RESEARCH ARTICLE

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Effectiveness of Text Messaging in Encouraging Smoking Cessation among Non-Communicable Disease Patients: A Randomized Controlled Trial

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Abstract

Objective: To assess the impact of a text-messaging intervention on smoking cessation among patients with non-communicable diseases. **Methods:** A total of 200 participants were randomly assigned to either a text-messaging intervention group or a control group. The 7-day point prevalence of smoking cessation and exhaled carbon monoxide (CO) levels were measured at baseline, 6 weeks, and 18 weeks. Mixed linear regression was employed to examine the interaction effect of exhaled CO between the intervention group and follow-up time. **Results:** The 7-day point prevalence of smoking cessation increased by 16.16% (95% CI: 10.98, 21.33) at the 6-week follow-up and by 15.46% (95% CI: 10.68, 21.33) at the 18-week follow-up. In the intervention group, exhaled CO was significantly lower compared to the control group at 6 weeks (mean difference: -5.79; 95% CI: -7.26, -4.32) and at 18 weeks (mean difference: -4.19; 95% CI: -5.67, -2.71). **Conclusion:** The text-messaging intervention proved effective in increasing the prevalence of smoking cessation and reducing carbon monoxide levels among non-communicable disease patients.

Keywords: Smoking cessation- text messaging- non-communicable diseases

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Introduction

Non-communicable diseases (NCDs) represent a significant global cause of mortality [1]. These diseases are influenced by various factors, including self-management, genetic predisposition, environmental conditions, and socio-economics factors [2]. Among these factors, smoking stands out prominently. The prevalence of smoking among NCD patients is notably high [3, 4], underscoring the importance of motivating these individuals to quit smoking for the sake of their quality of life. Currently, smoking cessation strategies typically involve advice, behavioral support, and pharmacological treatment [5]. Within this framework, Mobile Health (mHealth) presents an innovative approach to smoking cessation, combining advice and behavioral support. Specifically, mHealth (mobile health) interventions utilize smartphone applications to deliver interventions, primarily through short message services (SMS) [6].

Several studies have reported the effectiveness of a text messaging interventions in reducing smoking behavior through systematic reviews, meta-analyses [7-10], and randomized controlled trials [11-14]. The a text-messaging intervention for smoking cessation in India, known as mCessation, has successfully aided tobacco users in quitting by providing motivation and support to registered participants through mobile text messages [15]. This intervention targeted smokers in general and was not specifically aimed at non-communicable disease (NCD) patients. In Thailand, an adapted version of mCessation, utilizing text messaging with infographics, was tested among young smokers, resulting in a reduction in cigarette consumption [16]. However, a text-messaging intervention for non-communicable smokers in Thailand was rarely found. Therefore, this study aimed to investigate the impact of a text-messaging intervention on smoking cessation among NCD patients.

Materials and Methods

A randomized controlled trial was conducted between March 2021 and January 2023 in the Kalasin Province. Participants were recruited from four sub-district health-promoting hospitals. Inclusion criteria consisted of being a current smoker, being a non-communicable disease patient (diabetes, hypertension, and chronic kidney disease), being aged between 20 and 80 years old, and possessing a mobile phone. Exclusion criteria included having documented type I diabetes, cancer, severe chronic pulmonary diseases requiring home oxygen therapy, a known diagnosis of a previous cardiovascular disease (CVD) event; using other drugs such as methamphetamine

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or heroin, and being pregnant or planning to become pregnant. Seven hundred and sixty-three people were assessed for eligibility criteria, and 200 participants were allocated to either the intervention or control groups. Figure 1 illustrates the flow diagram of recruitment. Research assistants underwent one day of training to collect the data.

Randomization and sample size calculation

Participants were randomly assigned to one of two groups: the modified mCessation program or the control group. The internet was utilized to generate a randomization plan (www.randomization.com). We estimated the sample size determination with a test power set at 80% and a significance level of 0.05. Sample size calculation was based on Cohen's estimation, assuming a moderately estimated effect size of 0.45 and accounting for a loss to follow-up of 30%. Consequently, the total sample size was determined to be 200 participants, with 100 allocated to each group [17].

