

# Development and Evaluation of an Evidence Based Smoking Cessation App for the Malaysian Population: The Self-Determination Theory Approach

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## ARTICLE HISTORY

## ABSTRACT

Received  
26 September 2017

Received in revised form  
15 December 2017

Accepted  
22 December 2017

*Tobacco use in Malaysia accounts for 35% of in-hospital deaths, principally from cancer, heart disease and stroke. Thus, effective interventions to support smoking cessation are urgently needed. Smartphones are increasingly receiving attention as a means to assist individuals' health management through the usage of apps such as smoking cessation apps. However, recent content analysis found that they do not typically adhere to evidence-based principles for smoking cessation and may not sufficiently stimulate autonomous-motivation. This research aims to develop and evaluate a bilingual (Malay/English) evidence-based smoking-cessation app which incorporates self-determination theory features for the Malaysian population. This project was conducted in three-phases. Content development phase involved identifying ideal features of an app for behaviour modification in smoking cessation. The technical development phase focused on the technical development of the app which involved creating a programming- language framework. The final phase involved testing and evaluation using the 23-item MARS rating scale which is a validated measure of rating mobile health apps. Preliminary evaluation showed that the MARS total mean score which correspond to a star rating scale was ( $M=3.35$   $S.D \pm 0.50$ ), while the mean score for each domain are as follows; engagement ( $M=3.30$   $SD \pm 0.54$ ), functionality ( $M=3.46$   $SD \pm 0.64$ ), aesthetics ( $M=3.46$   $SD \pm 0.62$ ), information ( $M=3.39$   $SD \pm 0.63$ ), subjective quality ( $M=2.91$   $SD \pm 0.65$ ). More than 90% of the sample felt that this app is likely to increase awareness, knowledge, and motivation, influence change the attitude to smoking cessation in terms of help seeking and behaviour. Thus, the smoking cessation app developed incorporated the three parameters in SDT and fulfils the basic criteria of a health management app as measured by the MARS scale and can potentially aid in smoking cessation activities.*

**Keywords:** smoking cessation, self-determination theory, mobile apps, tobacco, MARS

## 1. INTRODUCTION

Tobacco consumption is a leading preventable cause of death and disease worldwide, causing nearly six million deaths each year [1]. The Ministry of Health Malaysia, reports that tobacco use in Malaysia accounts for 35% of in-hospital deaths, principally from cancer, heart disease and stroke.[2] More than 10,000 Malaysians die from smoking-related illnesses each year.[2]

In 2012, Malaysia completed The Global Adult Tobacco Survey organised by the World Health Organization (WHO) and Institute of Public Health. Findings show that almost half (48.6%) of adult smokers (current smokers plus former smokers who had been abstinent for less than 12 months) had tried to quit smoking in the past 12 months [2]. Four out of five smokers who had attempted to quit smoking in the past 12 months had tried to do so without any assistance. Among those who smoked on a daily basis, only 9.5% have successfully quit; thus, effective interventions to support smoking cessation are urgently needed [3].

Today, public health scholars and practitioners are increasingly focusing on smartphones as a means to assist individuals' health management [4]. The proliferation and availability of smartphones has provided a powerful communication channel to strengthen health information systems [5]. The properties of mobile phones which include low start-up cost, text messaging, and flexible payment plans, make them suitable tools for use in keeping contact with patients in various health care processes [5]. While these smartphones can be used to disseminate pertinent information to patients, when used in conjunction with health care-related software apps, they can also serve as an invaluable platform that provides real-time feedback in monitoring treatment compliance or effect, and can also at the same time serve as data collection tools [5]. The proliferation of smoking cessation apps began in recognition of this potential. The problem, however, is that the apps developed by individuals are not regulated and therefore it is hard to determine if these apps were actually developed based on theoretical and scientific evidence. Apps with unverified contents and which are not evidence based may have adverse effects on the health of its users. For example, it has been argued that some smartphone apps for depression actually produce counter effects by fostering depression rather than offering a cure for depression [6].

To date, the Apple iTunes store has released more than 100,000 iPhone apps, which have been downloaded by consumers more than 3 billion times [7, 8] of which, 200 have been identified as smoking cessation apps [9].

However, recent content analysis of these apps found that these apps did not typically adhere to evidence-based principles for smoking cessation or may not sufficiently stimulate autonomous motivation as explained by the self-determination theory [4]. Only a handful of apps actually provide information or activities that have been shown with other modes of delivery to aid smoking cessation.

