smoking cessation apps for the presence or absence of evidence-based behaviour change techniques and CTC addressed four out of five behaviour change strategies as compared to an average of only one across the 137 apps reviewed. They also assessed CTC as having an ease of use score of 95% which was the same as the average of all apps reviewed and 82% for engagement compared to only 45% overall[30]. A more fulsome description of the development of the CTC app is available elsewhere[31].

Self-help booklet

The control group received a standard, print-based self-help guide known as On the Road to Quitting[32] that was developed by Health Canada for young adult smokers. Participants were able to both view and download the self-help guide via the internet and request a printed version of the guide. Forty-seven percent of participants allocated to the control group requested a printed version of the guide. The guide contained similar content to the CTC app. It contained information on the health benefits of quitting, the monetary rewards of quitting, smoking triggers, suggestions on how to deal with withdrawal and cravings, setting a quit date or quitting ‘cold turkey’, seeking counselling or NRT, linking to a social support network of family or friends, telephone quitline support, preventing weight gain, and dealing with slip-ups or relapse.
**Study Procedures**

All study procedures were reviewed and approved by the clinical research ethics review committee of the University of Waterloo (Full ethics clearance October 29, 2013, 19275).

**Randomization and Blinding**

Participants had an equal probability of being allocated to intervention or control group using a computer-generated simple randomization procedure. Participants were blinded as to group allocation and were not aware as to which was the control and intervention condition. Investigators were blinded to group allocation until completion of the trial after initial analysis of the primary and secondary outcomes.

**Data Collection**

Baseline data were collected via a self-administered, online questionnaire completed by all consenting participants in both intervention and control groups from July 2014 to March 2015. The baseline questionnaire included the following demographic items: age, gender, ethnicity, marital status, education, income, and employment status. Variables related to tobacco consumption included: current smoking status, amount smoked, and number and duration of past quit attempts, and the degree of nicotine dependence. Participants were also asked a series of psychosocial questions, including beliefs and attitudes about quitting, self-efficacy or confidence in quitting, perceived stress and social support, and social norms related to smoking. Furthermore, participants were asked about experience with smartphone apps and self-help, use of NRT, e-cigarette use, and other cessation aid or supports, such as quitlines.

Follow-up data were collected from the same participants at 3 and 6 months post-randomization in the same manner as the baseline. In addition to the questions asked at baseline, participants were asked core smoking status questions. Participants were also asked questions on nicotine
withdrawal, level of support received from friends and family for quitting smoking, use of e-cigarettes, additional cessation services that they sought for help to quit, overall satisfaction with the app or self-help guide, use of and opinions and beliefs about the app and the guide, and challenges they experienced in quitting smoking.

A modified Dillman method[33] for follow-up of participants completing the online survey questionnaires was used and up to 10 attempts (email) were made to reach participants if they did not complete the online questionnaire within two weeks of 3 and 6 month follow-up periods. Participants who did not complete 3 or 6 month follow-up questionnaires were contacted by telephone and up to 10 attempts were made to collect smoking status at 3-month, 6 month follow-up, or both. Following the intention-to-treat principle, participants were analyzed in the groups to which they were allocated, regardless of whether they received or adhered to the allocated intervention[34]. All instruments were piloted with a convenience sample (n=10) that comprised an equal number of male and female young adult smokers.

Measures

The primary outcome measure was continuous self-reported abstinence defined as having been abstinent for 3-months post baseline[35]. Secondary outcome measures were: self-reported 30-day point prevalence abstinence (PPA) from smoking at 3 and 6-months, operationalized as not having smoked any cigarettes, even a puff, or used other tobacco in the last 30-days[36]; 7-day PPA at 3 and 6-months[36]; the number of quit attempts – “How many times did you stop using tobacco for 24 hours or longer?” over the past 3 and 6-months[37]; and, the reduction in consumption of cigarettes at 3 and 6 months – “On average, how many cigarettes do you smoke
per day on the days that you smoke”[36]. Biochemical validation of smoking status was not done.

Secondary measures included nicotine dependence using the two-item Heaviness of Smoking Index (HSI) from the Fagerstrom Test for Nicotine Dependence that combines the number of cigarettes smoked per day and the time to first cigarette in the morning[38]. High scores on the HSI indicate higher levels of addiction and greater difficulty in quitting. HSI was categorized as low (scores of 0 to 2), medium (scores of 3 and 4), and high (scores of 5 and 6). Self-confidence in quitting was measured using a 5 item Likert scale from 1 ‘not at all’ to 5 ‘extremely’ and the question “How confident were you in your ability to quit smoking?” [39]. Perceived stress was measured with four question items on feelings of control and ability to handle personal problems using 5 item Likert scales of 0 ‘never’ to 4 ‘very often’ and totalled to create a score [40]. Stress was categorized as low (scores of 0 to 6), medium (scores of 7 to 9), and high (scores 10 to 16). Current and past use of NRT and e-cigarettes were measured with the question “Did you use or are you currently using NRT/e-cigarettes to help you quit smoking?” with a yes/no response option to current use and past use. A partner who smokes was measured by asking the question “Does your partner, spouse, or significant other currently smoke?” and number of friends smoking was measured by asking “Of the five closest friends or acquaintances that you spend time with on a regular basis, how many of them are smokers?” Social Support was measured with 3 question items on feelings of support from family and friends using 5 item Likert scales of 1 ‘not at all’ to 5 ‘extremely’ and totalled to create a score [39]. Support was categorized as low (scores of 3 to 8), medium (scores of 9 to 11), and high (scores 12 to 15).

