SmokeFreeNZ: Designing and Evaluating the Effectiveness of a Mobile Application in Reducing Cigarette Consumption

Lian Wu[1*], Daniel Stamp[1], Erin Hanlon[1], Jacqueline Hampton[1], Jayne Mercier[1], Karen Hicks[1], Nilufar Baghaei[2], John Casey[2] and Bin Su[3]

[1]BHSD, Community Development Practice Pathway, Unitec Institute of Technology, New Zealand

[2]Department of Computer Science, Unitec Institute of Technology, New Zealand

[3]Department of Architecture, Unitec Institute of Technology, New Zealand

[*]**Corresponding author:** Lian Wu, BHSD, Community Development Practice Pathway, Unitec Institute of Technology, New Zealand, Tel: + 09 815-4321 ext. 7525; E-mail: lwu@unitec.ac.nz

Abstract

Background: Smoking is one of the leading causes of mortality and morbidity in New Zealand and the greatest burden of disease in the health of New Zealanders. A novel mobile application, SmokeFreeNZ, was developed for android phone systems.

Objective: To investigate the efficacy of the SmokeFreeNZ app on prevalence of abstinence, self-reported number of cravings per day and smoking knowledge index measures.

Methods: Forty Unitec smokers (30 android users and 10 controls) were recruited. Smokers' demographics and their smoking information were investigated at baseline. The efficacy of the mobile app was evaluated by measuring prevalence of abstinence, self-reported number of cravings per day and smoking knowledge index measures.

Results: After the mobile app use, mean Smoking Knowledge Index Measures increased from 62 (± 9)% to 96 (± 3)% (p<0.001) compared to the control group. Maximum number of days of continuous abstinence was 5.2 (± 0.5) days in the app user group and 2.1 (± 0.5) days in the control group (p<0.02). The prevalence of seven days abstinence in users of SmokeFreeNZ was also improved significantly in comparison to the control group (26.7% in the app user group compared to 10.0% in the control group, Chi-square tests; p<0.05). These findings indicate that the SmokeFreeNZ app did help smokers at Unitec to quit smoking.

Conclusion: The SmokeFreeNZ app provided flexible and effective approach to coach smokers about the health risks of smoking and also improved seven days' abstinence rates in the study period. Future investigation is required to compare the cost-benefit effects and to evaluate the efficacy in smoking cessation in a larger-scale trial.

Keywords: Health promotion; Health informatics evaluation; Smoking cessation; Health education

Introduction

Globally, about six million people die annually as a result of smoking [1]. By estimation, about 30% of the current smokers will die from smoking related medical conditions. It is also believed that tobacco smoking will make life expectancy 10 years shorter than normal [2].

Currently, tobacco smoking is still one of leading causes of mortality and morbidity in New Zealand, and the greatest burden of disease in the health of New Zealanders [3]. Worldwide, it is expected that smoking will contribute to 10 million deaths annually by 2030 [4]. Smokefree Aotearoa, New Zealand 2025 is an official government goal [5]. In 2011, Maori smoking and tobacco use report which was published by Ministry of Health [3] and it was reported that tobacco is still a leading cause of preventable death in New Zealand, and the current smoking rate for Māori is 44 percent, which is still significantly higher than for non-Maori is 18 percent [3].

Other studies have investigated efficiency of various smoking cessation strategies, such as telephone hotlines [6], printed self-help materials [7], cell phone text messages [8] and online interventions [9]. These different approaches which are different to traditional methods (face to face approach) have demonstrated great reach potential and better efficacy than previous approaches [10].

Within these strategies, txt message and online services have shown some advantages. First of all they can be managed by computer automatically. Secondly, once the system is setup properly, it can provide services (Such education, referral and coaching) to huge amount of clients at the same time day and night. Thirdly, the contents of these systems can be updately regularly, spontaneous and easily [11]. However, since smartphone technology has become more and more popular in younger generations, smartphone apps have much wider and more important uses in smoking cessation than other approaches. In New Zealand, smartphone ownership/access has increased sharply since 2013 (from 48 percent in 2013 to 70 percent in 2015). Smartphone and laptop ownership was particularly high amongst 18 to 34-year-old (91 percent and 85 percent respectively) although more than three-quarters of those aged 35-54 years also owned or had access to these devices [12].