According to the Self-determination theory, the gratification of 3 basic psychological needs—autonomy, competence, and relatedness—is essential to the development of intrinsic or autonomous motivation and the maintenance of behavioral change [10].

To address this issue, in the present study we used the self-determination theory (SDT) as a basis for the development of the framework of this app [10-12]. According to SDT, the types of motivation that drive individuals' behaviours can vary on the degree of autonomy; if behaviours are triggered by autonomous motivation rather than controlled motivation, people are more likely to engage voluntarily in behavioural changes, which in turn are more likely to be sustained. A number of studies support the effect of autonomous motivation on long-term behaviour change, which lasts for a year or longer [3, 13-17]. Hence, smoking cessation apps that incorporate SDT in their features and functions are expected to be more effective in bringing about behaviour change.

Autonomy support is characterized by the following: (1) providing meaningful reasons for a behaviour, (2) providing choices and alternatives for a behaviour, (3) supporting individuals' initiatives, and (4) acknowledging individuals' perspectives (e.g., negative effect regarding difficult behaviours) [15, 18]. To this regard, we can expect that smoking cessation apps with such characteristics would bear greater effect on smoking cessation.

A sense of competence would be formed and supported by skills, tools, or pertinent feedback that assist individuals to implement behavioural changes as well as to overcome obstacles that inhibit behavioural changes [11]. Therefore, smart phone apps would promote competence for smoking cessation with features such as: (1) providing informational resources concerning skills and knowledge for smoking cessation, (2) providing supporting tools for behavioural implementation, and (3) providing feedback on behaviours implemented and on the individual's progress.

According to SDT, relatedness is important for autonomous motivation because it promotes the internalization of extrinsic causes; individuals may voluntarily engage in behavioural change because of someone else who means a lot to them, even though the behaviour by itself is not interesting. In fact, the importance of relatedness, noted as "social support," has been evidenced in various domains of health behaviours, such as breast cancer [19], human immunodeficiency virus (HIV) [20], and exercise [21]. The positive effect of social support on smoking cessation has also been reported in several studies [22, 23].

Social support is now available in cyberspace owing to advancements in information technology. For example, various forms of online communities, such as chat rooms, weblogs, or bulletin board systems, can provide social support related to health behaviours.[19-25] The up-and-coming social media is also expected to contribute to social capital formation by enabling individuals to connect with one another [26]. Smartphone apps are often developed in conjunction with social media or offer functions to access communities online. By taking advantage of these characteristics, smoking cessation apps are expected to satisfy relatedness.

In summary, autonomy, competence, and relatedness are important factors to induce intrinsic motivation for long-term behavioural changes. Smoking cessation apps addressing these basic needs are expected to have greater effects on changing smoking behaviour. To this regard, this study proposed to develop a smoking cessation app that incorporates SDT in the app features.

Moreover, in the Malaysian scenario, there is no bilingual (Malay/English) app available to fulfil the needs of the non-English speaking population.

Thus, this present study was therefore designed to develop a bilingual (Malay/English) evidence based smoking cessation app which incorporates self-determination theory features for the Malaysian population. This study also conducted a preliminary evaluation of the smoking cessation application

## **2. METHODOLOGY**

This project was conducted in three phases:

Phase 1: Content development. This phase involved a review of literature to identify the ideal properties and features of an app for behaviour modification specifically smoking cessation. This phase also involved review of existing clinical guidelines for smoking cessation to identify the evidence-based content to be included in the app. This phase also focused on incorporating the self-determination theory features into the content.

In developing the content for this app, the first step was identifying the behaviour theory that would be used as the framework to understand behaviour patterns and bring about change in smoking behaviour. To address this issue, in the present study the self-determination theory (SDT) was used as a basis for the development of the framework of this app [10, 12].

In addition to the theoretical principle of SDT, the intervention components were selected based on behaviour change techniques from evidence based clinical guidelines such as the Malaysian Clinical Practice Guideline of Treatment of Tobacco Use Disorder 2016, and The New Zealand Guidelines for Helping People to Stop Smoking. Wellington: Ministry of Health 2014.

In developing a smoking cessation app based on the SDT framework, the content of the app must have values that are significant to the three parameters in SDT which are autonomous, competence and relatedness.

