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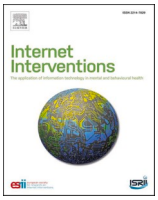

Characterizing perceived usability and its correlation with smoking cessation: An analysis of user assessments of the smoking cessation app quitSTART

Ziyan Chen [a], Leeann N. Siegel [b], Yvonne M. Prutzman [b], Kara P. Wiseman [a,*]

[a] University of Virginia School of Medicine, Charlottesville, VA, USA
[b] National Cancer Institute, National Institutes of Health, Bethesda, MD, USA

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ABSTRACT

Background: As smartphone ownership has become common in all demographic groups in the United States, smartphone applications (apps) for smoking cessation have grown in popularity due to their potential for supporting the diverse populations in the United States who are attempting to quit smoking. Usability is commonly assessed in mobile health (mHealth) technology as an important aspect of the user experience that could influence users' adherence to a health app and health outcomes. However, the variation of perceived usability across demographic groups, and the implications of that variation for app success, have not been well studied.
Objective: The aims of this study were to characterize variation in the perceived usability of the National Cancer Institute Smokefree.gov Initiative smoking cessation app quitSTART across demographic groups, and to assess the correlation between perceived usability and short-term smoking cessation.
Methods: We conducted a secondary analysis of data from a randomized controlled trial conducted from 2020 to 2021, which used a 16-item modified version of the mHealth App Usability Questionnaire (MAUQ) to quantify perceived usability four weeks after app download among 131 smokers attempting to quit. Responses were coded on a 5-point Likert-type scale ranging from strongly disagree (1) to strongly agree (5) and total perceived usability was calculated as the sum of all 16 items (range: 16–80). Associations between participant demographic characteristics (gender, race, education level, age, etc.) and total usability were determined using an ANCOVA model. A multivariable logistic regression model was used to assess the association between usability and smoking cessation, also assessed 4 weeks after app download.
Results: The ANCOVA model demonstrated that race was associated with perceived usability, with participants from a racial minority group reporting higher total usability than White participants ($p < 0.001$). White participants had an adjusted mean total usability of 55.8 (95 % CI: 52.8, 58.8) while racial minority group participants had an adjusted mean total usability of 66.5 (95 % CI: 61.2, 71.6). Other participant demographic characteristics, such as gender and sexual minority status, were not associated with mean total usability. Total usability was positively associated with smoking cessation (OR: 1.04, 95 % CI: 1.00, 1.08, $p = 0.031$).
Conclusions: Total perceived usability of quitSTART was higher among adults from a racial minority group compared to White adults, and perceived usability was positively associated with cessation success. These findings emphasize the importance of ensuring high usability of mHealth smoking cessation apps for diverse populations.

1. Introduction

Cigarette smoking is the leading cause of preventable death in the United States (Cornelius et al., 2023). Additionally, >16 million Americans experience smoking-attributable diseases, such as cancer, cardiovascular disease, stroke, and diabetes (Cornelius et al., 2023). Despite the high morbidity and mortality caused by cigarette smoking, successful cessation rates are low. In 2017, more than half of adults who smoked attempted to quit (66 %), but only 5 % successfully quit (US Department of Health and Human Services, 2020). Additionally, the

* Corresponding author at: Department of Public Health Sciences, University of Virginia School of Medicine, P.O. Box 800717, Charlottesville, VA 22908, USA.
E-mail address: kara.wiseman@virginia.edu (K.P. Wiseman).

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health burden of smoking disproportionately affects racial and ethnic minorities in the U.S. For example, Black Americans tend to begin smoking later in life compared to their White and Hispanic counterparts but have a higher likelihood of dying from smoking-related disease (Centers for Disease Control and Prevention, 2022).

