Original investigation

What Do Smokers Want in A Smartphone-Based Cessation Application?

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Abstract

Background: Fueled by rapid technological advances over the past decade, there is growing interest in the use of smartphones to aid in smoking cessation. Hundreds of applications have been developed for this purpose, but little is known about how these applications are accessed and used by smokers or what features smokers believe would be most useful.

Purpose: The present study sought to understand the prevalence of smartphone ownership and patterns of use among smokers as well as the perceived utility of various smartphone application features for smoking cessation that are currently in development or already available.

Methods: Daily cigarette smokers ($n = 224$) reported on smartphone ownership, their patterns of smartphone usage, and perceived utility of features. Features were ranked according to perceived utility and differences in both perceived utility and general smartphone use patterns were examined as a function of demographic and smoking-related variables.

Results: Most smokers (80.4%) own a smartphone, but experience with smoking cessation applications is extremely rare (6.1%). Ownership and patterns of usage differed as a function of demographic and smoking-related variables. Overall, gain-framed features were rated as most useful, while loss-framed and interpersonal features were rated as least useful.

Conclusions: Mobile health interventions have the potential to reach a large number of smokers but are currently underutilized. Additional effort is needed to ensure parity in treatment access. Gain-framed messages may be especially useful for engaging smokers, even if other features ultimately drive treatment effects.

Implications: This study describes patterns of smartphone usage among smokers and identifies the smartphone application features smokers believe would be most useful during a quit attempt. Findings indicate which subgroups of smokers are most likely to be reached with mobile health interventions and suggests that inclusion of specific features may be helpful for engaging smokers in the smoking cessation process.

Introduction

Interest in the application of technology to improve health and shape behavior has grown tremendously over the past decade.¹⁻³ Given the ubiquity and advances in mobile technology, it has become a seemingly ideal method for implementation of novel smoking cessation interventions that would not have been possible 10 years ago.⁴ This opportunity has been welcomed by the research community, and several smartphone applications for smoking cessation have been developed and tested,⁵⁻⁷ with additional trials currently underway.⁸ That said, recent estimates indicate over 500 smartphone-based smoking cessation applications are available for download,⁶ with only a very small number integrating evidence-based practices.⁹⁻¹¹ In order to improve both the reach and the efficacy of smartphone-based interventions, studies are needed that establish the prevalence of smartphone ownership among regular smokers as well as patterns of smoking cessation application use and application features that smokers perceive to be most useful.

Present Study

The purpose of this study was threefold. First, we sought to understand the prevalence of smartphone ownership and patterns of use among smokers in order to determine potential reach of mobile health interventions for this population. We also examined whether ownership and use patterns differed as a function of demographic variables to understand barriers and limitations of these interventions. Second, we aimed to determine the *perceived* utility of various features of smoking cessation applications that currently exist or are in varying stages of development, both in the overall sample and within subgroups. Third, we sought to categorize smokers based on their relative feature preferences using cluster analysis. Together, these results will inform the development and refinement of mobile health interventions for smoking cessation by providing insight into which features smokers *believe* will maximize treatment efficacy, which could also impact their likelihood of using such applications. Moreover, differences in preferences across either preexisting subgroups or the empirically derived clusters could aid the development of tailored interventions and inform cessation application marketing strategies.

Methods

Participants and Procedures

Participants in the present report were daily cigarette smokers ($n = 224$) who were screened for participation in one of several laboratory-based studies or clinical trials between March 2013 and March 2017. Participants were recruited through a variety of means, including word-of-mouth, ads in local print and online newspapers, radio ads, flyers posted in common smoking locations (e.g., bars and bus stops), Internet ads (e.g. craigslist), and referrals from treatment providers. All participants were between the ages of 18 and 65, reported daily use of combustible cigarettes (≥ 5 cigarettes per day) when screened by phone and were not actively engaged in smoking cessation treatments or regularly using nicotine replacement products. Exact medical exclusion criteria varied across parent studies based on study-specific protocols, but participants were required to be in generally good physical health. Participants with significant medical comorbidities (e.g., heart disease, emphysema, and cancer) were excluded as were any participants who reported being currently pregnant or breast-feeding. Participants with an

active psychotic disorder or who were regular users of illicit drugs (except THC) were excluded. A detailed description of individual studies, compensation, and inclusion/exclusion criteria is available in the supplemental material. The Duke University Institutional Review Board reviewed approved all elements of the parent studies. Following consent and study-specific screening procedures, all participants completed a comprehensive battery of smoking-related questionnaires at their initial appointment. Measures were completed in the laboratory under staff supervision using either paper-and-pencil or an electronic device (e.g., computer and tablet).