Intervention

This study utilized a smoking cessation program called "mCessation", which is designed to assist smokers in quitting using mobile health (mHealth) technology. The program was developed by the Ministry of Health and Family Welfare and the Ministry of Communications and Information Technology in India [15]. We refined a text-messaging by piloting it initially. We adapted the smoking cessation program initially developed by Intarut et al., which they named "uQUIT" [16]. After modifications, the intervention is now referred to as "ncdQuitSMK". It consists of 93 text messages, including examples such as: "Living a smoke-free life is the path to good health," "Please inform your loved ones or family members that you are making an effort to quit smoking," and "If you feel the urge to use tobacco, take a deep breath, go for a walk, listen to music, or watch TV." In brief, the "ncdQuitSMK" text messaging program containing motivational tips, behavioral strategies, encouragement, and reminders to stay smoke-free. These messages also include information on coping with cravings, setting quit dates, managing stress, and accessing additional support resources such as quitlines or counseling services. The text messages are often tailored to the individual's preferences, smoking habits, and stage of quitting.

For participants in the intervention group, they received SMS messages for 45 days. During the first 15 days, the intervention group received three messages per day. From days 16 to 30, they received two messages per day. Then, from days 31 to 44, they received one message per day, and on day 45, they received two messages. In total, they received 91 post-trial (6 weeks) evaluation messages and were followed up at 18 weeks [18]. For the control group, participants were placed on a waiting list. At the conclusion of the study, they were given the option to receive the intervention if they requested it after the research was completed.

The primary outcome measured in this study was the 7-day point prevalence of smoking cessation that evaluated by asking participants two questions: "Did you smoke in the past 7 days?" with response options of "yes" or "no," and if they answered "yes," they were asked to specify the number of cigarettes smoked.

We also measured the exhaled carbon monoxide (CO) levels in parts per million (ppm), assessed using a PiCO Smokerlyzer from Bedfont Scientific Ltd. Prior to the implementation trial, the equipment was calibrated by a certified company. Research assistants underwent training to ensure proficiency in operating the PiCO Smokerlyzer. Additionally, participants were asked, "Did you smoke in the past 30 days?" with response options of "yes" or "no," and if they answered "yes," they were prompted to indicate the number of cigarettes smoked.

For demographic data, we collected the following information: age in years, education level, income in Thai baht, marital status, occupation, and the Fagerström Test for Nicotine Dependence (FTND) score.

Statistical analysis

Descriptive statistics were employed to characterize the study samples in both the intervention and control groups. Additionally, differences in baseline characteristics between the intervention and control groups were assessed using either the Chi-square test or Fisher's exact test. Mixed linear regression was utilized to test the difference in the exhale carbon monoxide (CO) levels across follow-up time points. All analyses were conducted using R software version 4.2.2 and the epiDisplay package [19]. A significance level of $p < 0.05$ was deemed statistically significant.

The study received approval from the university's Institutional Review Board (IRB) under identification number 102-081/2564. Additionally, it was registered with the Thai Clinical Trials Registry (TCTR) under registration number TCTR20220427004.

Results

We assessed 263 individuals for eligibility criteria. Out of these, 200 participants met the criteria and were randomized into either the intervention group (n=100) or the control group (n=100). The flowchart depicting data screening and random allocation is presented in Figure 1.

Table 1 presents the baseline characteristics of the participants. The majority were male (71.5%), aged over 60 years, with primary school education (90.0%), earning a lower income of less than 5000 Thai Baht (87.0%), married (79.0%), engaged in farming (66.0%), and moderately dependent on nicotine (68.5%). Statistical analysis comparing baseline characteristics between the intervention and control groups revealed no significant differences.