To fulfil the autonomous parameter, the smoking cessation app would offer relevant information addressing reasons to stop smoking such as evidence based health risks of smoking. The app would also include functions that allows a person to create their own smoking cessation plan. This allows users with different approaches to quit smoking such as the tapering approach or the cold turkey approach to successfully quit smoking using the app as a partnering tool.

Competence is formed and supported by skills, tools, or pertinent feedback that assists individuals to implement behavioural changes. Competence is promoted in the apps by offering the information resources concerning skills and knowledge for smoking cessation; including offering specific guidelines or tips for course of actions to quit smoking and resources to increase knowledge regarding smoking cessation. In conjunction to this competence theory, functions to send alert or alarm messages to warn or remind, and functions to record and track one's own quitting or smoking attempts are included. Apart from that, feedback functions, such as offering

an analysis of one's own quitting attempts or efforts or providing cues to progress or achievement toward smoking cessation were also included to fulfil the competence parameter.

And finally, the relatedness parameter which concerns feelings of being connected to others, were fulfilled in the apps through functions that allowed for interacting with others or receiving social support from others. This is in the form of feedback from social media once a user posted his track of progress, or shared with the other users of the app.

The Fagerström Test for Nicotine Dependence (FTND), the standard instrument for assessing the intensity of physical addiction to nicotine was also included in the app. The test is designed to provide an ordinal measure of nicotine dependence related to cigarette smoking. In scoring the Fagerstrom Test for Nicotine Dependence, yes/no items are scored from 0 to 1 and multiple-choice items are scored from 0 to 3. The items are summed to yield a total score of 0-10. The higher the total Fagerström score, the more intense is the patient's physical dependence on nicotine.

**Phase 2: Technical development:** This phase focused on the technical development of the smoking cessation app. In this phase, the smoking cessation app was developed based on the ideal properties and evidence based content collated in phase 1 which was converted to a programming language framework.

For this phase, the first step was deciding on the platform to build the app. As reported in International Data Corporation (IDC) through its website, android users were still contributing to the biggest number of smartphone users up to year 2015, with a whopping 82.8 percentage stake in the smartphone market. Thus it was decided that the app would be created on an android platform. Android Studio version 2.0 was used to develop the app; which provides the simulation mode showing how the apps is running on the android device even on a Windows operated computer.

Translating the content into app features involved working with a web developer through a series of discussion and iterations. A flowchart for the app to be operational was created (Figure 1 and Figure 2). The flowchart was used to guide the developer in creating the Java programming language.

**Phase 3: Testing and evaluation:** In this phase the app was tested and evaluated. The testing and evaluation was focused on the content evaluation. This included an evaluation of availability of features that satisfies the basic needs identified in SDT, which in turn stimulates autonomous motivation and also an evaluation of adherence to evidence based clinical guidelines. This was done in the form of a quantitative study using the 23 item MARS rating scale (Mobile apps rating scale).

The evaluation of the application was carried out amongst clinical undergraduate dental students in the Faculty of Dentistry Universiti Teknologi MARA (UiTM). Ethical approval was obtained from the Research Ethics Committee, Faculty of Dentistry, UiTM (66-IRMI (5/1/6) REC/99/16. All clinical undergraduate dental students were sampled, of which 112 out of 150 students responded. All participants were asked to download the smoking cessation app and use it. They



were given a link to download this app through the Apps Store/ Google Store. Together with that, they were also asked to complete the MARS (Mobile Application Rating Scale) evaluation after familiarising and using the smoking cessation app.