Process measures included having downloaded the intervention and measures of use, satisfaction and helpfulness at 3 and 6-months. Participants completed a brief satisfaction instrument that
included four 5-point Likert scale items such as “I used the program frequently” and “I thought the program was easy to use”, with response choices that ranged from “strongly agree” to “strongly disagree” [41]. Perceived overall satisfaction was measured on a 5-point Likert scale that ranged from “not at all satisfied” to “very satisfied” and helpfulness was measured on a 10-point scale that ranged from “not at all helpful” to “very helpful”.

Sample Size

Sample size calculations were based on the difference in the objective measure of the primary outcome event – continuous abstinence from smoking – between intervention and control groups. Assuming a ratio of 1:1 for intervention to control subjects, an alpha of 0.05, power of 80%, and an effect size equal to 10% in the intervention versus 6% in the control condition for self-reported continuous abstinence – the required sample size was 800 per group for a total of 1,600 participants using a two-tailed test on proportions [42].

Statistical Analysis

Demographic and smoking characteristics (e.g., HSI, use of e-cigarettes, self-confidence to quit, etc.) were compared between groups at baseline using a $\chi^2$ test of association or a Fisher’s exact test for binary variables. All participants were analysed in the study arm to which they were randomized.

Logistic regression was used to test between group comparisons on the primary outcome variable continuous abstinence and the secondary outcomes 7-day and 30-day PPA at 3 and 6 month follow up. For comparisons of secondary continuous outcomes (number of quit attempts and cigarettes per day) that did not meet normal distribution assumptions, a non-parametric Mann-Whitney test was conducted. For the process measures of having downloaded the intervention,
frequency of use, satisfaction and helpfulness, a $\chi^2$ test of association was applied to binary and categorical variables and for the ordinal variables approximating a normal distribution, a t-test for independent groups was applied.

The intention-to-treat principle was followed for the analysis of continuous abstinence and the outcomes 30-day and 7-day PPA using three approaches to handle missing information about smoking status: 1) imputation using the baseline observation carried forward or classifying non-responders at 3 and 6 months as smokers in accordance with the Russel standard[35]; 2) imputation using the last observation of smoking status carried forward for non-responders at 6 months; and, 3) multiple imputation (n=18) by chained equations which used the observed predictors of outcome and the predictors of loss to follow-up to impute missing outcome data to correct for any potential bias caused by missing data [43]. The imputation model included age, gender, education, province, marital status, ethnicity, income, heaviness of smoking, self-efficacy, perceived stress and intervention group. In addition, a complete case analysis was done in which any participants with missing information on any outcome were excluded. Finally, a sub-group analysis was undertaken for key demographic, smoking and cessation characteristics, social support, and use of intervention variables to assess homogeneity in treatment effects using logistic regression. Tests were two-sided and statistical analyses were completed using SAS 9.4.

Results

Participants were enrolled from July 4, 2014 to March 31, 2015. Follow-up was completed in October, 2015. As shown in Figure 1, 4,269 completed the online screening survey, of whom 2,670 were excluded because they did not meet the inclusion criteria, did not consent to participate, did not complete the baseline intake survey, or provided no contact information.
Participants with repeat logins from the same IP address were recorded and excluded. In total, 1,599 young adult smokers were eligible and consented to participate. Participants were randomly allocated to the CTC intervention condition (n=820) or the On the Road to Quitting (OnRQ) self-help control condition (n=779). The survey follow-up rates were 55.5% and 58.3% at 3 and 6 months respectively. Forty-five percent of participants (n=725) are considered complete cases having completed baseline intake, 3 and 6 month follow-up for the primary outcome (see Figure 1), without any significant difference between the intervention and control conditions in follow-up proportions [43.2% vs. 47.6%, χ2 (1, N =1,599) = 3.20, p = .08].

The intervention and control groups were balanced with regard to demographic, behavioural, and social support characteristics at baseline as well as at 6 month follow-up (see Table 1). Further, there was no significant difference between conditions among participants lost to follow-up confirming no apparent differential attrition between conditions [44]. Overall, the majority of participants were male 54.1% (858/1587), Caucasian 75.1%(1168/1556), had post-secondary or higher education 55.2% (878/1590), and incomes of less than $45,000 (65.1%(941/1445)). At baseline, 26.8% (424/1581) of participants had moderate to high nicotine dependence and 25.7% (408/1589) smoked a pack of cigarettes per day or more. In addition, 52.8% (843/1599) were currently using or had used nicotine replacement therapy (NRT) in the past and 60.8% (972/1599) were currently using or had used e-cigarettes in the past. Thirty-two percent (478/1486) reported a high level of social support at baseline while 84.7% (1321/1560) reported having two or more friends that smoked and 28.7% (457/1593) reported living with a partner who smokes (see Table 1).
Smoking Cessation