Numerous interventions can increase smoking cessation, including the use of FDA-approved medications and behavioral counseling, whether delivered via quit lines, social support, or in-person. Mobile health (mHealth) technology is a promising and relatively new method of delivering accessible and equitable smoking cessation support. Data collected between 2020 and 2021 shows that 85 % of U.S. adults own a smartphone on which they can access a smoking cessation application (app), and smartphone ownership is consistently high across racial (83–85 %) and gender (85 % in both men and women) groups, but more variable across socioeconomic groups (76 %–96 %) (Pew Research Center, 2021). Smoking cessation apps have increased in popularity in recent years due to their convenience, cost-effectiveness, customizability, ability to provide social support, and ability to deliver tailored content based on time of day and the user's geographic location (Barroso-Hurtado et al., 2021). However, more research is needed to understand and improve the effectiveness of these apps. For example, a content analysis of popular smoking cessation apps conducted in 2013 found that apps have low consistency with evidence-based smoking cessation guidelines (Abroms et al., 2013). Additional research is needed to understand the relationship between specific app characteristics and clinical outcomes (Vilardaga et al., 2019).

To better understand how to create mHealth apps with high adherence and enhanced clinical outcomes, it is necessary to consider their usability. App usability is an important metric for measuring the quality of an mHealth intervention (Zhou et al., 2019). Distinct from app usage, app usability reflects various aspects of the user's perceived experience, including ease of use, willingness to use the app frequently, perceived complexity of the app, and ability to recover from a mistake while using the app (Zhou et al., 2019). A nationally representative survey of mobile phone owners found that mHealth app users report data entry burden, loss of interest, and high cost as primary reasons for stopping app use (Krebs and Duncan, 2015). High data entry burden is directly related to usability, and loss of interest can also partially be attributed to problems with usability (Zhou et al., 2019). Another recent systematic review (Wang et al., 2020) of mHealth interventions aimed at treatment of diabetes and obesity found that effectiveness of the interventions varied widely by study; the authors concluded that future studies should aim to improve the usability of interventions in order to maximize the effectiveness of mHealth apps.

While numerous studies have examined the perceived usability of mHealth apps targeted towards other health behaviors, such as diet modification, exercise, and disease management, few have examined the perceived usability of smoking cessation apps (Zhou et al., 2019; Armin et al., 2017; Luna-Perejon et al., 2019; Paige et al., 2018; Vinci et al., 2020). Additionally, most studies evaluating usability of mHealth apps report usability as their sole outcome (Baumel et al., 2017; Baumel and Kane, 2018; Kennedy et al., 2019); few studies have examined usability as a predictor of other measures, such as app usage (Kirwan et al., 2012; Tahsin et al., 2021), and no studies to date have examined usability as a predictor of behavior change or clinical outcomes. Further, most do not compare perceived usability by user characteristics (Chang et al., 2019; Gabbard et al., 2021; Lee et al., 2019; McWilliams et al., 2021; Lee et al., 2022; Ruf et al., 2021). To our knowledge, there are no studies focused on smoking cessation apps that have compared usability across demographic groups or evaluated usability as a predictor of cessation. The potential benefit of mHealth intervention scalability will be undermined if disseminated apps are not equitably usable across groups. Elucidating variation across user groups in the perceived usability of smoking cessation apps allows the mHealth field to move towards a more complete understanding of the specific factors that drive successful engagement among individual user groups. Knowing the magnitude of the association between usability and cessation allows for better understanding of the importance of usability scores for mHealth apps designed to support smoking cessation.

The purpose of this study was to 1) characterize usability of the National Cancer Institute (NCI) Smokefree.gov Initiative's smoking cessation app quitSTART across various participant characteristics and 2) determine the correlation between usability and short-term (4-week) smoking cessation.

2. Methods

2.1. quitSTART app

quitSTART is a free and publicly available smoking cessation app that is operated and maintained by the NCI's Smokefree.gov Initiative and available for IOS and Android. The app provides users with information about smoking, cessation tips and motivation, tools for monitoring progress (e.g., badges that can be earned for smokefree milestones), games that offer distractions when experiencing cravings, and challenges to maintain motivation to quit. Users can add sets of content, called “cards,” into their own personal “quit kits” to individualize their cessation plan. The app also enables users to track their nicotine cravings and “tag” them to a specific time of day or a specific location so that they can receive supportive push notifications at that specific time or location (Prutzman et al., 2021). Upon downloading the app, users automatically start a two-week ecological momentary assessment (EMA) protocol, which prompts them to enter information related to mood, smoking behavior, and cravings three times a day for 14 days. Users may opt-out of the EMA protocol at any time.