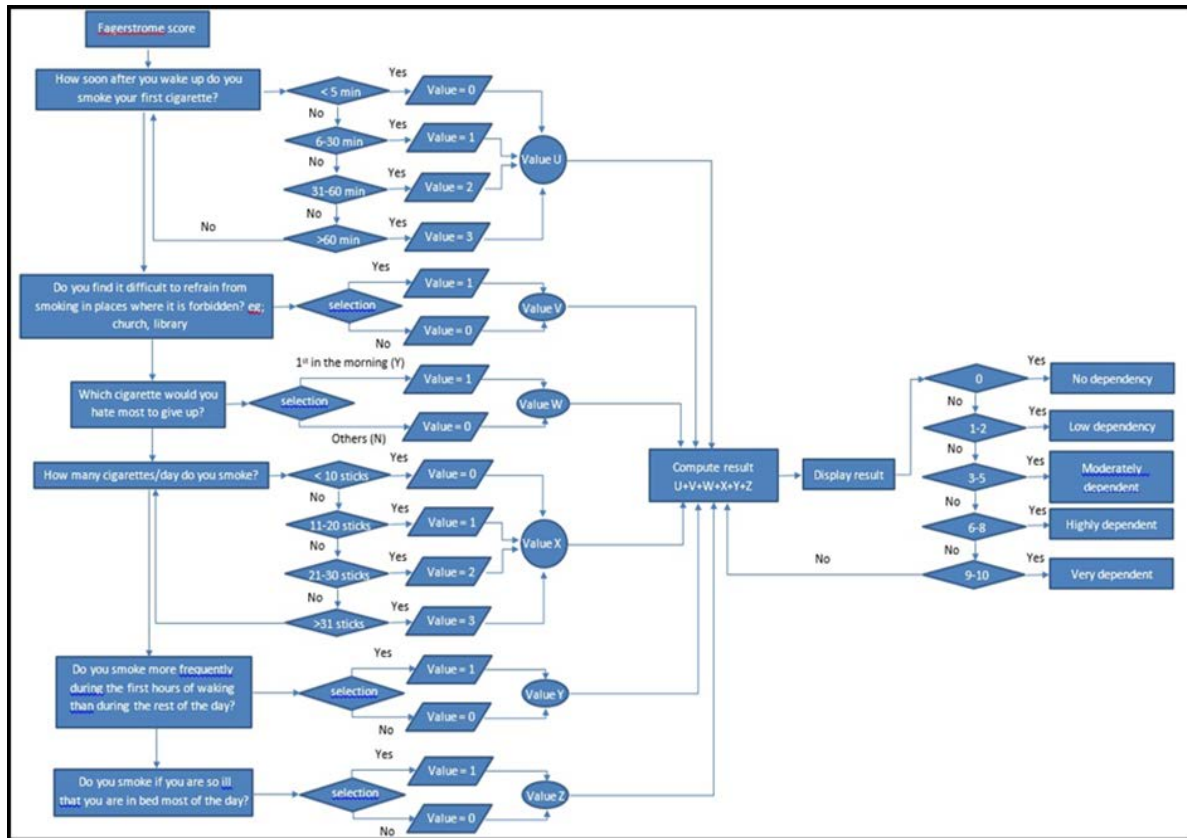


Figure 1: The Fagerstrom test calculation flowchart

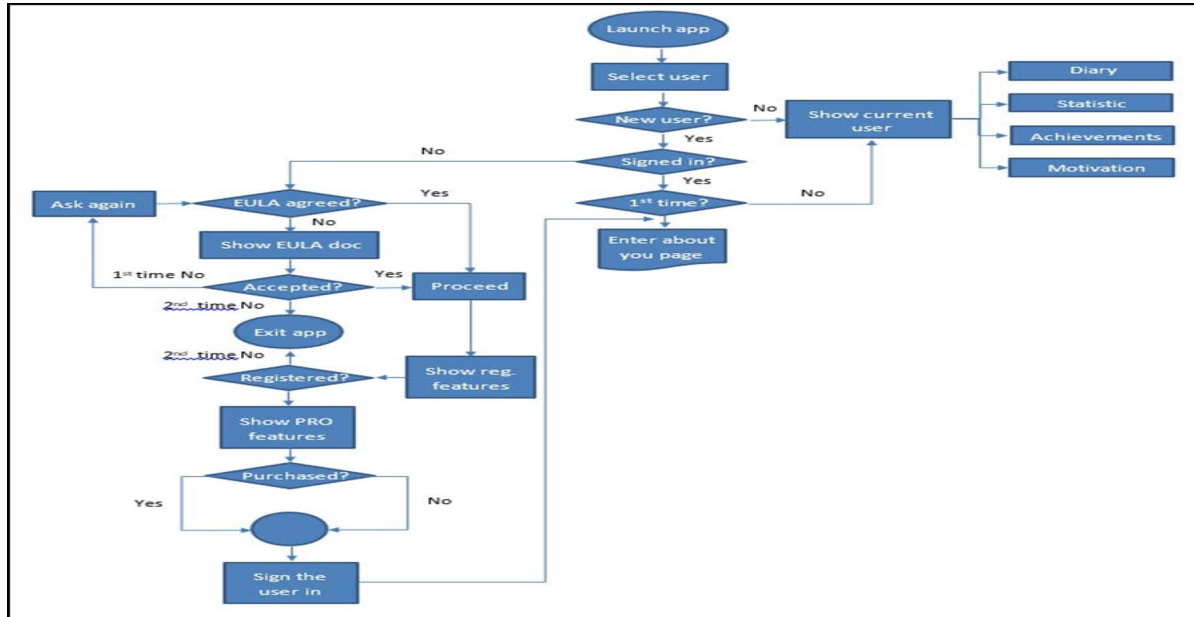


Figure 2: The first user sign-in flowchart

The Mobile App Rating Scale (MARS) was designed by a research team involved in the development and validation of eHealth and mHealth intervention with an aim to provide researchers, clinicians and developers with a list of evaluation criteria, and a gradient response scale for their objective evaluation of a health mobile app .[27]

The MARS questionnaire was divided into sections A, B, C, D, E and F. Section A measures the engagement of the app in terms of how fun or interesting the app will be to the population. Section B rates the performance of the app in terms of the accuracy and speed of the features of the add functions. Section C is about the aesthetics – graphic design, overall visual appeal, color scheme, and stylistic consistency. Information in this app was evaluated in section D, and section E and F measures the subjective quality of the app.

Data from the questionnaire were entered manually into a spread sheet developed using the Statistical Package for Social Sciences (SPSS 20) software. Data were coded and made anonymous by assigning a participant number to each participant to replace names. Data entry was followed by checking for errors, outliers and missing data and descriptive analysis.

### 3. RESULTS

#### Phase 3 – Evaluation

Table 1, shows the distribution of respondents based on gender, year of study and a few variables of interest. The distribution of respondents were almost equal between year 3 and year 5 students

however, year 4 students only contributed about 18% of the sample. A majority of the sample were non-smokers and 100% of the sample had experience in tobacco cessation as part of their dental course. However, only 10% from the sample had prior success in helping smokers to quit