Table 2 shows the primary and secondary smoking cessation outcomes after 3 and 6-months for intention to treat (n=1,599) and complete cases (n=725). Intention-to-treat (baseline observation carried forward) continuous abstinence after 6 months was not significantly different at 6% for CTC versus 7.3% for OnRQ (OR = 0.81, 95% CI 0.54-1.20, p = .28). Last observation carried forward was also not statistically significant for continuous abstinence at 7.8% for CTC versus 9.2% for OnRQ (OR = 0.83, 95% CI 0.59-1.18), p = .30. Similarly, 30-day PPA at 6 months was not significantly different for baseline observation carried forward at 12.9% and 15.8% (OR = .79, 95% CI 0.60-1.05, p = .10) and for last observation carried forward at 14.4% and 16.9% (OR = 0.82, 95% CI 0.63-1.08, p = .16) for CTC and OnRQ participants respectively. However, 7–day PPA at 6 months using baseline observation carried forward showed a significant difference in favour of OnRQ at 22.3% versus 18.3% for CTC (OR = .79, 95% CI 0.61-0.99, p = .05). The significant difference for 7-day PPA at 6 months was not apparent with last observation carried forward at 22% and 24.4% for CTC and OnRQ participants respectively (OR = 0.87, 95% CI 0.69-1.10, p = .25).

Intention-to-treat continuous abstinence using multiple imputation analysis[43] to impute status for loss to follow-up participants was 12.6% for CTC and 12.1% for OnRQ participants, OR = 1.05, 95% CI 0.78-1.41, p = 0.76. Intention-to-treat based on multiple imputation analysis for 7
day and 30 day PPA at 6 months showed no significant differences between conditions (see Table 2).

Findings for complete cases (n=725) showed continuous abstinence rates of 13.8% for CTC and 15.4% for OnRQ, OR=0.89, 95% CI 0.59-1.34, \( p = .56 \). For self-reported 7 day and 30 day PPA at 6 months findings were similar to the multiple imputation intention to treat analysis (see Table 2). At 3 months, no statistically significant differences were observed between CTC and OnRQ for 7 day and 30 day PPA according to the complete case and the intention-to-treat analyses (see Table 2).

Secondary measures of quit attempts and the number of cigarettes smoked per day at 6 month follow-up for those who had not quit smoking at 6 months (N=671) did not reveal any significant difference between groups. Ninety-five percent of OnRQ participants and 92% of CTC participants had made at least one quit attempt \( \chi^2 (1, N = 543) = 1.93, p = .17 \). Further, there was no difference in the number of quit attempts between groups \( (\text{Mdn} = 4, U = 40284.5, p = .821) \), nor in the number cigarettes smoked per day between groups \( (\text{Mdn}= 5 \text{ for OnRQ versus Mdn } = 6 \text{ for CTC, } U = 34337.5, p = .44) \).

**Sub-group analysis**

For complete cases (N=725) the sub-group analysis for pre-specified variables included gender, age, education, heaviness of smoking, self-confidence to quit, level of social support, use of a smoking cessation aid at baseline and frequency of assigned intervention use. No statistically significant sub-group effects were found when comparing continuous self-reported abstinence between the intervention (CTC) and control (OnRQ) conditions (see Figure 2). Although not statistically significant, higher cessation outcomes favoured the OnRQ condition for participants with high school education or less (19.1% versus 11.1%), OR=0.53, 95% CI 0.27-1.03, \( p = .06 \).
Similarly, higher cessation outcomes favoured the OnRQ condition for those reporting high levels of social support (18.2% versus 9.5%), OR=0.48, 95% CI 0.22-1.06, \( p = .07 \) (see Figure 2).

Satisfaction and Use

As shown in Table 3, at 6 months 85.1% of CTC participants downloaded the app as compared to 81.8% of OnRQ participants having downloaded or requested a printed copy of the self-help guide, \( \chi^2 (1, N = 845) = 1.64, p = .23 \). Further, OnRQ participants reported significantly higher levels of overall satisfaction (M=3.3, SD=1.1 versus M=2.6, SD=1.3, \( t(644)=6.87, p < .0001 \)) and perceived helpfulness (M=5.8, SD = 2.4 versus M=4.3, SD = 2.6, \( t(657)=8.0, p < .0001 \)) as well as higher levels of frequency of use, confidence in using, ease of use, and perceptions of the intervention being well laid out as compared to CTC participants (see Table 3).