2.2. Setting and study population

This study is a secondary analysis of data from a randomized controlled trial that was designed to determine the impact of app-based EMAs on smoking cessation. Briefly, between 2020 and 2021, 152 smokers were recruited using advertisements posted on the Smokefree.gov Initiative's webpages and social media sites and text messages sent to users of Smokefree.gov Initiative text messaging programs. Enrolled participants were randomized to either an “incentivized EMA” arm or a “non-incentivized EMA arm.” Participants randomized to the incentivized arm were compensated, in part, based on the number of EMAs they completed during the two-week EMA protocol. Participants in the non-incentivized EMA arm were compensated for completing the baseline survey and the follow-up assessments but not for completing EMAs. Follow-up assessments were sent to all participants at two and four weeks after app download. For this study, only the responses from the 4-week follow-up assessment were analyzed. Participants who did not respond to the 4-week follow-up assessment (n = 18) and those who did not respond to all items of the perceived usability scale (n = 21) were excluded, resulting in 131 participants in the final study sample.

2.3. Measures and coding

Perceived usability was measured using a modified version of the mHealth App Usability Questionnaire (MAUQ) of Zhou et al. (Zhou et al., 2019) The modified MAUQ included 16 items, each with a five-point Likert-type scale; response options ranged from strongly disagree (1) to strongly agree (5) (Supplemental Table 1). Two items were excluded from the original 18-item MAUQ as they were not applicable in the context of the quitSTART app. A total perceived usability score was calculated as the sum of all 16 questions, resulting in a final range of 16–80.

Smoking cessation was assessed using self-reported 7-day point prevalence abstinence. Specifically, participants were asked, “Have you smoked a cigarette (even a puff) in the past 7 days?”. Responses were coded as quit (“no, not smoked in the last 7 days”) or continued smoking

("yes, smoked in the last 7 days").

Participant characteristics in this secondary analysis included all demographic variables surveyed at baseline in the primary randomized controlled trial, and included gender identity ("male," "female," or "non-binary or trans;" due to small sample size, "non-binary or trans" respondents were coded as missing and omitted in analyses that included the gender variable), race ("White" or "racial minority," which included "Black or African American," "American Indian," "Asian, Pacific Islander," "something else," or "multiple races"), education level ("less than or equal to high school/GED," "some college," or "college graduate or more"), partnership status ("partnered," which included response options "married" and "living as married or living with a romantic partner," or "unpartnered," which included response options "divorced," "widowed," "separated," and "single, never been married"), sexual minority status ("heterosexual/straight" or "LGB+," which included the response options "gay or lesbian," "bisexual," and "something else"), rural residence ("rural" or "not rural" based on participant zip code), phone type ("iPhone" or "Android"), and age (continuous).

2.4. Statistical analysis

All analyses were conducted in R version 4.2.1 for macOS. Before conducting our analyses, we assessed the reliability of the MAUQ in our study sample by computing the Cronbach's alpha for the scale as well as a bootstrap 95 % confidence interval based on 1000 samples.

2.4.1. Perceived usability as outcome

Bivariate *t*-tests and f-tests were used to compare total perceived usability scores across all categorical variables and bivariate linear regression was used to assess the correlation between age and total perceived usability score. An ANCOVA model was used to determine independent associations between participant characteristics and perceived total usability. Chi square and ANOVA tests for multicollinearity between potential variables to include in the ANCOVA model were performed before building the final model. All variables with bivariate p-values of association ≤ 0.20 and without collinearity were included in an initial ANCOVA model. Chi square tests revealed collinearity (i.e., a significant association) between sexual minority status and gender identity ($p < 0.001$). To determine which of these two variables to include in the final model, gender identity and sexual minority status were each added separately to the initial model and the percent change in the original point estimates were calculated. When added separately to the initial model, the inclusion of gender identity resulted in larger changes to the point estimates of the other variables; thus, it was retained in the final model. In the final ANCOVA model, the residuals were normally distributed, with a Shapiro-Wilk normality test p-value of 0.150. A Levene test confirmed homogeneity of variance, with all p-values >0.05. ANCOVA models also provided estimated adjusted means and 95 % confidence intervals of the means.