Measures

All participants completed standard demographic forms that included assessment of age, gender, race, ethnicity, educational attainment, and current income. In addition, participants completed an extended smoking history questionnaire and the Fagerström Test for Nicotine Dependence,¹² a brief self-report measure of dependence on cigarettes that has been shown to be predictive of success following a quit attempt.^{13,14} Participants were coded as treatment seekers if they were seeking enrollment in a cessation study when completing the measure. Central to the present study, all participants reported whether or not they currently own a mobile/cell phone and whether or not that phone was a “smartphone.” They also completed a questionnaire that assessed (1) mobile phone ownership and patterns of use (e.g., frequency of apps used and type of apps used) and (2) perceived usefulness of various smoking cessation application “features” that are either currently in development or already available in commercially available applications. This list of features was developed by the study team based on a thorough review of the scientific literature, consultation with mobile health experts and examination of popular smoking cessation applications, as well as qualitative feedback from smokers. Features were rated using a 7-point scale ranging from 1 (not at all useful) to 7 (extremely useful). Although all participants rated perceived usefulness of various features, only those who reported owning a smartphone are included in analyses examining feature utility, as nonowners may be unfamiliar with the capabilities of smartphones and unable to adequately assess smartphone application (app) utility. A copy of the full mobile phone use patterns and feature preferences questionnaire is provided in the supplemental material.

Data Analysis

Due to the small number of participants identifying their race as Asian ($n = 7$), multiracial ($n = 6$), or other/unknown ($n = 4$), all analyses involving race presented throughout focus only on contrasts between Black/African American participants ($n = 117$) and White/Caucasian participants ($n = 90$). Income exhibited an extreme positive skew with more than half of participants (52.2%) reporting incomes equal to or below \$16,000 per year, so this variable was dichotomized into lower income ($\leq \$16,000/\text{year}$) and higher income ($\geq \$16,001/\text{year}$). Patterns of mobile phone use were examined using a series of logistic regressions. Participant characteristics (i.e., gender, race, education, income, age, nicotine dependence, number of cigarettes smoked daily, and treatment-seeking status) were entered as predictors in separate, unadjusted models for these logistic regression analyses. Next, differences in overall feature preferences as a function of participant characteristics were determined through a series of multivariate analysis of variance (MANOVA) analyses. Only when MANOVA findings revealed a significant overall effect of

the predictor were findings subsequently broken down into univariate post hoc analyses to highlight differences. A false discovery rate (FDR) correction was used to correct for type I error in all smartphone use pattern and feature preference analyses.¹⁵

Clusters of smokers were created based on feature preferences using a two-step clustering procedure to automatically identify the optimal number of clusters and assign cases.¹⁶ A log-likelihood approach was used for calculating distance and Akaike's Information Criterion for determining the optimal cluster solution.¹⁷ To ensure cluster solutions were based on relative rather than absolute preference for features (i.e., to adjust for response bias), feature ratings were transformed to within-participant Z scores for purposes of the cluster analysis. Deviation contrasts were then used to examine relative preferences within each cluster (contrasting the average score for a given feature to the overall average across all features within each cluster). Differences in absolute scores between clusters were examined using MANOVA, identical to the procedure used for smoking/demographic variables.

Results

Sample Characteristics and Cell Phone Usage

Sample characteristics and general statistics on mobile phone usage in this sample are presented in Table 1. A majority of participants owned a cell phone (97.3%), particularly among individuals with higher levels of educational attainment (odds ratio [OR] = 10.3,

95% confidence interval [CI] [1.18–89.66], $p = .035$). A substantive majority owned a smartphone (80.4%). Smartphone ownership was more common among women (OR = 2.19, 95% CI [1.07–4.51], $p = .033$) and individuals with household income $\geq$ \$16,000/year (OR = 2.96, 95% CI [1.10–7.98], $p = .032$). It was less common among heavier smokers (OR = 0.94, 95% CI [0.90–0.98], $p = .003$).