Discussion

This is the first randomized control trial of a smoking cessation app with a large sample size of Canadian young adults followed-up at 3 and 6 months. The results of this trial show that there were no statistically significant differences between the intervention and control conditions on key outcome measures. With participants lost to follow-up treated as smokers (last observation carried forward), the CTC app and OnRQ resulted in continuous abstinence rates of 7.8% and
9.2% respectively. Unlike this trial, BinDhim and colleagues[26] recently assessed the efficacy of an interactive smoking cessation smartphone app compared with a static information only smartphone app on adults using a double-blind RCT and found a significant difference in continuous abstinence rates of 3.2% and 7.3% for the control and intervention conditions respectively. In comparison, this trial found a continuous abstinence rate comparable to BinDhim and colleagues of 7.8% for the intervention condition. In addition, Bricker and colleagues [14] conducted a small sample size (n=196) double-blind RCT with adults to assess the efficacy of the smartphone app SmartQuit as compared to the National Cancer Institute’s QuitGuide smartphone app. The primary outcome for this smaller study was 30-day PPA at two-month follow-up based on complete cases and no statistically significant difference was found between the intervention (13%) and the control (8%) conditions. In comparison, our study found 30-day PPA rates at 3 months of 18% and 17% for the CTC intervention and comparison condition respectively. Finally, Buller and colleagues [24] conducted a very small sample size RCT with young adults (n=102) to compare a smartphone application versus a text messaging application for smoking cessation. With participants lost to follow-up treated as smokers, continuous abstinence at 3 months for the smartphone app was 16% in comparison to text messaging at 27%. Although substantive, this difference was not statistically significant due to the small sample.

In Canada, the typical unassisted abstinence rate based on 30-day PPA (having not smoked in the previous 30 days prior to being interviewed 6 months after baseline) is 5% (95% CI 4%-6%) among adult smokers based on a large sample size (n=4,355) population-based longitudinal cohort study of Ontario smokers[45]. According to the same Ontario longitudinal cohort study of smokers, the unassisted 30-day PPA for young adult smokers (aged 18-29 years) is 11.5% (68/592) as assessed 6 months after baseline[46]. This suggests that the CTC smartphone app
has favourable 6-month ITT continuous abstinence rates compared to the 30-PPA rates of unassisted adult smokers and ITT 30-PPA rates at 6 months that are favourable compared to the unassisted abstinence rates for young adult smokers. In addition, the 30-day PPA at 6 months for complete cases and based on multiple imputation analysis are substantially higher than what is typical among unassisted young adult smokers (see Table 2).

CTC was not superior to the control condition OnRQ; however, the continuous abstinent rate and 30-day abstinent rate for CTC is comparable to previous research on smoking cessation smartphone apps [14,26] and is more favourable than what is typical among unassisted young adult smokers[46]. This study is unique in that both the CTC app and OnRQ were similar in their content and evidence-base but very different in their mechanism of delivery. Furthermore, this is a large sample size study comparing a smoking cessation smartphone app to the usual self-care, low intensity intervention of a self-help guide. This is contrary to the approach by BinDhim and colleagues, for example, who examined two different apps (one based on evidence and theory while the other was not based on an evidence-informed structure). Evidence to-date has demonstrated the effectiveness of mobile text messaging interventions[20]; however, this trial has revealed that, although the quit rates are favourable compared to unassisted quitting, an evidence-informed smoking cessation app is not superior to an evidence-informed self-help guide. These findings pave the way to examine specific evidence-informed components that do or do not translate well in the mHealth context, which has implications for future research and successful scale-up [47].

It is interesting that those with higher education and those with low social support favour the CTC app and that some populations may prefer alternative low-intensity evidence-informed interventions such as self-help guides. In addition, men’s interest in using CTC is noteworthy. In
our recently published qualitative work, it was found that men were particularly receptive to CTC’s ability to present personalized and relevant information in relation to their smoking behaviour, and engage them in autonomous behaviour change [49]. That men prefer the tailoring capabilities inherent in technology-based health interventions is supported in the general mHealth literature [50]. Intervention preferences for those with perceived lower levels of social support from friends and/or colleagues in quitting smoking along with gender and other characteristics can be further explored.

Despite the positive assessment of Ubhi and colleagues [30] regarding user engagement and usability of CTC, findings indicate higher satisfaction with the OnRQ compared to the CTC app. There is, therefore, the potential for improvements to the content and usability of CTC that may result in higher abstinence rates. This brings forward the need for qualitative research to understand user experiences and preferences in relation to an app’s design and related functions to enhance user satisfaction.

Limitations

This study has several limitations. Despite a rigorous process for encouraging participants to complete follow-up, an overall response rate of 58% at 6 month follow-up is considered sub-optimal. However, this level of follow-up response is similar to other web-based cessation intervention studies such as BecomeAnEX with a 3-month follow-up rate of 59% [51]. Despite the less than optimal response rate, there was no differential attrition between groups as presented in Table 1 that shows that the groups were balanced with regard to all characteristics measured at baseline and at follow-up. Since the baseline characteristics of those lost to follow-up did not differ between conditions, any possible differences in the outcome measures between
conditions are unlikely to be associated with these characteristics [44]. Further, the intention-to-treat principle was followed for the analysis of outcomes using three standard approaches to handling missing data [35,43,52].

Although it was demonstrated that the rates continuous abstinence and 30-day PPA for the CTC intervention condition were comparable to the few trails of smoking cessation apps to-date as well as being favourable in comparison to unassisted rates of quitting, an important limitation of this study is the lack of a no intervention control group. However, it is often difficult to avoid attrition bias when conducting trials with inactive controls [53] and inactive controls are sometimes challenged as unethical in settings in which participants could be given an existing usual care intervention[54].