2.4.2. Smoking cessation as outcome

Variables identified as potentially associated with usability were also

Table 1
Descriptive statistics: Smoking cessation and total usability scores across participant characteristic groups.

Characteristic	Overall	Four-week successful smoking cessation[a]			Total usability (mean = 59.1, SD = 14.3)	
	n (%)	Yes (n = 37, 28.2 %)	No (n = 94, 71.8 %)	p value[b]	Mean (SD)	p value[c]
		n (%)	n (%)			
Gender identity[d]						
Male	31 (24.2 %)	8 (22.2 %)	23 (25.0 %)	0.920	56.1 (13.62)	**0.132**
Female	97 (75.8 %)	28 (77.8 %)	69 (75.0 %)		60.5 (14.37)	
Race						
White	102 (77.9 %)	25 (67.6 %)	77 (81.9 %)	**0.122**	56.5 (14.19)	**p < 0.001**
Racial minority[e]	29 (22.1 %)	12 (32.4 %)	17 (18.1 %)		68.1 (10.81)	
Education level						
High school or less	17 (13.0 %)	5 (13.5 %)	12 (12.8 %)	0.708	60.4 (17.46)	0.561
Some college	50 (38.2 %)	16 (43.2 %)	34 (35.9 %)		59.6 (12.91)	
College graduate or more	64 (48.9 %)	16 (43.2 %)	48 (51.1 %)		58.4 (14.65)	
Partnership status[f]						
Partnered	67 (51.1 %)	21 (56.8 %)	46 (48.9 %)	0.541	60.1 (15.09)	0.402
Unpartnered	64 (48.9 %)	16 (43.2 %)	48 (51.1 %)		58.0 (13.50)	
Sexual minority status[g]						
Straight	105 (80.2 %)	27 (73.0 %)	78 (48.9 %)	0.294	60.0 (14.34)	**0.169**
Not straight	26 (19.8 %)	10 (27.0 %)	16 (51.1 %)		55.7 (13.93)	
Rural residence						
Not rural	116 (88.5 %)	32 (86.5 %)	84 (89.4 %)	0.872	58.7 (14.86)	0.223
Rural	15 (11.5 %)	5 (13.5 %)	10 (10.6 %)		62.1 (8.88)	
Phone type						
iPhone	72 (55.4 %)	18 (48.6 %)	54 (58.1 %)	0.436	58.0 (14.50)	0.338
Android	58 (46.6 %)	19 (51.4 %)	39 (41.9 %)		60.4 (14.22)	
Study arm[h]						
Non-incentivized EMA	70 (53.4 %)	26 (70.3 %)	44 (46.8 %)	**0.026**	61.0 (13.46)	**0.114**
Incentivized EMA	61 (46.6 %)	11 (29.7 %)	50 (53.2 %)		57.0 (15.07)	
Age: Mean (SD)	45.7 (12.59)	44.7 (12.79)	25.1 (12.56)	0.576	0.004231	0.4604

[a] "Successful" = responded no to question "Have you smoked a cigarette, even a puff, in the past 7 days?" at four weeks. "Unsuccessful" = responded yes to previously specified question.

[b] p value obtained from chi square or t-test, as appropriate. All p values ≤ 0.2 are bolded.

[c] p values are calculated from *t*-tests, ANOVA, and linear regression as appropriate. All p values ≤ 0.2 are bolded.

[d] Some responses suppressed due to small sample size.

[e] "Racial minority" includes Black, American Indian, Pacific Islander, something else, and multiple races.

[f] "Partnered" = married/partnered. "Unpartnered" = divorced, widowed, separated, or single, never been married.

[g] "Not straight" = gay or lesbian, bisexual, or something else.

[h] "Non-incentivized EMA" = participants who, in the original study, were randomized to use app however they like, and to be compensated only for survey completions. "Incentivized EMA" = participants who, in the original study, were randomized to receive compensation based in part on level of EMA (ecological momentary assessment) participation.

included in the model for smoking cessation. Additionally, bivariate descriptive statistics were calculated using chi-square tests and *t*-tests as appropriate to identify any other characteristics to consider including in a multivariable logistic regression model to determine the association between perceived usability and smoking cessation, also using a p-value of ≤0.20 as the criteria for inclusion. No new variables were identified for inclusion in the final logistic regression model; thus, the final smoking cessation model included the same predictors as the usability ANCOVA. Model results provided odds ratios and 95 % confidence intervals.

