Get with the program: Adherence to a smartphone app for smoking cessation

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Abstract

Introduction—Although engagement is generally predictive of positive outcomes in technology-based behavioral change interventions, engagement measures remain largely atheoretical and lack treatment-specificity. This study examines the extent to which adherence measures based on the underlying behavioral change theory of an Acceptance and Commitment Therapy (ACT) app for smoking cessation predict smoking outcomes, and user characteristics associated with adherence.

Methods—Study sample was adult daily smokers in a single arm pilot study (n=84). Using the app's log file data, we examined measures of adherence to four key components of the ACT behavior change model as predictors of smoking cessation and reduction. We also examined baseline user characteristics associated with adherence measures that predict smoking cessation.

Results—Fully adherent users (24%) were over four times more likely to quit smoking (OR = 4.45; 95% CI = 1.13, 17.45; p = 0.032). Both an increase in tracking the number of urges passed (OR = 1.02; 95% CI = 1.00, 1.03; p = 0.043) and ACT modules completed (OR = 1.27; 95% CI = 1.01, 1.60; p = 0.042) predicted cessation. Lower baseline acceptance of cravings was associated with over four times higher odds of full adherence (OR = 4.59; 95% CI = 1.35, 15.54; p = 0.014).

Conclusions—Full adherence and use of specific ACT theory-based components of the app predicted quitting. Consistent with ACT theory, users with low acceptance were most likely to adhere to the app. Further research is needed on ways to promote app engagement.

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1. Introduction

Smoking remains an undertreated public health problem worldwide, accounting for six million deaths and an economic burden of half a trillion dollars annually.[1] Smartphone applications could play an integral role in reducing the personal and societal costs of smoking due to their high population reach[2,3] and immediate accessibility. Apps, like other technology-based platforms for delivering behavioral interventions, are plagued by the problem of attrition[4]—this includes low utilization of apps for weight loss,[5–7] PTSD,[8] and smoking cessation.[9] This limits potential for behavioral change because engagement is generally predictive of positive outcomes,[10–17] although there have been some mixed findings in this regard.[12,17,18] These mixed findings may be attributable to the state of the literature on engagement with electronic health (eHealth) interventions, in which engagement is broadly defined and largely atheoretical, encompassing frequency, length, and depth of use. Empirically-based engagement metrics guided by the theory of behavior change underlying the intervention might better inform what users need to do in order for the intervention to be effective.

Another engagement-related application of behavioral theory is to examine which types of users engage with the theoretically-consistent components of a behavioral intervention. Doing so might inform whom to target to increase engagement with these key ingredients. While studies have looked at how user characteristics predict utilization in web[11,16,19–24] and app-based[25] smoking cessation interventions, none have examined theory-based psychological change targets as predictors. In Acceptance and Commitment Therapy (ACT) theory, a key psychological change target is experiential acceptance, defined as a willingness to allow aversive internal states (e.g., anxiety or physical discomfort) to be present without smoking as a means of reducing them. ACT also helps people identify what is important to them in life (i.e., their values) and commit to behaviors in line with their values. Based on the theory, those who stand to benefit most from the intervention are those with low acceptance. Indeed, evidence different modalities of treatment delivery (i.e., phone and app-based interventions) indicates that those with low baseline acceptance benefit most from ACT.[26,27] In addition, an increase in acceptance of smoking-related thoughts, feelings, and sensations mediates quit outcomes in ACT-based smoking cessation studies.[26–30]

In this study, we tested whether theory-based engagement metrics predict behavioral change outcome in the context of an ACT-based cessation app that contains evidence-based features.[31] To inform which user characteristics predict key indices of engagement, we examined the role of acceptance in addition to variables that have previously been found to predict general utilization in web[11,16,19–24] and app-based[25] cessation studies. Although it is not possible to detect the directionality of the relationship between adherence and smoking outcomes, results from this study will inform development of cessation apps by identifying

which specific app features might optimize cessation outcomes and which types of users engage with these features.