Among smokers who owned a smartphone, the vast majority (91.7%) reported having downloaded at least one application for it, but far fewer had paid for an application (28.3%; Table 1). Usage of health-tracking applications was somewhat uncommon and the use of smoking cessation applications was extremely rare (6.1% of smartphone owners). Individuals with at least some education beyond high school were more likely to have downloaded an app, paid for an app, and have downloaded health tracking/management apps in the past. Higher income individuals were also more likely to have downloaded a health tracking/management app. In contrast, older smokers were less likely to have ever downloaded an app, paid for an app, were less likely to use >2 apps at least once per week, and were less likely to have downloaded health tracking in the past. More nicotine-dependent smokers were less likely to have paid for an app. See Table 2 for detailed findings.

Overall Feature Preferences and Predictors of Preference

See Figure 1 for feature list (ranked in order of preference) and descriptive statistics among smartphone owners. Features perceived

Table 1. Sample characteristics and mobile phone usage

Variable	Overall	Cluster 1	Cluster 2	Cluster 3
	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %
Demographics				
Age	41.2 (12.0)	40.3 (13.2)	41.1 (11.9)	41.6 (11.8)
Gender (% female)	52.7%	59.4%	54.4%	53.1%
Race				
White/Caucasian	40.2%	43.5% ¹	45.6% ³	18.8% ^{1,2}
Black/African American	52.2%	52.2% ¹	43.0% ³	71.9% ^{1,2}
Asian	3.1%	1.4%	5.1%	6.3%
Multiracial/Unknown/Other	4.4%	2.8%	6.4%	3.1%
Ethnicity (% Hispanic)	2.6%	1.4%	5.1%	0.0%
Education (% $\leq$ High School Graduate)	34.0%	34.8% ²	19.0% ^{1,3}	50.0% ²
Income ($\leq$ \$16,000/year) ^a	52.2%	48.1% ³	37.7% ³	71.4% ^{1,2}
Smoking				
FTND	5.0 (2.1)	4.7 (2.3)	4.9 (1.8)	5.0 (2.3)
CPD	16.0 (8.1)	14.7 (7.3)	16.2 (7.6)	13.6 (6.8)
Years of smoking	20.8 (11.9)	21.6 (12.7)	19.3 (11.8)	20.1 (12.9)
Treatment-seeking (% Yes)	69.2%	66.7%	70.9%	78.1%
Mobile phone use				
Currently own mobile phone (% Yes)	97.3%	–	–	–
Currently own smartphone (% Yes)	80.4%	–	–	–
Usage among current smartphone owners (N = 180)				
Ever downloaded an “App” (% Yes)	91.7%	92.8%	93.7%	84.4%
Ever paid for an “App” (% Yes)	28.3%	31.9%	27.8%	21.9%
Ever used health tracking App (% Yes)	35.6%	34.8%	43.0%	18.8%
Ever used smoking cessation App (% Yes)	6.1%	4.3%	7.6%	6.3%
Number of Apps used weekly				
0–2 Apps	22.2%	21.7%	21.5%	25.0%
3–5 Apps	38.3%	42.0%	35.4%	37.5%
6+ Apps	39.4%	36.3%	43.1%	37.5%

CPD = cigarettes per day; FTND = Fagerström Test for Nicotine Dependence. Superscript numbers indicate a significant difference ($P < .05$) with that cluster. Analyses of race were restricted to White/Caucasian and Black/African American participants.

^aInformation was unavailable for 63 participants (Overall), 17 participants (Cluster 1), 26 participants (Cluster 2) and 4 participants (Cluster 3).