We know that the main drivers of smoking become significantly reduced after a month of total abstinence [13]. Based on the theory of motivation, successfully stopping smoking involves keeping the desire and capacity to inhibit smoking sufficiently high to override the impulses to smoke that can arise at any time following the start of a quitting attempt [14].

Previous studies have shown that text (txt) message intervention (when smokers are sent text messages to support them while they are quitting) can help boost motivation and can significantly improve the success rates of smoking cessation. Compared to normal face to face intervention, these methods have shown greater feasibility and better delivering rate [15].

Our proposed mobile app further improves the txt message approach because:

1) Our app provides two-way interaction between the server and client, whereas txt interventions only provide one-way communication (from server to client). This intervention is similar to a face-to-face approach, but without the limitation of resourcing.

2) The app is more likely to engage younger people than the txt method, as young people are most likely to have access to a smartphone with social media apps.

3) The app will provide interventions, but will also be useful to monitor the progress of cessation. We will know if further or more frequent interventions are required, particularly within the first month of cessation.

4) The app can include elements of static text but also multimedia such as video, music, cartoons and even games.

5) The app can be tailored to deliver materials to suit different cultural backgrounds (for example Māori or Pasifika).

Mobile technologies such as smartphone apps for smoking cessation already show promising advantages in intervention and education [16]. Compared to txt-aided smoking cessation, a smartphone app can not only deliver text content, but also can deliver multimedia content, can record self-motivation content and can be linked to popular social media such as facebook. In one of the recent studies [17], authors found that online social groups provided a useful platform for the delivery of cessation support and encouragement of reporting abstinence, which support relapse prevention. They concluded that quitters who participate in the online social groups can benefit from peer support and information sharing, which help prevent smoking relapse.

Objectives

In this paper,the research objectives are:

1) Quantitatively discover how much the proposed mobile application can improve smoking cessation rates in smokers.

2) Investigate the effectiveness of the mobile app on smokers' knowledge levels which may affect smoking cessation.

Materials and Methods

This project was composed of three sections:

- Design
- Implementation and

- An experimental trial.

Design of the mobile app

Main functions of the application and system architecture were designed were:

- To deliver tailored multimedia intervention content to each smoker regularly to encourage, persuade, rouse and maintain their motivations.
- To investigate smokers cravings and try to identify the causes of craving.
- To record their progress such as the amount of cigarettes have been reduced.
- To assess health benefits and the change of life expectancy due to decrease of the amount of smoking.
- To record how long they have been smoke free, to see the money they have saved from not smoking.
- To provide a "push service" to maintain their motivation.

Development of the mobile app

A wire frame and storyboard was developed, to illustrate the application to potential users (Wire framing is the process of creating a prototype of the application). Then the back end of the mobile app was defined, such as deciding on the structure of the server and database.
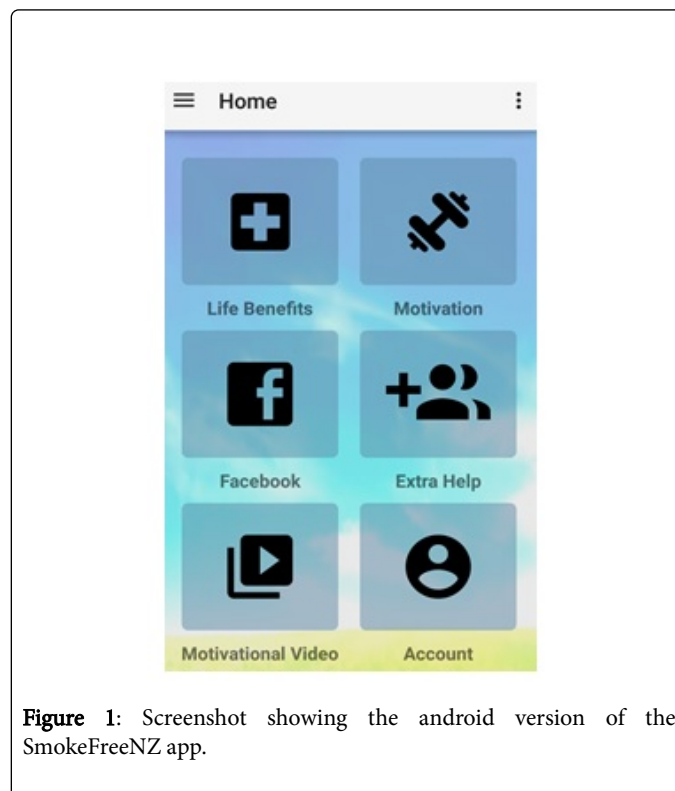

Figure 1: Screenshot showing the android version of the SmokeFreeNZ app.