Although participants were blind, both interventions were potentially available to any participant, implying a risk of contamination. However, we took measures to minimize this through ensuring unique IPs at recruitment and only 6% reported use of a self-help guide and less than 1% use of a smartphone app in groups not allocated to these interventions.

Recall bias with regard to self-reported use of interventions is possible. Although automated recording of use of CTC is possible as reported elsewhere [31], it was not possible to automatically record use of the self-help guide OnRQ and consequently self-reported satisfaction and use measures were chosen to allow for comparison between conditions and there is no evidence that recall bias was different across conditions.

Finally, lack of biochemical validation of smoking abstinence is a limitation that may have resulted in an overestimation of smoking abstinence [55]. However, a Cochrane review of low-intensity internet-based interventions for smoking cessation found that very few studies used
biochemical validation given the difficulties in obtaining samples from participants[56] and expert consensus suggests that biochemical verification of abstinence is impractical and unnecessary in large studies such as the current one due to cost considerations and limited face-to-face contact [57]. Further, accurate estimates of the prevalence of cigarette smoking among Canadians can be derived from self-reported smoking status data [58].

**Generalisability**

This study reached a large sample of Canadian male and female young adults from various ethnicities, education and income groups, including unemployed and low income young people, who owned smartphones and were motivated to quit smoking. The inclusion criteria of understanding, reading, and speaking English resulted in a lack of representation from young adult francophone smokers. French is the mother tongue of approximately one fifth of the Canadian population, most of whom live in Quebec. Therefore, the study sample is limited to English speaking Canada and the findings may not be generalizable to young adult smokers with smartphones in other settings.

**Implications for Practice**

CTC did not show a significant difference from a usual care self-help guide. Despite the rates of quitting being comparable to other smoking cessation app interventions, research into improving the overall satisfaction and helpfulness of CTC is needed before practitioners may recommend an evidence-informed mHealth app, such as CTC, to smokers wanting to quit. Smoking cessation apps may eventually warrant inclusion in the overall cessation picture for Canadian young adults. In addition, the widespread reach that cessation apps, such as CTC, can have, particularly for hard-to-reach populations, supports the relevance and need for mHealth cessation interventions. For example, among 18 to 29 year olds, smartphone ownership is nearing
saturation among all socioeconomic groups [10] and as a result, population health practitioners need to consider the impact and the reach of these interventions as mHealth cessation interventions could potentially help to eliminate tobacco-related health disparities. Further, since smartphone apps for health and healthy behaviour change are so numerous and often downloaded, it is important that studies like this are conducted and findings, particularly if not overly supportive of the effects of these apps, are published.

Future Research

To date, the effects of smartphone apps for smoking cessation are largely unknown and the present study is one of a very few trials that have been undertaken. A number of larger randomized controlled trials are underway to assess the effect of smartphone apps for smoking cessation [59–62]. In the near future, the evidence from these studies will be brought together and reviewed to determine the overall effectiveness of mHealth for smoking cessation, under what conditions and for whom. In the interim, future research to establish the cost-effectiveness of mHealth cessation interventions is needed[63]. While the findings from this study indicate comparability to another low-intensity intervention, lower levels of satisfaction suggest that future research should explore the app’s usability using qualitative research[49], followed by an evaluation of the improvements and exploration of the program features/components that account for differences among smokers [64]. Due to the multicomponent nature of CTC, there is a limited understanding as to what intervention mechanisms are associated with behaviour changes such as quitting smoking. Research to disentangle which elements of a multicomponent intervention are accounting for change may be useful [65]. Similar to the experience of BinDhim and colleagues[26] testing of a smoking cessation decision-aid app, this trial experienced the loss of some CTC app functionality, notably push notifications, likely due to the
Apple app store and Google Play changing their regulation policies and technical specifications. Future research on smartphone apps should take into consideration these potential changing policy and technical issues. Finally, a superiority trial was conducted and future research may consider inferiority or equivalence designs when comparing mHealth against established evidence-based, low-intensity interventions such as self-help guides [66,67].

Conclusions

CTC was feasible for delivering cessation support but was not superior to a self-help guide in helping motivated young adults to quit smoking. Both conditions in this trial are considered low intensity, self-help interventions and achieved rates of continuous abstinence comparable to other mHealth studies for smoking cessation and higher than typical unassisted rates of quitting. There is a need to conduct further research to understand how smartphone apps for smoking cessation can be improved and become better in supporting population health efforts to reduce the overall prevalence of smoking.
References


44. Dumville JC, Torgerson DJ, Hewitt CE. Reporting attrition in randomised controlled trials. BMJ 2006 Apr 20;332(7547):969–971. PMID:16627519


Declarations

Ethics Approval

Ethics approval was granted on October 29, 2013 by the University of Waterloo, Office of Research Ethics ORE# 19275.

Competing Interests

NBB led the initial design and development of Crush the Crave.