3. Results

Demographic characteristics of the sample are presented in Table 1. The study population was mostly female (75.78 %) and White (77.86 %). The average age of participants was 45 years old (SD = 12.59). The Cronbach's alpha for the MAUQ was 0.96 (bootstrap 95 % confidence interval: 0.95, 0.97), indicating high scale reliability. Overall, mean total perceived usability was high (mean = 59.1, SD = 14.3). Mean perceived usability scores were significantly higher among racial minority participants than among white participants (mean usability 68.1 for racial minority participants; 56.5 for white participants, $p < 0.001$), and for participants who reported cessation at four weeks, compared with those who had not quit at four weeks (mean usability 65.0 and 56.8 for participants who had quit or not, respectively, $p = 0.003$, data not shown). Mean perceived usability did not differ significantly across the other included characteristics (gender identity, education level, partnership status, sexual minority status, rural residence, phone type, and age). Overall, 28.2 % of participants reported smoking abstinence at four weeks. Cessation rates were higher among participants in the non-incentivized EMA arm compared to the incentivized EMA arm ($p = 0.026$).

The ANCOVA model demonstrated that participant's race was associated with mean total usability ($p < 0.001$, Table 2). White participants had an adjusted mean total usability of 55.8 (95 % CI: 52.8, 58.8) compared to racial minority group participants with adjusted mean total usability of 66.4 (95 % CI: 61.2, 71.6). Gender identity and study arm were not associated with mean total usability ($p = 0.132$ and 0.101, respectively). Total usability was positively associated with smoking cessation (OR: 1.04, 95 % CI: 1.00, 1.08, $p = 0.031$, Table 3).

Table 2
ANCOVA results: Total usability as outcome.

Predictors	Adjusted total usability (95 % CI)	p value[a]
Gender identity[b]		
Male	63.1 (59.4–66.8)	0.132
Female	59.1 (55.0–63.3)	
Race		
White	55.8 (52.8–58.8)	**p < 0.001**
Racial minority[c]	66.4 (61.2–71.6)	
Study arm[d]		
Non-incentivized EMA	63.1 (59.4–66.8)	0.101
Incentivized EMA	59.1 (55.0–63.3)	

[a] p values <0.05 are bolded.
[b] Some responses suppressed due to small sample size.
[c] "Racial minority" includes Black, American Indian, Pacific Islander, something else, and multiple races.
[d] "Non-incentivized EMA" = participants who, in the original study, were randomized to use app however they like, and to be compensated only for survey completions. "Incentivized EMA" = participants who, in the original study, were randomized to receive compensation based in part on level of EMA (ecological momentary assessment) participation.

Table 3
Multiple logistic regression results: Cessation as outcome.

Predictors	OR (95 % CI)	p value[a]
Gender identity[b]		
Male	1.04 (0.40–2.87)	0.939
Female	Referent	
Race		
White	Referent	
Racial minority[c]	0.70 (0.27–1.84)	0.462
Study arm[d]		
Non-incentivized EMA	Referent	
Incentivized EMA	**0.42 (0.17–0.96)**	**0.045**
Usability[e]	**1.04 (1.00–1.08)**	**0.031**

[a] p values <0.05 are bolded.
[b] "Racial minority" includes Black, American Indian, Pacific Islander, something else, and multiple races.
[c] Some responses suppressed due to small sample size.
[d] "Non-incentivized EMA" = participants who, in the original study, were randomized to use app however they like, and to be compensated only for survey completions. "Incentivized EMA" = participants who, in the original study, were randomized to receive compensation based in part on level of EMA (ecological momentary assessment) participation.
[e] Calculated as the sum of 16 questions adapted from the MAUQ (Zhou et al., 2019).