Table 2. Relationship between demographic/smoking variables and mobile phone use

Outcome variable	Predictor Variable							
	Gender	Race	Education	Income	Age	FTND	CPD	Treatment-seeking
1. Have you ever downloaded an app to your phone?	0.62 [0.20–1.88]	1.54 [0.53–4.45]	7.56 [2.29–24.99]	2.03 [0.64–6.40]	0.91 [0.86–0.96]	0.87 [0.67–1.12]	0.93 [0.88–0.99]	0.34 [0.08–1.58]
2. Have you ever paid for an app?	0.60 [0.31–1.15]	0.58 [0.29–1.16]	3.08 [1.34–7.10]	2.35 [1.03–5.35]	0.94 [0.92–0.97]	0.78 [0.66–0.93]	1.00 [0.96–1.05]	0.88 [0.43–1.78]
3. Have you ever downloaded a health tracking app?	0.75 [0.41–1.39]	0.64 [0.34–1.22]	5.75 [2.41–13.69]	2.48 [1.17–5.25]	0.96 [0.94–0.99]	0.94 [0.81–1.10]	1.00 [0.96–1.04]	0.88 [0.45–1.70]
4. Have you ever downloaded a smoking cessation app?	0.94 [0.28–3.18]	0.08 [0.01–0.62]	4.70 [0.59–37.62]	1.97 [0.35–11.14]	0.95 [0.89–1.00]	1.04 [0.77–1.40]	1.06 [0.99–1.14]	1.12 [0.29–4.40]
5. How many apps do you use $\geq$ 1x/week	0.82 [0.40–1.67]	1.00 [0.48–2.06]	1.98 [0.96–4.11]	1.78 [0.78–4.09]	0.94 [0.91–0.97]	0.98 [0.83–1.17]	0.98 [0.94–1.03]	0.35 [0.13–0.89]

CPD = cigarettes per day; FTND = Fagerström Test for Nicotine Dependence. Table values are Odds Ratios [95% Confidence Interval]. Bolded values are statistically significant (FDR $P < .05$; correcting for number of predictors separately for each outcome variable). Predictor variable coding: Gender is coded as 0 = Male; 1 = Female. Race is coded as 0 = White/Caucasian; 1 = Black/African-American. Education is coded as 0 = $\leq$ HS diploma; 1 = $>$ HS diploma. Income is coded as 0 = $\leq$ \$16,000/year; 1 = $>$ \$16,000/year. Treatment-Seeking is coded as 0 = Not seeking treatment; 1 = Seeking treatment. Age, FTND and CPD were continuous. Outcome variable coding: #1–4 are coded as 0 = No/Unsure; 1 = Yes. #5 is coded as 0 = $\leq$ 2 apps; 1 = $>$ 2 apps.

Figure 1. Perceived usefulness of possible smoking cessation app features. *Note.* Items ranked in order of preference.

as being the most useful were “Tells me how much my health is improving each day that I don’t smoke,” “Tells me how much money I have saved each day that I don’t smoke,” and “Assesses my reasons for smoking and develops a personalized quit plan for me.” Features perceived as being the least useful were “Sends information to my Facebook or other social network account about my progress in quitting smoking,” “Connects me to a social network of other smokers who are trying to quit,” and “Gives me information about the harmful effects of smoking.”

An overall MANOVA indicated that feature preferences differed as a function of race [$F(19, 145) = 2.58, p = .001$]. Follow-up tests indicated that participants who identified as Black/African American perceived greater usefulness in sending information to social media about progress quitting ($B = 1.34, 95\% \text{ CI } [0.64–2.04], p < .001$)

relative to participants identifying as White/Caucasian. Initial results also suggested impacts of age [$F(19, 160) = 1.90, p = .017$] and education [$F(19, 160) = 2.47, p = .001$] on overall feature preferences, although no follow-up tests reached significance after FDR correction. No other demographic or smoking variables, including treatment seeking status, were related to feature preferences.

Cluster Analysis, Cluster Differences, and Relative Feature Preferences

A cluster analysis revealed three clusters of smokers based on their relative feature preference (cluster 1 $n = 69$; cluster 2 $n = 79$; and cluster 3 $n = 32$). Results were confirmed via a discriminant function analysis, which correctly classified 92.2% of participants. Sample

characteristics and mobile phone usage patterns separated by cluster are included in Table 1. The clusters had significantly different educational attainment [$\chi^2(2) = 11.27, P = .004$], with both cluster 1 members [$\chi^2(1) = 4.74, P = .030$] and cluster 3 members [$\chi^2(1) = 10.88, P = .001$] having significantly less educational attainment relative to cluster 2 members. Significant differences were also present for income [$\chi^2(2) = 8.35, P = .015$], with a larger proportion of cluster 3 members reporting incomes below \$16 000/year relative to either cluster 1 [$\chi^2(1) = 4.03, P = .045$] or cluster 2 [$\chi^2(1) = 8.32, P = .004$]. Finally, the clusters also differed in racial makeup [$\chi^2(2) = 8.03, P = .018$]. Cluster 3 was comprised of a larger number of participants identifying as Black/African American relative to either cluster 1 [$\chi^2(1) = 5.25, P = .022$] or cluster 2 [$\chi^2(1) = 7.93, P = .005$]. The clusters did not differ on any other characteristics, including treatment-seeking status. Cluster 3 was comprised exclusively of participants who exhibited no variability in feature preferences, with all features being given identical ratings (typically the minimum or maximum ratings). Accordingly, this cluster was excluded from subsequent analyses examining feature ratings.