After the first prototype was developed, the back end of the app was built and tested. The application 'skins' were then designed to suit different cultural backgrounds such as Māori. The prototype was then tested again, further bugs were fixed and improved. The app was further revised by different users and refinements continued to be made. After a further three rounds of testing, reviewing and improving cycles, the first version of the app was released to the Google Play Store

for users to download free. Due to the limitation of resources, only the Android version of the app was developed at this time (Figure 1).

Experimental trial

In the trial phase, a controlled test was conducted on the Unitec campus for six weeks. Before users can use the full functions of The SmokeFreeNZ app, users need to sign up the app. During the sign up step, users need to provide information about themselves and their smoking history.

Each smoker can select start date to quit. Each user received tailored txt messages to encourage them to use the app each day, from start date to the end of study period. At the end of the study period, the app will stop updating. The app can collect users' useful data, including each login and the self-report if they are still abstinent. Self-reported continuous smoking abstinence was used as one of the end point measurements.

Steps included

Ethics approval

- All subjects gave their informed consent for inclusion before they participated in the study.
- This study has been approved by the Unitec Research Ethics Committee (2016-1011).

Study subjects: Sixty-four students and staff members registered for the study. Of those, 40 eligible current unitec smokers consented to and participated in this six-week study.

Inclusion criteria for smokers to participate this study:

1) Current smokers.

2) Have a mobile phone (IOS or android). Finally, 30 android phone users and 10 iPhone users were recruited. The iPhone users were used as control group, since they can't use the SmokeFreeNZ app.

Baseline measures: Smoking history variables, demographic parameters and smoking knowledge were assessed by a pre-use survey and app-imbedded registration process, information such as when did first start to smoke, average number of cigarettes smoked every day, previous number of quit attempts, etc.

Outcome measures: Outcome measures were administered after using the SmokeFreeNZ app for six weeks. A post-use smoking questionnaire and app evaluation survey were used to measure the endpoint parameters such as the prevalence of abstinence, which was defined as having been completely smoke free for seven days and self-reported number of cravings per day.

Before users can use the full functions of the SmokeFreeNZ app, users need to sign up the app. During the sign up step, users need to provide information about themselves and their smoking history. Users then can select a quit date and they can also select whether they intend to use smoking cessation medications.

Participants received SMS messages every day to encourage and maintain their motivations for at least 28 days. After 42 days, the app will stop to update. The app can collect users' activities within app, including each login and progress report and upload it to cloud storage.

Smoking knowledge index measures: The smoking knowledge index survey used a questionnaire based on the World Health Organization (WHO) Global Adult Tobacco Survey [18] with modifications by researchers. The questionnaire comprised 20 true or false questions, asking basic knowledge about smoking and the negative impact of smoking on health.

Questions included: "Smoking during pregnancy can increase the chance of miscarriage" and "Smoking may trigger an asthma attack."

An identical questionnaire was surveyed before and after using the app. The correct answer of each question was given a score of 1 and the wrong answer of each question was given a score of 0. The maximum score of the Smoking Knowledge Index is 20.

Data analysis: Pre-use and post-use measurements were analysed by using prism statistical software (version 5.0). Paired t-tests and two sample t-tests were used to test statistical difference. The 0.05 significance level was used for two tailed tests. Mean (M) and standard deviation (SD) for continuous variables are used in the following notation: M ($\pm$ SD).

Based on the online calculation from Australian National Statistical Service web site, the recommended sample size is 28 and the sample size of our proposed plan is large than the recommended sample size.

The parameters we used for online calculation are:

- Confidence level 95%.
- Estimated population size 5000.
- Estimated proportion 20%.
- Estimated standard error 5%.

Results

Demographic characteristics of Unitec smokers

Participants demographic status is listed in Table 1. Sixty-four students and staff registered for the study. However, 40 eligible current unitec smokers consented to and participated in this six-week study. The mean age of participants was 28.3 (+8.73) years old.