2. Methods

2.1. Participants

In this secondary analysis, we examined app usage data from 84 adult daily smokers in a single-arm pilot study who provided two-month follow-up data. The eligibility criteria for the pilot study were: (1) age 18 or older, (2) smokes at least five cigarettes daily for at least the past year, (3) wants to quit smoking in the next 30 days, (4) has daily access to a smartphone, which was either an iPhone IOS Version 6 or higher or Android Version 4.1 or higher and (5) not participating in any other cessation interventions. See Table 1 for descriptive statistics of the study sample.

2.2. Recruitment

Potential participants were recruited through their employers (n=150) or through Facebook advertisements (n=293) and were emailed a link to the recruitment website. Participants who screened eligible (n=347), completed consent (n=221), filled out baseline measures (n=201), and provided their email address twice for confirmation (n=161), were e-mailed a secured link and passcode to download the app (n=99 downloaded). Afterwards, participants were sent e-mail reminders to open the app.

2.3. Data Collection

Participants who completed the consent form were administered an online baseline survey that assessed demographic and smoking characteristics. At 2-month post-randomization follow-up, participants were administered a survey assessing their quit outcomes. Consistent with complete case analytic methods, only those (n=84) who responded to questions about their smoking status in the outcome survey (85% retention) are included in these analyses.

2.4. App Description

Upon initial app access, users were prompted to complete a quit plan, including picking a quit date. From the home screen, users complete one ACT exercise each day for the first 8 days of use in addition to tracking smoking urges and letting urges pass. After these activities are completed, other features of the app are unlocked in the "Anytime Coaching" section, which includes ACT-based exercises to support quitting (e.g., how to deal with lapses, motivation for quitting, inspirational stories of past quitters). Informed by results from a prior study of the features of our app that predict smoking cessation,[31] we defined the requirements to earn a Certificate of Completion as the completion of four app components: (1) creating a quit plan, (2) completing 8 daily ACT modules, (3) tracking letting 10 urges pass, and (4) visiting the Anytime Coaching section at least once (see screenshots of each component in supplementary materials). The ACT exercises focus on building and maintaining motivation by connecting with values guiding quitting, handling urges through development of acceptance skills (e.g., mindfulness, obtaining psychological distance from thoughts that trigger smoking), and handling lapses by practicing self-compassion. Heffner et al. (2015) provides more information on the ACT exercises in the app.[31]

2.5. Measurements

2.5.1. Adherence Measures—We extracted and analyzed log file data to assess adherence across the first two months of usage, as this was the pre-established period of evaluation. We measured full adherence as whether or not the user completed all of the four program components required for a Certificate of Completion (listed above), partial adherence as the number (out of four) of the components completed, and depth of adherence as the number of uses within each component.

2.5.2. Smoking Cessation—The two-month post-randomization follow-up survey assessed 7-day point prevalence abstinence via self-report, based on the consensus that biochemical verification of smoking status is not necessary in studies that do not involve face-to-face contact.[32]

2.5.3. Smoking Cessation Progress—On the follow-up survey, participants were asked how often they currently smoke cigarettes. Because daily smokers who reduce to less-than-daily use are more likely to make quit attempts and quit smoking compared to continued daily smokers,[33] we operationalized smoking cessation progress as a decrease in frequency of smoking from daily to less-than-daily.

2.5.4. Covariates—To address confounding in models with adherence measures as predictors of smoking outcomes, we adjusted for variables that are associated with abstinence rates. Baseline covariates included education,[34] living with a smoker,[35] quit medication use,[35] electronic cigarette use,[36] and heaviness of smoking index,[35] a 6-point scale combining smoking level and time to first cigarette after waking.[37] We assessed use of quit medications and electronic cigarettes at follow-up by asking participants whether they had used either since joining the study.

2.5.5. Baseline User Characteristics—The baseline survey assessed gender, age, education (high school or less vs. post-secondary), smoking level (light, < 10 cigs/day vs. heavy, 10 cigs/day), and acceptance of physical cravings to smoke. With the exception of acceptance of cravings, these variables were chosen as potential predictors of adherence because they were predictive of utilization either in a prior version of the app[25] or in smoking cessation websites.[11,16,19–24] We measured acceptance of physical cravings to smoke—ACT's theory-based mechanism of change[38]—with a 9-item bodily sensations subscale of the Avoidance and Inflexibility Scale. This score is calculated as an average of item responses.[29] Examples of the Avoidance and Inflexibility Scale items include, "How often do you have bodily sensations that encourage you to smoke?" and "How willing are you to experience these bodily sensations without smoking". Response options are "Never", "Seldom", "Sometimes", "Frequently", and "Always".