Table 3 provides descriptive data on feature ratings for clusters 1 and 2, including analysis of differences in feature ratings between clusters and relative preferences within each cluster. Crucially, the top and bottom features as rated by the overall sample were rated as being more useful and less useful (respectively) by each individual cluster with only two exceptions (“Tells me how much money I have saved each day that I don’t smoke” and “Connects me to a

social network of other smokers who are trying to quit” did not differ from the mean for cluster 1). This indicates preferences for these features was highly stable across clusters. Differences were primarily observed for mid-ranked features. Cluster 1 exhibited a relative preference for features that provided sources of motivation (e.g., “Provides me with points or other rewards for being able to achieve my quit goals,” “Sends me motivational messages throughout the day”). Cluster 2 exhibited a relative preference for features that provided practical assistance with quitting (e.g., “Helps me track my stress and craving levels” and “Provides me with reminders about taking smoking cessation medications”). Although social features (e.g., “Sends information to my Facebook or other social network account about my progress in quitting smoking,”) were rated as least useful by both clusters, Cluster 2 rated these features as significantly less useful even relative to Cluster 1.

Conclusions

The goal of this study was threefold. First, we examined patterns of mobile phone use among smokers in order to better understand the potential reach of mobile health interventions in this population as well as factors that could impact treatment dissemination. Next, we examined the perceived utility of features included in existing smoking cessation applications as well as those that are in varying stages of development. Finally, we used cluster analysis to determine whether subgroups of smokers could be identified based on their

Table 3. Feature Preferences by Cluster

	Cluster 1 M (SD)	Cluster 2 M (SD)	Cluster Differences
1. Tells me how much my health is improving each day that I don't smoke	5.36 (2.06) +	5.86 (1.53) +	$F = 1.8, p = .178$
2. Tells me how much money I have saved each day that I don't smoke	4.96 (2.26)	5.97 (1.47) +	$F = 10.8, p = .001$
3. Assesses my reasons for smoking and develops a personalized quit plan for me	4.94 (2.10) +	5.78 (1.61) +	$F = 7.6, p = .007$
4. Provides me with tips and suggestions for decreasing my craving for cigarettes	5.20 (1.97) +	5.51 (1.75) +	$F = 1.0, p = .324$
5. Helps me track my stress and craving levels	4.91 (2.05)	5.33 (1.84) +	$F = 1.7, p = .196$
6. Gives me information and tips for avoiding weight gain when I quit smoking	4.87 (2.29)	5.24 (1.98) +	$F = 1.1, p = .293$
7. Provides me with reminders about taking smoking cessation medications	4.68 (2.09)	5.16 (2.05) +	$F = 2.0, p = .158$
8. Detects situations where I might be tempted to start smoking again and alerts me	4.46 (2.19)	5.33 (1.84) +	$F = 6.8, p = .010$
9. Sends me motivational messages throughout the day	5.25 (2.09) +	4.65 (2.22)	$F = 2.8, p = .094$
10. Provides me with points or other rewards for being able to achieve my quit goals	5.42 (1.83) +	4.47 (2.11)	$F = 8.5, p = .004$
11. Provides me with feedback and encouragement from family members and friends	5.22 (2.01) +	4.25 (2.21) -	$F = 7.6, p = .007$
12. Provides me with distracting games or other tasks when I am having an urge to smoke	4.91 (2.11)	4.42 (2.21)	$F = 1.9, p = .167$
13. Provides me with product information about smoking cessation medications	4.29 (2.16)	4.80 (1.9)	$F = 2.3, p = .130$
14. Can connect me to a smoking cessation counselor or quitline	4.36 (2.22)	4.68 (2.06)	$F = 0.8, p = .363$
15. Tracks my smoking locations before I quit and then alerts me when I am entering one of those locations after I quit	3.72 (2.28) -	4.84 (2.03)	$F = 9.8, p = .002$
16. Sends information to my healthcare provider or quit smoking counselor about my quitting smoking progress	4.03 (2.24) -	4.20 (2.29) -	$F = 0.2, p = .643$
17. Gives me information about the harmful effects of smoking	3.35 (2.33) -	4.32 (2.26) -	$F = 6.6, p = .011$
18. Connects me to a social network of other smokers who are trying to quit	4.71 (2.19)	2.96 (2.00) -	$F = 25.8, p < .001$
19. Sends information to my facebook or other social network account about my progress in quitting smoking	3.49 (2.30) -	2.04 (1.59) -	$F = 20.5, p < .001$
Overall	4.63 (1.62)	4.72 (1.40)	$F = 0.1, p = .725$