About 60% of participants were women. Most of the participants of about 80% were first-year or second-year students. The majority of about 90% were self-reported to have a good level of computer skills. More than half of participants were Māori or Pasifika students.

Demographic characteristics	N=40	Percentage
Gender		
Male	16	40%
Female	24	60%
Current relationship status		
Education		
Unitec 1st Yr	22	55%
Unitec 2nd Yr	10	25%
Unitec 3-4 Yr	8	20%
Level of computer skills		
None/basic	4	10%
Good/advanced	36	90%

Race		
European	8	20%
Māori/Pacific	22	55%
Asian	2	5%
Africa	4	10%
Others	4	10%
	Mean	SD
Age	28.3 yr	8.7 yr

Table 1: Participants demographic status.

The smoking history of the study participants is summarised in Table 2. The number of cigarettes smoked per day was 9.2 (± 5.7) and the average number of years of smoking was 3.8 (± 3.2). The average number of previous attempts to quit smoking was 1.6 (± 0.7).

Smoking history	Results
How many number of cigarettes do you consume on average in a day?	9.2 (± 5.7 SD)
How many years have you smoked regularly?	3.8 (± 3.2 SD)
How many people in your household smoke?	2.5 (± 2.1 SD)
When did you start smoking cigarettes?	18.4 (± 2.2 SD)
How many times have you tried to quit smoking previously?	1.6 (± 0.7 SD)
Would you seriously like to give up smoking altogether?	Yes 70%
	No/not sure 30%

Table 2: Smoking information of participants.

Knowledge levels in users of the SmokeFreeNZ app and control group

In this study, users of the mobile app statistically significantly demonstrated an increased knowledge about the hazards of smoking in the smoking knowledge index survey. In the app user group, participants smoking knowledge scores were improved from 62% (+9%) to 96% (+3%) after using app for six weeks (Figure 2).

This 34% improvement was statistically significant (paired t-test; $p < 0.001$) compared to the non-user control group, which only had 8% improvement. The baseline (pre-use), smoking knowledge index survey indicated that participants already had reasonable knowledge about the addictive properties of smoking and causative risks for stroke, heart disease, lung cancer and other respiratory conditions among smokers.

However, they seemed to have limited knowledge about other systemic effects of smoking such as increased risk for Chronic Obstructive Pulmonary Disease (COPD), leukaemia, colon cancer and miscarriage.
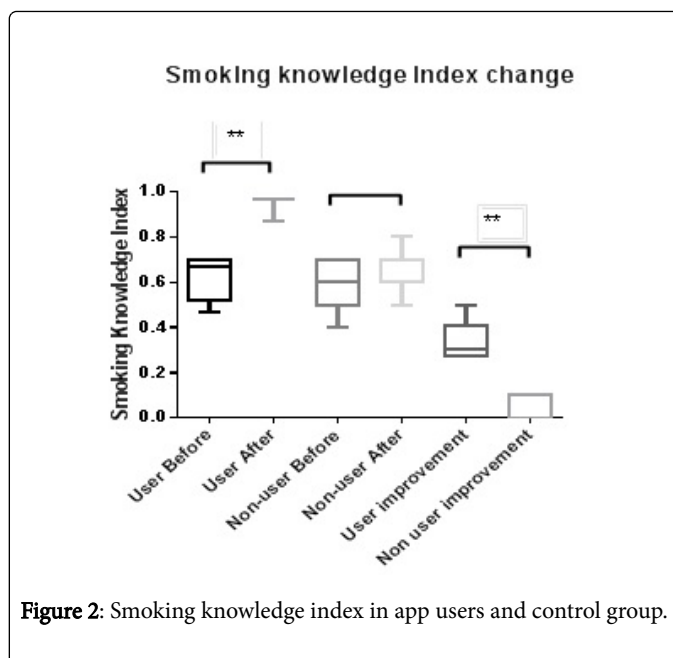

Figure 2: Smoking knowledge index in app users and control group.