2.6. Data Analysis

All statistical tests were two-sided, with $\alpha = 0.05$. No adjustments for multiple tests were made due to the exploratory nature of this study. Logistic regression models were used to examine the relationship between each adherence measure and smoking outcomes. For the depth of adherence measure, we ran four separate models with degree of usage of each of

the four components as a predictor of smoking cessation and reduction. We then tested a full model with all four components included as predictors of cessation and reduction. In addition, we used logistic (for categorical adherence measures) or linear regression (for continuous adherence measures) to test whether user characteristics predicted adherence, using only the measures of adherence that were predictive of smoking cessation as the dependent variables.

3. Results

3.1. Does Adherence Predict Smoking Outcome?

3.1.1. Full Adherence—Twenty-four percent of users were fully adherent. The odds of 7-day point prevalence abstinence were over four times higher among fully adherent users compared to users who were not fully adherent (OR = 4.45; 95% CI = 1.13, 17.45; p = 0.032). No significant relationships were observed between full adherence and smoking reduction.

3.1.2. Partial Adherence—No significant relationships were observed between the number out of four components completed and cessation or reduction.

3.1.3. Depth of Adherence—Tracking a greater number of urges passed was predictive of cessation (OR = 1.02; 95% CI = 1.00, 1.03, p = 0.043) and reduction (OR = 1.02; 95% CI = 1.00, 1.03; p = 0.027). A greater number of ACT modules completed also predicted cessation (OR = 1.27; 95% CI = 1.01, 1.60; p = 0.042). In addition, there was suggestive but inconclusive evidence of relationships between (1) number of quit plan views and cessation (OR = 2.00; 95% CI = 0.92, 4.34; p = 0.078), and reduction (OR = 1.86; 95% CI = 0.93, 3.71; p = 0.077) and (2) number of ACT exercises completed and smoking reduction (OR = 1.17; 95% CI = 0.98, 1.40; p = 0.088). We did not observe any significant associations between the number of Anytime Coaching visits and cessation or reduction. In a multivariable model which included all four components of adherence, none of the components predicted cessation, with no evidence of multicollinearity contributing to this outcome (variance inflation factors ranging from 1.34 to 1.93). Number of times users accessed Anytime Coaching predicted a lower odds of reduction (OR = 0.79; 95% CI = 0.62, 1.00; p = 0.047) in the multivariable model.

3.2. What User Characteristics Predict Adherence?

We identified only one baseline predictor of treatment adherence; users who had lower baseline acceptance of cravings were more likely to be fully adherent (OR = 4.59; 95% CI = 1.35, 15.54; p = 0.014).

4. Discussion

This is the first study to examine the relationship between theoretically- and empirically-informed measures of adherence to a smoking cessation app and smoking outcomes. The findings showed that users who were fully adherent had over four times higher odds of quitting smoking as compared with those who were not fully adherent. This main finding

suggests the value of full program adherence to an app-based smartphone intervention for smoking cessation.

Moreover, the study found that the depth of use of two specific ACT theory-based components of the app predicted smoking cessation: tracking urges passed and ACT modules completed. There was suggestive but inconclusive evidence that quit plan views predicted cessation. Overall, these findings specify theory-driven features to target for enhancing intervention impact.

In the multivariable model, number of times users accessed Anytime Coaching was associated with lower rates of reduction, but not of cessation. This finding is difficult to interpret due to the multiple components included within Anytime Coaching (e.g., stories from ex-smokers, exercises for lapses). It is possible that some features within Anytime Coaching are not helpful to reducing, but there is a lack of power in this study to ascertain the effects of each specific component.

Prior research has found that low acceptance is a barrier to quitting[39,40] and people with lower baseline levels of acceptance tend to have higher quit rates from ACT interventions.[26,27] Consistent with ACT theory and prior research, smokers with low baseline acceptance of cravings were more likely to complete the program, suggesting that the app is engaging to those who the ACT model posits would derive the most benefit from it. Improving adherence to an ACT app for smoking cessation should focus now on developing methods to engage smokers who are *high* in baseline acceptance of cravings.