Comparing carbon monoxide levels, differences between the intervention and control groups were observed at both the 6-week and 18-week follow-ups. At the 6-week follow-up, the intervention group exhibited lower CO concentrations compared to the control group (mean difference (MD): -5.35; 95% confidence interval (CI): -6.24, -4.46), and this trend persisted at the 18-week follow-up (MD: -3.58; 95% CI: -4.37, -2.79). Additionally, Figure 2 illustrates the mean CO levels across follow-up

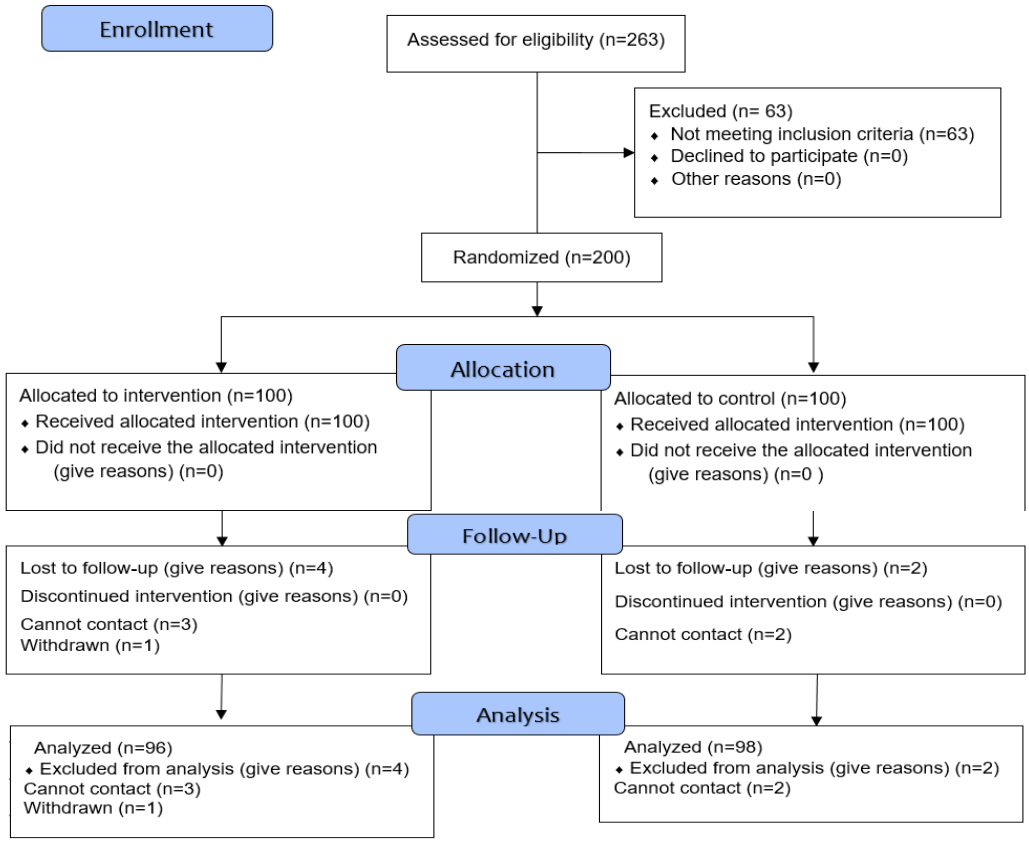

Figure 1. CONSORT Flow Diagram of Study

time points. The 7-day quit smoking rate increased by 16.16% (95% CI: 10.98, 21.33) and 15.46% (95% CI: 10.68, 21.33) at both the 6-week and 18-week follow-ups. Similarly, the 30-day quit smoking rate in the intervention

Table 1. Baseline Characteristics

Variables	Total (n=200)	Control (n=100)	Intervention (n=100)	p-value
Age (Years)				0.273
< 60	57 (28.5)	25 (25.0)	32 (32.0)	
≥ 60	143 (71.5)	75 (75.0)	68 (68.0)	
Education				0.637
Primary school	180 (90.0)	91 (91.0)	89 (89.0)	
Secondary school	20 (10.0)	9 (9.0)	11 (11.0)	
Income (Thai baht)				1
< 5,000	174 (87.0)	87 (87.0)	87 (87.0)	
≥ 5,000	26 (13.0)	13 (13.0)	13 (13.0)	
Marital status				0.728
Married	158 (79.0)	78 (78.0)	80 (80.0)	
Single/divorced/Separated/Widowed	42 (21.0)	22 (22.0)	20 (20.0)	
Occupation				0.447
Unemployed	19 (9.5)	12 (12.0)	7 (7.0)	
Employed	49 (24.5)	25 (25.0)	24 (24.0)	
Farmer	132 (66)	63 (63.0)	69 (69.0)	
Fagerstrom test scores				0.653*
Low	55 (27.5)	26 (26.0)	29 (29.0)	
Moderate	137 (68.5)	71 (71.0)	66 (66.0)	
High	8 (4.0)	3 (3.0)	5 (5.0)	