Smoking cessation parameters in users of the SmokeFreeNZ app and control group

Based on smokers' self-reported results, users of the SmokeFreeNZ app had significantly improved smoking cessation parameters compared to the non-user control group. Similar results were also shown in average length of continuous abstinence in users of the SmokeFreeNZ app and non-users (Figure 3).
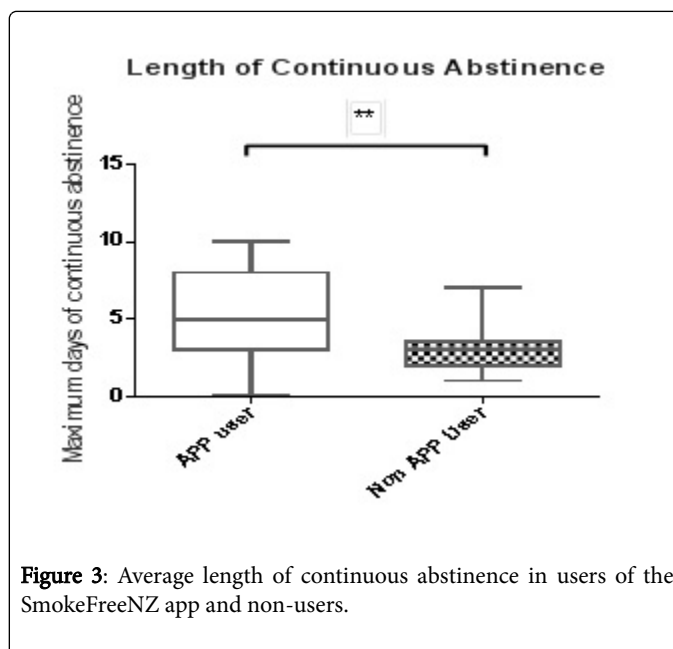

Figure 3: Average length of continuous abstinence in users of the SmokeFreeNZ app and non-users.

Based on smokers' self-reported results, in the app user group participants reported significantly longer maximum length of continuous abstinence than non-users. The maximum number of days of continuous abstinence was 5.2 (± 0.5) days in the app user group

and was 2.1 (± 0.5) days in non-user control group. The difference was statistically significant (paired t-test; p<0.02).

The percentage of seven days' abstinence was also higher about 26.7% in the app user group than in in the non-user control group about 10.0%. The difference was statistically significant (chi-square tests; p<0.05) as shown in Figure 4.
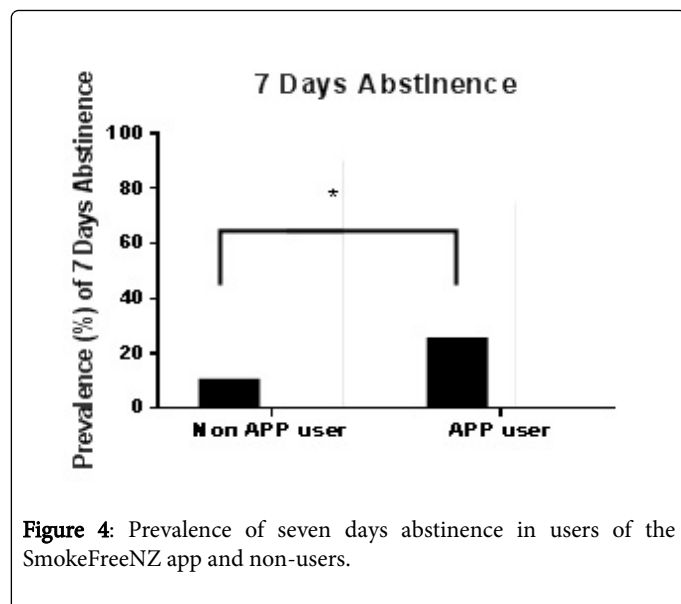

Figure 4: Prevalence of seven days abstinence in users of the SmokeFreeNZ app and non-users.