Table 1: Overview of demographic factor and the sample population

<b>Demographic Factor</b>	<b>Frequency, N</b>	<b>Percentage (%)</b>
<b>Gender</b>		
Male	32	26.2
Female	90	73.8
<b>Year of Study</b>		
3	52	42.6
4	23	18.9
5	47	38.5
<b>Smoking Status</b>		
Active Smoker	1	0.8
Former Smoker	3	2.5
Non-Smoker	118	96.7
<b>Experience in Conducting Tobacco Cessation</b>		
Yes	122	100
No	0	0
<b>Succeeding in Helping Patient Quit</b>		
Yes	13	10.7
No	109	89.3

An independent T-test was also conducted to compare test score for all domains between male and female. There was statistically significant difference for male and female in all domains except for the app subjective quality domain. The magnitude of the difference in the mean scores was small for the domains engagement and app specific, moderate for all other domains and big for the total score.

Table 2: Result of mean score based on gender and domain

<b>Domain</b>	<b>Gender</b>	<b>N</b>	<b>Mean score</b>	<b>Std. Deviation</b>	<b>P value</b>	<b>Eta Squared</b>
<b>Engagement</b>	Male	32	3.1000	.42805	0.012	0.0518
	Female	90	3.3756	.55187		
<b>Functionality</b>	Male	32	3.1797	.51679	0.001	0.0850
	Female	90	3.5611	.65053		
<b>Esthetic</b>	Male	32	3.1979	.46265	0.001	0.0870
	Female	90	3.5556	.63600		
<b>Information</b>	Male	32	3.1183	.46490	0.001	0.0947
	Female	90	3.4973	.64961		
<b>App subjective quality</b>	Male	32	2.8359	.63693	0.417	0.3563
	Female	90	2.9444	.64995		
<b>App-specific</b>	Male	32	3.3125	.50045	0.011	0.0534
	Female	90	3.6167	.72474		
<b>Total</b>	Male	32	3.1241	.33560	0.001	0.1024
	Female	90	3.4251	.52850		



Table 3 shows the mean score for all the domains. The app specific domain shows the highest mean score while app subjective quality domain shows the lowest mean score among other domains.