Cluster 1, $n = 69$. Cluster 2, $n = 79$. Cluster 3 exhibited stable preferences across all features and thus was excluded from these analyses. An FDR correction for 19 outcomes was applied to both between- and within-subjects tests. Degrees of freedom are (1, 147) for all between-subject F tests. Significant between-subject tests following FDR correction are bolded. Superscript + and - indicate features perceived as more (+) or less (-) useful relative to each overall cluster average at the FDR $P < .05$ level.

feature preferences. To our knowledge, this is the first study to examine how smokers perceive the utility of novel cessation approaches made possible through advances in mobile technology.

Findings indicate that the vast majority (> 80%) of smokers own a smartphone device. This number is comparable to smartphone ownership in the general population¹⁸ and confirms potentially high reach of mobile health interventions. However, the odds of smartphone ownership were twice as high among women, nearly 3 times as high among higher income individuals and decreased by 6% with each additional cigarette smoked per day. A recent survey in the general population also found smartphone ownership was less common among lower income individuals.¹⁹ This is concerning given that smoking prevalence is highest among disadvantaged groups.²⁰ Yet given the tremendous growth in smartphone ownership in recent years,²¹ it seems unlikely this disparity will persist. Nonetheless, it is important to recognize that presently, mobile health interventions will not have universal reach, and heavy smokers who are arguably in the greatest need of intervention may not as readily access smartphone-based mobile health treatments. Additional effort will be needed to ensure equitable access by these individuals, where high smoking rates create the potential for a large impact on overall population health. For instance, SMS-based interventions may not allow for integration of as many technical features but could nonetheless offer added value through greater reach.^{22,23} In contrast, smartphone apps appear to be an ideal method for reaching certain smokers (e.g., light smokers) who would also benefit from quitting.^{24–27}

Although most smartphone owners reported having downloaded an application, certain subgroups (i.e., older smokers and smokers with lower educational attainment) were less likely to have done so. Importantly, only 28.3% of smokers reported having paid for any application in the past. Although applications are typically inexpensive relative to behavioral or pharmacologic treatments, this nonetheless may be a barrier that limits use. Accordingly, it is critical for developers of smoking cessation applications to explore alternative funding sources (e.g., advertisements, private or government sources) in order to maximize reach to the population of smokers. Such an approach could also help overcome potential financial barriers to care and minimize disparities in treatment access.²⁰ Ensuring applications are readily accessible to a majority of smokers is particularly critical given that the use of health tracking/management applications was relatively uncommon in this population (35.6%) and use of smoking cessation applications was extremely rare (6.1%). A focus on the development of applications and initial evaluation of their efficacy is needed, given the current state of the literature and the relatively recent emergence of mobile health applications. However, it is critical that both application developers and clinical researchers draw on lessons learned within the general clinical literature.²⁸ Most notably, development and testing of effective interventions alone is insufficient. Demonstrably efficacious interventions must also be disseminated widely and implemented appropriately in order to maximize impact on public health.^{29,30} The nature of smartphone applications arguably makes each of these processes more straightforward than other types of interventions, potentially providing an advantage over traditional behavioral or pharmacological interventions. Nonetheless, findings suggest utilization of cessation applications is low even compared to other types of cessation interventions.³¹

Findings indicated substantial variation in the perceived utility of listed features across smokers. The highest rated features can be construed as providing gain-framed messages to enhance motivation