4.1. Limitations

As an exploratory study, the findings should be considered preliminary. The study had a small sample size (n=84), short time period of intervention exposure (2 months), and used a brief baseline user characteristics assessment. Considering the multiple baseline measures examined as predictors of engagement, there is a risk for Type I error. Since users volunteered for a study and agreed to provide follow-up data, they might be more likely to complete the program than if they were to use the app outside of a research context. Future studies should examine whether these findings can be replicated in larger samples and with longer exposure to the intervention. Additionally, experimental research designs are needed to test the effects of specific app feature usage on smoking outcomes.

4.2. Conclusion

Given the finding that full adherence and engagement with specific app features is associated with cessation and reduction, the next step in this line of research is to identify ways to promote engagement with theory-based content in cessation apps. This research is critical to understanding how to effectively deliver smoking cessation interventions via smartphone app, which has received very little attention in the literature; only four apps have published data on utilization or cessation outcomes.[9,25,27,31,41,42]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Highlights

- Study identified empirically and theoretically-informed measures of engagement in a smoking cessation app based on Acceptance and Commitment Therapy (ACT).

- Fully adherent users (24%) to the smoking cessation app program were over four times more likely to quit smoking.

- Lower acceptance of cravings to smoke was a predictor of full adherence to the app program.

- Research is needed on methods to promote engagement with app components predictive of desired smoking cessation outcomes.

Table 1

User characteristics of participants from a single-arm smoking cessation app study (n=99)

Demographics	Value
Age, mean (SD)	38.4 (8.9)
Male, n (%)	22 (22.2)
White	96 (97.0)
HS or less education, n (%)	25 (25.3)
Smokes more than half a pack (>10 cigs) a day, n (%)	82 (82.8)
Smoked 10 years or more, n (%)	80 (80.8)
Working, n (%)	69 (69.7)
Living with partner who smokes n (%)	24 (24.2)

Table 2

App adherence indicators as predictors of smoking cessation and smoking reduction

Adherence Measure		7-day PPA	Smoking Reduction
Model 1. Full Adherence	OR	4.45	2.59
	95% CI	1.13, 17.45	0.76, 8.83
	p-value	0.032 *	0.127
Model 2. Partial Adherence	OR	1.53	1.33
	95% CI	0.91, 2.58	0.86, 2.05
	p-value	0.113	0.205
Depth of Adherence			
Model 3. Number of Quit Plan views	OR	2.00	1.86
	95% CI	0.92, 4.34	0.93, 3.71
	p-value	0.078	0.077
Model 4. Number of ACT[b] Modules Completed	OR	1.27	1.17
	95% CI	1.01, 1.60	0.98, 1.40
	p-value	0.042 *	0.088
Model 5. Number of times Tracked Urges Passed	OR	1.02	1.02
	95% CI	1.00, 1.03	1.00, 1.03
	p-value	0.043 *	0.027 *
Model 6. Number of Anytime Coaching uses	OR	0.97	0.93
	95% CI	0.87, 1.09	0.83, 1.04
	p-value	0.624	0.219
Model 7. Four-component Model			
Number of Quit Plan Views	OR	1.84	1.77
	95% CI	0.76, 4.45	0.78, 4.04
	p-value	0.174	0.172
Number of ACT[b] Modules Completed	OR	1.28	1.17
	95% CI	0.94, 1.74	0.89, 1.53
	p-value	0.122	0.262
Number of times Tracked Urges Passed	OR	1.01	1.02
	95% CI	0.99, 1.03	1.00, 1.04
	p-value	0.303	0.077
Number of Anytime Coaching uses	OR	0.87	0.79
	95% CI	0.73, 1.05	0.62, 1.00
	p-value	0.159	0.047 *

Note: Analysis adjusted for education, exposure to other smokers, heaviness of smoking index (HSI), quit medication use, and electronic cigarette use. ACT = Acceptance and Commitment Therapy.

*
= p < 0.05