Table 3: Distribution of Mean Score by Domain

<b>Domain</b>	<b>Mean Score</b>	<b>Standard Deviation</b>
<i>Engagement</i>	3.3033	.53458
<i>Functionality</i>	3.4611	.63881
<i>Esthetic</i>	3.4617	.61426
<i>Information</i>	3.3979	.62752
<i>App subjective quality</i>	2.9160	.64572
<i>App-specific</i>	3.5369	.68451

Table 4 shows the descriptive result for each individualised parameter in the subjective quality domain which include parameters about recommendation of this app to the other people by the respondent, willingness of respondents to pay for this app, and an overall star rating for the app by the respondent. Only 45.1% of the sample indicated willingness to pay for the apps even though 88.5% of the sample gave this app a positive rating which was  $\geq 3$  stars.

Table 4: Overall result of subjective quality for the apps domain

<b>Parameter</b>	<b>Frequency, N</b>	<b>Percentage%</b>
<i>Would you recommend this app to people who might benefit from it?</i>		
Yes		
No	112	91.8
	10	8.2
<i>Do you think you would use this app in the next 12 months if it were relevant to you?</i>		
Yes		
No	86	70.5
	36	29.5
<i>Would you pay for this app?</i>		
Yes	55	45.1
No	67	54.9
<i>What is your overall star rating of the app?</i>		
$\geq 3$ stars	108	88.5
$< 3$ stars	14	11.5

For the overall result for apps specific domain when analysed by each parameter, we found that about 95.1% of sample felt that this app is likely to increase the awareness of the importance of addressing smoking cessation, likely to increase the knowledge and understanding of smoking cessation, and also likely to change the attitude to smoking cessation. While 93.4% from the sample felt that this app is likely to increase the intention and motivation to address the smoking cessation, likely to encourage help seeking, and also likely to change their behaviour.

Table 5: Overall result of apps specific domain

Parameter	Frequency, N	Percentage%
<b>Awareness</b>		
Yes	116	95.1
No	6	4.9
<b>Knowledge</b>		
Yes	116	95.1
No	6	4.9
<b>Attitude</b>		
Yes	116	95.1
No	6	4.9
<b>Intention to change</b>		
Yes	114	93.4
No	8	6.6
<b>Help seeking</b>		
Yes	114	93.4
No	8	6.6
<b>Behavior change</b>		
Yes	114	93.4
No	8	6.6

#### 4. DISCUSSION

The MARS is the first mHealth app quality rating tool to provide a multidimensional measure of the app quality indicators of engagement, functionality, aesthetics, and information quality, as well as app subjective quality.[27] It is important to note that this app was tested on undergraduate dental students who were trained in smoking cessation activities as opposed to actual smokers who are the intended app users. This is because MARS was designed to be utilized by experts in the mHealth field and not the app user themselves.[27] A further evaluation should be done by users of the app utilizing the simpler MARS-app user scale.[27]

The smoking cessation app developed scored an average score of 3 and more across all domains of the MARS quality indicators. The lowest average score which was for the domain app subjective quality warranted a closer look at each individual parameter in this domain. The individualised result showed that only 45% of respondents answered that they are likely to be willing to pay to use this app. This is not surprising as at the time of evaluation the app itself was not yet on the market and the availability of other free smoking cessation apps might have been a deterrent factor.

The statistically significant difference in ratings given by male and female in all domains except for the app subjective quality domain indicates that this app may have a higher appeal to the female population. Hence this app may either be targeted to be used among female smokers, or some modifications need to be done to increase the appeal amongst the male users.

In general, majority of respondents agreed that the app would bring about behaviour change through increased intention and motivation to address smoking cessation, increased likelihood to encourage help seeking.

Limitations include the relatively limited time the participants had in using and familiarising with the app before being asked to rate the app, however as all participants were trained in smoking cessation, they provided invaluable advantage in assessing the quality of content and information in the app.

Evaluation of the app from the viewpoint of fulfilment of Self Determination Theory was not formally done in this study, as this app has not yet been released for public usage and is only in the testing phase. Further studies specifically evaluating the fulfilment of SDT in this app including the evaluation of the effectiveness of this app in tobacco cessation should be done in the future.

## 5. CONCLUSION

A smoking cessation app that incorporated the three parameters in SDT which are autonomous, competence and relatedness was developed. The smoking cessation app fulfils the basic criteria of a health management app as measured by the MARS scale and can potentially aid in smoking cessation activities.

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