4. Discussion

4.1. Principal findings

This secondary analysis of data from a randomized clinical trial evaluating the NCI's Smokefree.gov Initiative smoking cessation app quitSTART provides evidence that perceived usability of this app varied across racial groups, and that differences in usability scores may be relevant to smoking cessation outcomes. We compared usability scores across multiple participant characteristic groups and found that participants from racial minority groups rated the quitSTART app higher in usability than White participants. We also assessed the correlation between total perceived usability scores and smoking cessation outcomes and found that perceived usability and cessation are positively correlated. To our knowledge, our study is the first to demonstrate a significant difference in app usability across racial groups and to establish a relationship between perceived usability and behavior change for smoking cessation.

Previous evaluations of perceived usability have identified variability across demographic characteristics such as age (McWilliams et al., 2021), socioeconomic status (Lee et al., 2022), and gender identity (Ruf et al., 2021). Overall, there is a lack of research illuminating how adults of different racial and ethnic groups interact with technology (Heron et al., 2019; James and Harville, 2016), but existing research suggests that Black and Hispanic adults may have more comfort and experience using mHealth interventions than White adults (Heron et al., 2019; Bhuyan et al., 2016; Camacho-Rivera et al., 2020). Black and Hispanic adults are less likely than White adults to own computers but are equally likely to own smartphones or tablets (Atske and Perrin, n.d.). Additionally, Americans from racial/ethnic minority groups are more likely to use a smartphone as their primary means of accessing the Internet and, as a result, they are more likely to be smartphone-dependent for their healthcare needs (Cyriac et al., 2021). This dependence could increase their familiarity with using mHealth apps, which may produce higher usability scores. Although there are no previously published studies demonstrating a racial difference in mHealth app usability, some research examines racial differences in mHealth usage (Camacho-Rivera et al., 2020; Bender et al., 2014) and perceived usefulness (Bhuyan et al., 2016), and have found that Americans from racial minority groups have more experience with mHealth and have higher usage and perceived usefulness (Bhuyan et al., 2016; Camacho-Rivera et al., 2020), though findings from other studies are inconclusive

(Langford et al., 2020). Our study brings the metric of perceived usability into this discussion of varying app success between racial groups.

The finding that perceived usability may differ across racial groups is particularly salient because of our second main finding, that higher usability is a predictor of increased odds of short-term (4-week post enrollment) smoking cessation. The odds ratio of 1.04 in our study reflects the adjusted change in the odds of cessation for every one point increase in total usability out of 80. That is, compared to a participant who reported agreeing to all 16 perceived usability items (a total score of 64), a participant who strongly agreed to one item and agreed to the remaining 15 items (a total score of 65), would have 1.04 times the odds of cessation at 4 weeks. A change from agree to strongly agree to all 16 items (i.e., a total score of 80 compared to 64) would equate to 1.87 times the odds of cessation. To our knowledge, no other study has demonstrated a correlation between perceived usability and successful smoking cessation. To date, there has been little research focusing on app usability as a predictor of behavior change outcomes or other measures of app success; rather it is frequently reported as the study outcome. Tahsin et al. (Tahsin et al., 2021) conducted a secondary analysis of 44 patients with chronic health needs using an electronic Patient Reported Outcome-digital health intervention and measured app usage and perceived usability over a one-year period. They compared the post-study system usability questionnaire (PSSUQ) scores between short-term and long-term users and did not find a statistically significant difference between the groups. Thus, perceived usability was not associated with actual app usage. Kirwan et al. (Kirwan et al., 2012) also considered the relationship between perceived usability and app use, using a 10-item questionnaire to assess usability and actual app usage of a step counter app, and did not find a relationship between perceived usability and logging of step counts. Having evidence that perceived app usability is associated with smoking cessation outcomes emphasizes the need to consider usability when creating smoking cessation apps and suggests the need for more research into perceived usability as a predictor of app-associated behavior change in general.

Furthermore, this finding adds weight to the disparity in perceived usability scores across racial groups as observed in this study. White Americans are just as likely as Black or Hispanic adults to report current smoking (Cornelius et al., 2023), yet White participants in this study were found to have lower perceived usability scores than participants from racial minority groups. Ensuring that mHealth interventions are perceived as highly usable for all potential users is an important goal. This study did not explore whether perceived usability mediated the relationship between race and smoking cessation, but this would be a useful direction for future research to better understand the mechanism of perceived usability on behavior.