The average number of cravings was 3.2 (± 0.4) per day in the app user group and was 3.7 (± 0.7) per day in non-user control group. This difference was not statistically significant (paired t-test; p>0.05) as shown in Figure 5.
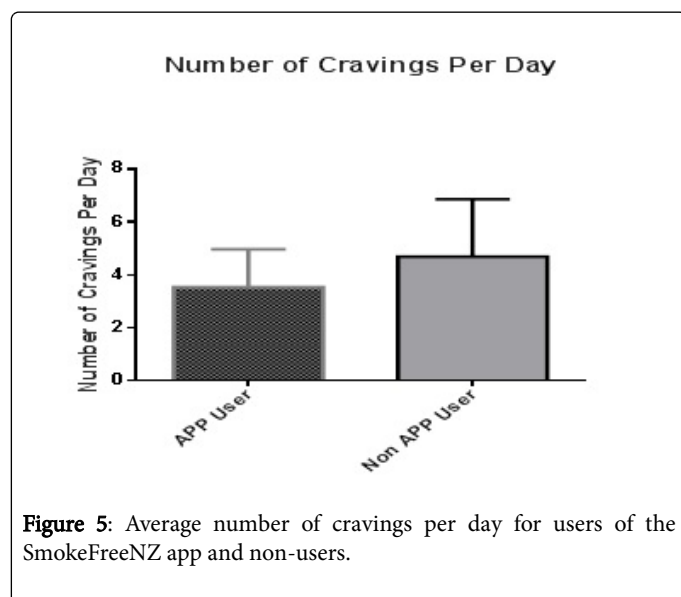

Figure 5: Average number of cravings per day for users of the SmokeFreeNZ app and non-users.

Discussion

Several interesting observations have been found in our study. The results show that in the app user group, participants' smoking knowledge scores were improved from 62% (± 9%) to 96% (± 3%) after using the app for six weeks. This 35% improvement was statistically significant (paired t-test; p<0.001, Figure 2) compared to the non-user control group, which only had 8% improvement. From the baseline (pre-use) smoking knowledge survey, it seems that most of participants already had reasonable general knowledge about addictive properties of smoking and health risks of smoking tobacco. They however seemed to have limited knowledge about other systemic effects of smoking such as increased risk for COPD, leukemia, colon cancer and miscarriage.

Based on smokers' self-reported results, users of the app had better smoking cessation parameters than the non-users (control group). The average maximum number of days of continuous abstinence was 5.2 (± 0.5) days in the app user group and was 2.1 (± 0.5) days in non-user control group. The difference was statistically significant (paired t-test; p<0.02), shown in Figure 3. Seven days' abstinence rates in users of the SmokeFreeNZ app were also higher than those in the control group. The percentage of seven days' abstinence was about 26.7% in the app user group and was 10.0% in the control group. The difference was statistically significant (chi-square tests; p<0.05) shown in Figure 4. These findings indicate that the SmokeFreeNZ app did help smokers to quit smoking in Unitec.

Comparison of the results of this study to txt-aided smoking cessation researches globally shows the SmokeFreeNZ app method can achieve similar improvement to txt-aided approaches. In Bramley's study in New Zealand [18], authors conducted a single-blind randomised controlled trial in a young Māori cohort. In that study, regular txt messages were sent to participants to provide smoking cessation advice, support and distraction. There were 355 Māori and 1350 non-Māori participated that study. Māori in the intervention group were more likely to report quitting (no smoking in the past seven days) at six weeks (26.1%) than those in the control group (11.2%).

Authors concluded that a mobile phone-based cessation programme was successful in recruiting young Māori, and was shown to be as effective for Māori as non-Māori at increasing short-term self-reported quit rates. In a UK study [19], a pilot randomised controlled trial (200 participants) of txt-based smoking cessation support intervention was conducted for four weeks. The results at four weeks show a doubling of self-reported quitting (26%) in the txt user group compared to 12% in the control group. Authors concluded that txt-based smoking cessation is an innovative means of delivering smoking cessation support which doubles the self-reported quit rate in the short term.

Our study has found that the participants using the SmokeFreeNZ app showed significantly increased knowledge about the hazards of smoking in the smoking knowledge index survey. We have also found that hit rates for our SmokeFreeNZ facebook page were increased by 80%.

Compared to traditional face-face smoking cessation methods, the main advantage of using a smartphone app is cost-effectiveness, scalability and wide reach. Rapid dissemination of such interventions and remote reach could potentially boost traditional treatment programs reduce waiting lines and increase the quit ratios in New Zealand.

Conclusion and Future Work

This work presented a novel mobile app (SmokeFreeNZ) based on evidence-based principles and behaviour change techniques. The efficacy of SmokeFreeNZ was evaluated on Unitec campus for six

weeks. The results showed that the SmokeFreeNZ app significantly increased users' knowledge about the hazards of smoking, as shown in the smoking knowledge index survey.