Funding

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Authors’ Contributions

NBB led the conceptualization and design of the study and EG, DH, CDN, RW, CB and KSB contributed to the design of the study. NBB and LLS drafted the manuscript. NBB, LLS, EG, CDN, EG, RW, CB, DH and KSB critically revised the manuscript for important intellectual content. NBB and DH are co-principal investigators and CDN, EG, RW, CMB and KSB are co-
investigators on the research funding application. LLS conducted research as a graduate student and as a postdoctoral fellow for the study. NBB supervised the study. NBB is the guarantor.
Table 1: Baseline characteristics of participants randomized to each arm, those lost to follow-up, and those remaining at 6 months

<table>
<thead>
<tr>
<th>Baseline Variable</th>
<th>All participants</th>
<th>Participants lost to follow-up</th>
<th>Remaining participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CTC (n=820)</td>
<td>OnRQ (n=779)</td>
<td>CTC (n=394)</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>p-Value</td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>364 (44.9)</td>
<td>365 (47.0)</td>
<td>0.39</td>
</tr>
<tr>
<td>Age 19 to 23</td>
<td>409 (49.9)</td>
<td>376 (48.3)</td>
<td>0.52</td>
</tr>
<tr>
<td>Single – never legally married</td>
<td>508 (62.6)</td>
<td>486 (62.8)</td>
<td>0.92</td>
</tr>
<tr>
<td>High school or less education</td>
<td>351 (43.0)</td>
<td>361 (46.6)</td>
<td>0.15</td>
</tr>
<tr>
<td>Caucasian</td>
<td>599 (75.4)</td>
<td>569 (74.8)</td>
<td>0.79</td>
</tr>
<tr>
<td>Paid work</td>
<td>539 (67.5)</td>
<td>527 (69.6)</td>
<td>0.38</td>
</tr>
<tr>
<td>Income &lt; $45,000</td>
<td>484 (65.6)</td>
<td>457 (64.6)</td>
<td>0.71</td>
</tr>
<tr>
<td><strong>Smoking and quitting behavior</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate to high nicotine dependence</td>
<td>219 (27.1)</td>
<td>205 (26.5)</td>
<td>0.79</td>
</tr>
<tr>
<td>Smokes at least a pack per day or more</td>
<td>210 (25.7)</td>
<td>200 (25.7)</td>
<td>0.99</td>
</tr>
<tr>
<td>Very/Extremely confident to quit</td>
<td>330 (40.8)</td>
<td>302 (39.2)</td>
<td>0.52</td>
</tr>
<tr>
<td>High stress level</td>
<td>240 (30.5)</td>
<td>237 (31.7)</td>
<td>0.60</td>
</tr>
<tr>
<td>Used NRT currently or in the past</td>
<td>424 (51.7)</td>
<td>419 (53.8)</td>
<td>0.41</td>
</tr>
<tr>
<td>Used E-cigarettes currently or in the past</td>
<td>500 (61.0)</td>
<td>472 (60.6)</td>
<td>0.87</td>
</tr>
</tbody>
</table>
### Friends/ partner smoking and level of support

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>n (%)</th>
<th>Mean (SD)</th>
<th>Correlation</th>
<th>Count</th>
<th>n (%)</th>
<th>Mean (SD)</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two or more close friends smoke</td>
<td>682</td>
<td>639</td>
<td>0.60</td>
<td>331</td>
<td>287</td>
<td>0.39</td>
<td>351</td>
<td>352</td>
</tr>
<tr>
<td></td>
<td>(85.1)</td>
<td>(84.2)</td>
<td>(86.0)</td>
<td>(83.7)</td>
<td></td>
<td></td>
<td>(84.4)</td>
<td>(84.6)</td>
</tr>
<tr>
<td>Living with partner who smokes</td>
<td>228</td>
<td>229</td>
<td>0.52</td>
<td>106</td>
<td>107</td>
<td>0.36</td>
<td>122</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>(28.0)</td>
<td>(29.4)</td>
<td>(27.2)</td>
<td>(30.2)</td>
<td></td>
<td></td>
<td>(28.7)</td>
<td>(28.8)</td>
</tr>
<tr>
<td>High social support level</td>
<td>235</td>
<td>243</td>
<td>0.38</td>
<td>110 (30.7)</td>
<td>110 (33.1)</td>
<td>0.50</td>
<td>125 (31.5)</td>
<td>133 (33.3)</td>
</tr>
<tr>
<td></td>
<td>(31.1)</td>
<td>(33.2)</td>
<td>(31.5)</td>
<td>(33.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2 Comparison of CTC and OnRQ on primary and secondary outcomes at three and six months (Intent to Treat)