(e.g., “Tells me how much my health is improving each day that I don’t smoke”), while loss-framed features (e.g., “Gives me information about the harmful effects of smoking”) were rated among the lowest. A substantial body of literature exists examining differences between gain and loss-framed messaging on both smoking^{32–34} and other health behaviors.^{35–38} Results generally—though not universally—indicate that gain-framed messages are more efficacious for encouraging smoking cessation. The fact that gain-framed features were *perceived* as useful by smokers in the present study is potentially important regardless of their actual efficacy. Barring demonstration of iatrogenic effects that might interfere with successful cessation, integration of these features could encourage downloading and use of the application, as well as greater engagement in the cessation process. Thus, even if such features are not the active mechanism responsible for improving cessation outcomes, increasing the appeal of an application could very well enhance its overall public health impact.³⁹ Social/interpersonal features (e.g., posting progress on social media and connecting to other smokers) were also generally viewed as unlikely to be helpful. Some variation in perceived utility was evident as a function of demographic variables (race and education), but examination of effects indicates these merely reflect certain subgroups perceiving these features as “less bad” rather than explicitly helpful. Aversion to social features may reflect a general aversion to sharing health-related problems online⁴⁰ as well as the increasing stigma of smoking behavior,⁴¹ fostering belief that involving others may induce stress and be counterproductive to cessation. It is also possible smokers were unaware of the potential benefits of social support and thus do not perceive it as likely to aid cessation. Alternatively, smokers may perceive low likelihood of successfully maintaining abstinence and be reluctant to broadcast anticipated failures.

The cluster analysis revealed two distinct subgroups of smokers based on their feature preferences, along with a smaller third cluster comprised of participants who rated all features as “Extremely Useful” or “Not at all useful.” Critically, the “top” and “bottom” features were consistent across the first two clusters, indicating that these preferences are relatively universal. The clusters were separated based primarily on the nature of intervention they appeared to be seeking. Cluster 1 was primarily seeking ways to enhance motivation to quit. Cluster 2 sought practical advice regarding quitting and was especially reluctant to involve others in the cessation process. These may reflect two discrete audiences or “markets” for smoking cessation applications and suggests potential advantage to developing multiple tailored applications based on the perceived utility of features for each group.⁴² For instance, just as often discussed with regard to traditional behavior change interventions,⁴³ separate applications could be developed aimed at either enhancing motivation to quit among unmotivated smokers or providing practical assistance to already motivated smokers. Despite this, the two clusters did not differ in treatment-seeking status. Differences in education level and other sample characteristics between the groups suggests there may be value to assessing these factors within applications for the purpose of strategic tailoring. A number of possible explanations exist for why the third cluster rated all features equally. It could reflect hopelessness with regard to cessation, very strong beliefs about the potential usefulness of technology-specific interventions, lack of insight into what would be helpful, or merely a strong response bias. This cluster reflected a particularly vulnerable group of smokers (minority, low education, and low income), so further research efforts are certainly needed to explore the preferences of this group

with regard to cessation applications and other potential intervention methods.

Several limitations exist in the present project. Although the sample was heterogeneous with respect to demographic characteristics, it was a convenience sample comprised of smokers within a narrow geographic region and may not be representative of smokers in general. For instance, smokers with severe mental illness were not included in the present report, despite the high rate of smoking within this population.⁴⁴ Smokers with chronic smoking-related illnesses were also excluded, and readers are cautioned against assuming these findings extend to this subgroup. Given rapid growth in the use of mobile technology,²¹ it seems extremely likely that usage patterns will shift over time and that this sample merely provides a “snapshot” collected over a period of several years. Similarly, technological innovations are occurring rapidly. The list of features is representative of available technology and that on the immediate horizon,⁴ but undoubtedly new possibilities that were not included will emerge.

Ultimately, findings from the present study indicate smoking cessation apps have the potential to reach a large portion of smokers, but only a very small portion of smokers have ever used this technology. This suggests that without additional effort to ensure accessibility and encourage utilization mobile health adoption will remain low. There was significant variation in the perceived utility of various smoking cessation application features, but a consistent preference did emerge for features broadly construed as gain-framed messaging, along with a relative aversion to social features. This information provides actionable guidance for the development and marketing of smoking cessation smartphone applications that can be used by academic researchers and industry scientists.

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Declaration of interests

None declared.

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