This values was tested by Fisher's exact test

Table 2. The Primary Outcome and Secondary Outcomes were Measured at Baseline, at 6 Weeks, and at 18 Weeks after the Baseline Measurement

	Baseline	At 6 weeks	Mean difference (95%CI)	At 18 weeks	Mean difference (95%CI)
Primary outcome					
7-day point prevalence of smoking cessation; n (%)					
Intervention	0 (0)	32 (16.16)	16.16 (10.98, 21.33)*	30 (15.46)	15.46 (10.68, 21.33)*
Control	0 (0)	0 (0)		0 (0)	
Secondary outcomes					
CO concentration (ppm) ; mean (sd)					
Intervention	13.34 (5.01)	5.08 (3.55)	-5.35 (-6.24, -4.46)	7.64 (5.09)	-3.58 (-4.37, -2.79)
Control	12.83 (4.91)	10.36 (5.45)		11.31 (5.96)	
30-day point prevalence of smoking cessation ; n (%)					
Intervention	0 (0)	32 (16.16)	16.16 (11.32, 22.04) *	31 (15.97)	15.97 (11.12, 21.91) *
Control	0 (0)	0 (0)		0 (0)	
Number of cigarettes smoked in 7 days ; mean (sd)					
Intervention	34.41 (29.53)	34.19 (30.39)	-1.76 (-3.99, 0.48)	33.19 (28.38)	-1.44 (-3.09, 0.21)
Control	22.43 (25.75)	19.86 (15.7)		20.29 (18.34)	
Number of cigarettes smoked in 30 days ; mean (sd)					
Intervention	136.5 (118.43)	92.37 (116.39)	-20.20 (-31.79, -8.61)	128.2 (112.19)	-2.77 (-10.16, 4.62)
Control	90.20 (100.48)	87.12 (59.45)		86.84 (67.97)	

Mean difference means the comparison between differences of baseline and follow up time of intervention and control; The unpaired t-test was conducted to test the mean difference; * Percentage and 95% confidence interval

Table 3. Mixed Linear Regression for Carbon Monoxide among the Intervention Group

	Estimate	95%CI	p-value
Intercept	14.73	12.52, 16.94	< 0.001
Group	0.33	-1.01, 1.67	0.627
(Intervention vs. Control)			
Time			
At 6 weeks vs baseline	-2.47	-3.51, -1.43	< 0.001
At 18 weeks vs baseline	-1.52	-2.56, -0.47	0.004
Groups x time (Control and baseline)			
Intervention vs 6 weeks	-5.79	-7.26, -4.32	< 0.001
Intervention vs 18 weeks	-4.19	-5.67, -2.71	< 0.001

Adjusted for age, education, occupation, income, marital status, and Fagerstrom test scores

groups increased by 16.16% (95% CI: 11.32, 22.04) at 6 weeks and 15.97% (95% CI: 11.12, 21.91) at 18 weeks. Furthermore, a statistically significant difference was observed in the number of cigarettes smoked within 30 days between the intervention and control groups at the 6-week follow-up (MD: -20.20; 95% CI: -31.79, -8.61). These results are summarized in Table 2.

The mixed linear regression analysis indicates a significant interaction effect between the intervention groups and follow-up time. Table 3 demonstrates a statistically significant mean difference between the intervention and control groups, both at the 6-week follow-up (MD: -5.79; 95% CI: -7.26, -4.32) and the 18-week follow-up (MD: -4.19; 95% CI: -5.67, -2.71).