<table>
<thead>
<tr>
<th></th>
<th>CTC n=820 (%)</th>
<th>OnRQ n=779 (%)</th>
<th>Odds Ratio (95% CI)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continuous self-reported abstinence at 6 months</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete cases (n=725 (%))</td>
<td>49/354 (13.8)</td>
<td>57/371 (15.4)</td>
<td>0.89 (0.59-1.34)</td>
<td>0.56</td>
</tr>
<tr>
<td>ITT – baseline observation carried forward</td>
<td>6.0</td>
<td>7.3</td>
<td>0.81 (0.54–1.20)</td>
<td>0.28</td>
</tr>
<tr>
<td>ITT – last observation carried forward</td>
<td>7.8</td>
<td>9.2</td>
<td>0.83 (0.59-1.18)</td>
<td>0.30</td>
</tr>
<tr>
<td>ITT – multiple imputation of outcomes¹</td>
<td>12.6</td>
<td>12.1</td>
<td>1.05 (0.78-1.41)</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>Secondary outcomes (3 months)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported non-smoking in past 7 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete cases (n=708 (%))²</td>
<td>105/345(30.4)</td>
<td>107/363(29.5)</td>
<td>1.05 (0.76-1.44)</td>
<td>0.78</td>
</tr>
<tr>
<td>ITT – baseline observation carried forward</td>
<td>16.2</td>
<td>15.9</td>
<td>1.02 (0.78–1.34)</td>
<td>0.87</td>
</tr>
<tr>
<td>ITT – multiple imputation of outcomes</td>
<td>32.7</td>
<td>31.2</td>
<td>1.07 (0.87-1.32)</td>
<td>0.52</td>
</tr>
<tr>
<td>Self-reported non-smoking in past 30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete cases (n=712 (%))²</td>
<td>61/347(17.6)</td>
<td>61/365(16.7)</td>
<td>1.06 (0.72–1.57)</td>
<td>0.76</td>
</tr>
<tr>
<td>ITT – baseline observation carried forward</td>
<td>8.8</td>
<td>9.1</td>
<td>0.96 (0.68-1.35)</td>
<td>0.82</td>
</tr>
<tr>
<td>ITT – multiple imputation of outcomes</td>
<td>18.4</td>
<td>18.7</td>
<td>0.98 (0.76-1.26)</td>
<td>0.87</td>
</tr>
<tr>
<td><strong>Secondary outcomes (6 months)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported non-smoking in past 7 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete cases (n=708 (%))²</td>
<td>114/342(33.3)</td>
<td>143/366 (39.1)</td>
<td>0.78 (0.57-1.06)</td>
<td>0.11</td>
</tr>
<tr>
<td>ITT – baseline observation carried forward</td>
<td>18.3</td>
<td>22.3</td>
<td>0.79 (0.61-0.99)</td>
<td>0.05</td>
</tr>
<tr>
<td>ITT – last observation carried forward</td>
<td>22.0</td>
<td>24.4</td>
<td>0.87 (0.69-1.10)</td>
<td>0.25</td>
</tr>
<tr>
<td>ITT – multiple imputation of outcomes</td>
<td>36.1</td>
<td>38.8</td>
<td>0.89 (0.73-1.09)</td>
<td>0.27</td>
</tr>
<tr>
<td>Self-reported non-smoking in past 30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete cases (n=709 (%))²</td>
<td>84/344(24.4)</td>
<td>107/365(29.3)</td>
<td>0.78 (0.56-1.09)</td>
<td>0.14</td>
</tr>
<tr>
<td>ITT – baseline observation carried forward</td>
<td>12.9</td>
<td>15.8</td>
<td>0.79 (0.60–1.05)</td>
<td>0.10</td>
</tr>
<tr>
<td>ITT – last observation carried forward</td>
<td>14.4</td>
<td>16.9</td>
<td>0.82 (0.63-1.08)</td>
<td>0.16</td>
</tr>
<tr>
<td>ITT – multiple imputation of outcomes</td>
<td>24.3</td>
<td>28.2</td>
<td>0.81 (0.65-1.02)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

¹ Multiple imputation by chained equations (number of imputations = 18).
² Number of cases is less than 725 due to missing data.
Table 3. Comparison of CTC and OnRQ on use and satisfaction measures at three and six months

<table>
<thead>
<tr>
<th></th>
<th>CTC n</th>
<th>OnRQ n</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3 Months (N=791)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downloaded, % (n)</td>
<td>384</td>
<td>407</td>
<td>.03</td>
</tr>
<tr>
<td>Satisfaction with application, mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used frequently</td>
<td>325</td>
<td>317</td>
<td>.003</td>
</tr>
<tr>
<td>Easy to use</td>
<td>312</td>
<td>308</td>
<td>.137</td>
</tr>
<tr>
<td>Well laid out</td>
<td>307</td>
<td>306</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Confidence in using</td>
<td>306</td>
<td>310</td>
<td>.227</td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>306</td>
<td>299</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Overall helpfulness</td>
<td>308</td>
<td>299</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td><strong>6 Months (N=845)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downloaded, % (n)</td>
<td>422</td>
<td>423</td>
<td>.23</td>
</tr>
<tr>
<td>Satisfaction with application, mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used frequently</td>
<td>351</td>
<td>334</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Easy to use</td>
<td>340</td>
<td>324</td>
<td>.01</td>
</tr>
<tr>
<td>Well laid out</td>
<td>337</td>
<td>324</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Confidence in using</td>
<td>331</td>
<td>318</td>
<td>.002</td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>332</td>
<td>314</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Overall helpfulness</td>
<td>337</td>
<td>322</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