4.2. Study strengths and limitations

This study has some limitations that need to be considered. First, to achieve an adequately large sample size for statistical tests, we combined multiple characteristic groups. For example, for race, all races other than White were collapsed into one group. Thus, we found that usability was higher among racial minority groups, but we were not able to explore which specific racial groups had higher usability scores. However, our findings are still relevant as it is useful to know that usability scores are not equal across racial groups. Similarly, we were not able to include participants who identify as non-binary or trans in statistical analyses involving the gender identity variable, due to small sample size of this group. Additionally, there are some participant characteristics not assessed in the baseline survey that would further clarify our findings. Specifically, the baseline survey did not include measures for socioeconomic status, overall smartphone usage, self-reported expectations of mHealth apps, self-reported attitudes towards using mHealth apps, or self-reported comfort with mHealth apps. Thus, we could not control for these variables. Finally, this study measured perceived app usability and smoking cessation simultaneously, preventing us from drawing conclusions about causal relationships between usability and smoking cessation. More research is needed to clarify whether smoking cessation status could have affected participants' self-reported usability scores; a user who failed to quit at 4 weeks after app download may be subconsciously more likely to say that the app had usability issues.

Our study used a modified version of the MAUQ to quantify usability. At present, the most popular measure of usability for mHealth apps is the Systems Usability Scale (SUS) (Brooke, 1995). We chose to utilize the MAUQ because it was developed specifically for assessing usability with mHealth apps, rather than systems in general. The MAUQ has been demonstrated to correlate with the SUS, and unlike the SUS, it has been validated specifically for mHealth apps (Zhou et al., 2019). Additionally, our findings with the MAUQ are consistent with expected findings, that usability should be associated with the outcome of interest, smoking cessation. Thus, we believe that the MAUQ was an adequate scale for measuring usability in our study.

4.3. Future research

Our finding that usability of a smoking cessation app was higher among adults from racial minority groups merits further study. Specifically, it is necessary to better understand which specific racial groups have higher usability scores to determine what may be driving racial differences. In future studies, a larger and more representative sample would allow for additional distinctions between specific racial groups and perceived usability. It is difficult to determine whether the association between race and perceived usability scores is due to app characteristics, or due to other systematic differences between groups, such as the fact that participants from racial minority groups currently rely on mobile applications for accessing healthcare (Atske and Perrin, n.d.) and thus are more accustomed to mHealth tools. This distinction warrants further investigation as it has implications for future approaches to equitable mHealth app design.

In this study we found a correlation between perceived usability and cessation. This secondary analysis was limited to the survey data assessed in the primary randomized controlled trial. Future research could further investigate other variables to clarify the pathway from perceived usability to successful behavior change. For example, it would be worthwhile to examine the link between perceived usability and app usage. While existing literature has not identified an association between perceived usability and app usage (Kirwan et al., 2012; Tahsin et al., 2021), this is a new area of investigation, particularly to understand the mechanism by which higher perceived usability lends itself to more successful app outcomes. Psychological factors are likely also at play - a more pleasant and easy to use app experience may allow users to feel more motivated, more empowered, and less frustrated. A better understanding of the relationship between app usage, user satisfaction, and behavior change would allow mHealth app designers to have clearer design objectives with the goal of successful behavior change.

5. Conclusions

In this study, we compared the perceived usability of the smoking cessation app quitSTART across multiple participant characteristics and found that usability was higher among adults from racial minority groups compared to White adults. More research is needed to understand the mechanism behind this finding, but our findings are an important reminder that mHealth usability scores for one demographic group may not be generalizable to another. It is also promising that the quitSTART app data suggest that this smoking cessation app is perceived as highly usable among people from racial minority groups, as these groups are likely to utilize mHealth resources. Additionally, we concluded that higher perceived usability was correlated with a higher chance of successful cessation. This finding reinforces the importance of measuring usability when developing mHealth interventions. Taken

together, these findings suggest the importance of ensuring that perceived usability is high for all users of an mHealth app.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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