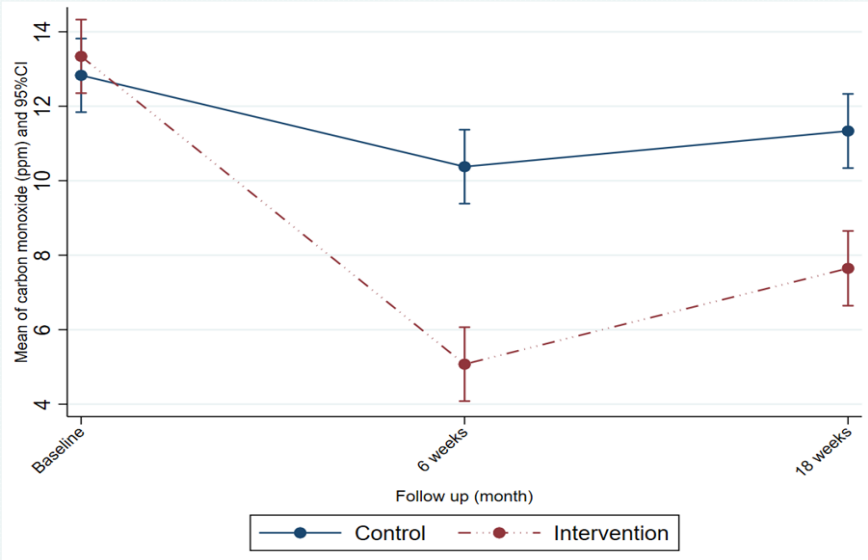

Figure 2. Comparing the Mean of Carbon Monoxide (ppm) at Baseline, 6 Weeks, and 18 Weeks

Discussion

Our results demonstrate the impact of the smoking cessation program on the smoking cessation rate and the reduction of carbon monoxide concentration at the 6-week and 16-week follow-ups. The quit smoking rate was 16.6% in the intervention group.

There are different types of interventions including behavioral intervention, drug therapy, or counseling. Our study focuses on a mHealth intervention that combines behavioral intervention and counseling. Our results are consistent with previous research on behavioral intervention in Thailand. For instance, Aung, M.N. et al. tested a multiple-component smoking cessation intervention for hypertension and diabetes in northern Thailand [20]. They found that the intervention positively impacted the quit smoking rate among patients with hypertension and diabetes. In another study by Bricker JB et al., they compared the quit smoking rates between two smartphone applications, iCanQuit and QuitGuide [21]. They discovered that smartphone applications, commonly used for smoking cessation in mHealth interventions, had significantly higher odds of quitting smoking in the iCanQuit application. Additionally, Müssener U et al. examined the effect of a text-based smoking cessation intervention among high school students in Sweden [11]. They sent text messages based on components of effective smoking cessation interventions for 12 weeks to participants and found that such programs might increase quit smoking rates among adolescents. Research in mobile health is quickly growing alongside the progress in mobile technology, indicating the possibility of using mobile text messages for delivering interventions to help people quit smoking. This implies the practicality and efficacy of employing mobile applications for offering health services and interventions. Our research provides evidence that mobile health interventions can boost smoking cessation rates and reduce exhaled carbon monoxide levels. However, these studies offer valuable insights into the exploration of novel technologies for interventions aimed at changing behaviors.

The strength of our study lies in our use of a biochemical measurement, specifically exhaled carbon monoxide (CO) levels, as an indicator of smoking cessation. Exhaled CO is a reliable biomarker that reflects recent smoking behavior, as it is directly related to the amount of tobacco smoke inhaled by an individual. By measuring the levels of CO in exhaled breath, we can objectively assess whether someone has been smoking recently. However, this study may have several limitations: firstly, the study may suffer from sampling bias, as it primarily focuses on mHealth interventions that based on text-messaging, potentially excluding other relevant interventions such as drug therapy or alternative counseling methods. This could limit the generalizability of the findings to the broader population of smokers who may benefit from different intervention approaches. Secondary, there was a generalizability issues because this study conducted in specific geographic locations and among certain populations (non-communicable disease). This limited scope may hinder the generalizability of the findings to other populations. Lastly, the study may not adequately account for potential confounding variables that could influence smoking cessation outcomes, such as physical activity, or dietary.

Our results indicate that mHealth programs are both well-received and efficacious for individuals with non-communicable diseases. This intervention could serve as a means to motivate and support smoker patients with non-communicable diseases in reducing their smoking habits and ultimately quitting altogether.

Author Contribution Statement

OS and NI contributed to conceptualizing the study. OS collected the data and analyses it. All authors contributed to interpreting the results, writing the draft, editing, and finalizing the manuscript.

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Conflict of interest

The authors declare that there they have no conflicts of interest.

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