1Scale of 1 to 5 – “strongly agree” to “strongly disagree”
2Scale of 1 to 5 – “not at all satisfied” to “very satisfied”
3Scale of 1 to 10 – “not at all helpful” to “very helpful”

Figure 1. CONSORT-EHEALTH diagram
Enrollment

Assessed for eligibility (n=4269)

Randomized (n=1599)

Allocated to intervention – ‘Crush the Crave’ (n=820)

Completed 3-month follow-up survey (n=387)
Did not complete 3-month follow-up (n=403)
Withdrew from trial (n=30)

Completed 6-month follow-up survey (n=426)
Did not complete 6-month follow-up (n=392)
Withdrew from trial (n=2)

3-month outcome (N=39)
6-month outcome (N=50)
Both 3-month and 6-month outcome (N=17)

Included for intention-to-treat analysis (n=820)
Complete case analysis (Baseline, T1 and T2) (n=354)

Allocation

Allocated to usual care condition – ‘On the Road to Quitting’ (n=779)

Follow-Up

Completed 3-month follow-up survey (n=416)
Did not complete 3-month follow-up (n=334)
Withdrew from trial (n=29)

Completed 6-month follow-up survey (n=425)
Did not complete 6-month follow-up (n=354)
No withdrawals

Telephone Follow-Up

3-month outcome (N=45)
6-month outcome (N=35)
Both 3-month and 6-month outcome (N=14)

Excluded (n=2670)
• Did not meet inclusion criteria (n=1346)
• Did not complete intake (n=682)
• Declined to participate (n=312)
• Multiple attempts to participate (n=219)
• No contact information (n=111)

Analysis

Included for intention-to-treat analysis (n=779)
Complete case analysis (Baseline, T1 and T2) (n=371)
Figure 2: Effect of the Crush the Crave Intervention on Primary Outcome by Subgroup (N=725)

<table>
<thead>
<tr>
<th>Gender</th>
<th>CTC Intervention (n=354)</th>
<th>OnRQ Control (n=371)</th>
<th>Subgroup Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (SE)</td>
<td>% (SE)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>14.3% (.03)</td>
<td>16.6% (.03)</td>
<td>0.84 (0.48-1.47)</td>
</tr>
<tr>
<td></td>
<td>12.9% (.03)</td>
<td>14.3% (.03)</td>
<td>0.89 (0.48-1.64)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 to 23</td>
<td>12.4% (.03)</td>
<td>17.3% (.03)</td>
<td>0.67 (0.37-1.23)</td>
</tr>
<tr>
<td>24 to 29</td>
<td>15.2% (.03)</td>
<td>13.6% (.02)</td>
<td>1.14 (0.64-2.01)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or less</td>
<td>11.1% (.03)</td>
<td>19.1% (.03)</td>
<td>0.53 (0.27-1.03)</td>
</tr>
<tr>
<td>Post-secondary or higher</td>
<td>15.6% (.02)</td>
<td>12.7% (.02)</td>
<td>1.27 (0.74-2.20)</td>
</tr>
<tr>
<td>Heaviness of smoking index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low to moderate</td>
<td>12.5% (.02)</td>
<td>14.6% (.02)</td>
<td>0.84 (0.51-1.37)</td>
</tr>
<tr>
<td>High</td>
<td>18.0% (.04)</td>
<td>17.0% (.04)</td>
<td>1.07 (0.48-2.35)</td>
</tr>
<tr>
<td>Self-confidence to quit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all/Slightly/Moderately</td>
<td>11.4% (.02)</td>
<td>12.7% (.02)</td>
<td>0.89 (0.50-1.60)</td>
</tr>
<tr>
<td>Very/Extremely</td>
<td>17.1% (.03)</td>
<td>16.0% (.03)</td>
<td>0.89 (0.49-1.62)</td>
</tr>
<tr>
<td>Social support level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low to moderate</td>
<td>16.2% (.02)</td>
<td>13.7% (.02)</td>
<td>1.22 (0.72-2.05)</td>
</tr>
<tr>
<td>High</td>
<td>9.5% (.05)</td>
<td>18.0% (.03)</td>
<td>0.48 (0.22-1.06)</td>
</tr>
<tr>
<td>Using smoking cessation aid at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>12.2% (.02)</td>
<td>15.6% (.02)</td>
<td>0.74 (0.45-1.22)</td>
</tr>
<tr>
<td>Yes</td>
<td>17.8% (.04)</td>
<td>14.3% (.03)</td>
<td>1.30 (0.62-2.70)</td>
</tr>
<tr>
<td>Frequency of use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>11.5% (.03)</td>
<td>14.2% (.03)</td>
<td>0.79 (0.38-1.62)</td>
</tr>
<tr>
<td>High</td>
<td>19.6% (.06)</td>
<td>17.9% (.04)</td>
<td>1.12 (0.49-2.73)</td>
</tr>
<tr>
<td>Overall</td>
<td>13.8% (.02)</td>
<td>15.2% (.02)</td>
<td>0.89 (0.59-1.34)</td>
</tr>
</tbody>
</table>

Two-sided intervention effect, p value = .60