As mobile phone technology continues to advance and with the growing popularity of smartphones, smartphone app interventions for smoking cessation will become more important. The improvement results of smoking knowledge and prevalence of seven days' abstinence reported by the users of the SmokeFreeNZ app indicate that it is an effective tool for smoking cessation. The SmokeFreeNZ app provided feasible and effective means to educate smokers about the hazards of smoking and also improved seven days' abstinence rates in the study period.

Further research is needed to evaluate the cost-effectiveness and long-term effects of this promising engagement and efficacy in smoking cessation in a larger scale of trial. Also in this study, a self-report survey was used to evaluate the efficacy of the app. For comparison, biochemical measurements will be used in further investigations on the efficacy of the app. We also plan to evaluate the effectiveness of the app on both android and IOS devices. We believe our research paves the way for the systematic design and development of full-fledged mobile apps dedicated to smoking cessation in the future.

Acknowledgment

Conflicts of Interest

None declared.

References

1. World Health Organization (2008) WHO report on the global tobacco epidemic 2008: The mpower package. Geneva.
2. Doll R, Peto R, Boreham J, Sutherland I (2004) Mortality in relation to smoking: 50 years' observations on male british doctors. BMJ 328: 1519-1533.
3. Māori Smoking and Tobacco Use (2011) Wellington: Ministry of Health.
4. Peto R, Darby S, Deo H, Silcocks P, Whitley E, et al. (2000) Smoking, smoking cessation and lung cancer in the UK since 1950: Combination of national statistics with two case-control studies. BMJ 321: 323-329.
5. McCool J, Bullen C (2016) Making the next steps the right ones: Progress towards the smokefree aotearoa 2025 goal. NZ Med J 129: 6-7.
6. Stead LF, Boyce HJ, Perera R, Lancaster T (2013) Telephone counselling for smoking cessation. Cochrane Database Syst Rev 12: 8.
7. Lancaster T, Stead LF (2005) Self-help interventions for smoking cessation. Cochrane Database Syst Rev p: 3.
8. Whittaker R, McRobbie H, Bullen C, Borland R, Rodgers A, et al. (2012) Mobile phone-based interventions for smoking cessation. Cochrane Database Syst Rev p: 11.
9. Civljak M, Sheikh A, Stead LF, Car J (2010) Internet-based interventions for smoking cessation. Cochrane Database Syst Rev p: 9.
10. Boyce HJ, Stead LF, Cahill K, Lancaster T (2013) Efficacy of interventions to combat tobacco addiction: Cochrane update of 2012 reviews. Addiction 108: 1711-1721.
11. Muñoz RF (2010) Using evidence-based internet interventions to reduce health disparities worldwide. J Med Internet Res 12: e60.
12. Zealand RN (2015) A report on a survey of New Zealanders' use of smartphones and other mobile communication devices 2015. Research NZ.
13. West R, Stapleton J (2008) Clinical and public health significance of treatments to aid smoking cessation. Eur Respir J 17: 1-6.
14. Michie S, Hyder N, Walia A, West R (2011) Development of a taxonomy of behaviour change techniques used in individual behavioural support for smoking cessation. Addictive Behaviors 36: 315-318.
15. Kong G, Ells DM, Camenga DR, Krishnan-Sarin S (2014) Text messaging-based smoking cessation intervention: A narrative review. Addict Behav 39: 907-917.
16. Zeng EY, Heffner JL, Copeland WK, Mull KE, Bricker JB (2016) Get with the program: Adherence to a smartphone app for smoking cessation. Addict Behav 63: 120-124.
17. Cheung YT, Chan CH, Wang MP, Li HC, Lam TH (2017) Online social support for the prevention of smoking relapse: A content analysis of the whatsapp and facebook social groups. Telemed J e-Health 23: 507-516.
18. Song Y, Zhao L, Palipudi KM, Asma S, Morton J, et al. (2016) Tracking mpower in 14 countries: Results from the global adult tobacco survey, 2008-2010. Glob Health Promot 23: 24-37.
19. Free C, Whittaker R, Knight R, Abramsky T, Rodgers A, et al. (2009) Txt 2 stop: A pilot randomised controlled trial of mobile phone-based smoking cessation support. Tob Control 18: 88-91.