Preplanned Studies

Comparative Effectiveness of Mobile Health-Based Comprehensive Smoking Cessation Modalities and Traditional Clinic-Delivered Treatments — Beijing Municipality, China, May 2022 to April 2024

Shuilian Chu[1]; Hang Jing[1]; Di Zhang[1]; Yuan Cao[2]; Yunliang Qian[2]; Xiurong Liu[2]; Lin Xiao[3]; Zhaohui Tong[4]; Lirong Liang[1,#]

Summary

What is already known about this topic?

Most Chinese smokers have not accessed professional help due to a lack of sufficient smoking cessation services. Mobile health (mHealth) can mitigate obstacles related to time and transportation, thereby providing effective support for smokers seeking to quit.

What is added by this report?

This study offers real-world evidence supporting the effectiveness of mHealth-based comprehensive smoking cessation interventions. The findings indicate that these modalities can significantly enhance abstinence rates, albeit to a lesser extent compared to traditional clinic-based treatments. Adherence to the intervention was identified as a critical factor influencing the effectiveness of smoking cessation strategies.

What are the implications for public health practice?

The mHealth-based comprehensive smoking cessation modalities, with or without mailing cessation medications, present a promising approach to enhancing access to and utilization of smoking cessation services. This strategy addresses the significant challenge of limited smoking cessation resources in China.

Smoking remains a challenge in China with high prevalence rates and low cessation success (*1*). Effective quit services are scarce in China, limiting their accessibility. Mobile health (mHealth) offers a promising solution to overcome geographical and logistical barriers. From May 2022 to April 2024, we conducted three cohort studies in Beijing, China, to evaluate the effectiveness of two mHealth-based modalities versus traditional clinic-delivered cessation treatments. Participants were grouped into four categories based on their utilization of cessation services: the "Way to Quit" (WQ) group, the WQ+ mailed nicotine replacement therapy (NRT) group, the smoking cessation clinic (SCC) group, and a control group, referred to as the none use group. Follow-up assessments were conducted at 1 and 3 months post-baseline. We included 1,107 eligible participants who completed at least one follow-up. The self-reported 1–3 month prolonged abstinence rates were 21.7% in the WQ group, 19.7% in the WQ+ mailed NRT group, and 29.9% in the SCC group, all significantly higher than the none use group (6.6%; all $P<0.001$). Adherence to treatment was correlated with higher cessation rates. This study demonstrates that mHealth-based interventions, both alone and in combination with mailed NRT, can improve smoking cessation outcomes. These findings support that mHealth approaches should be used to enhance smoking cessation access and effectiveness in China.

Three prospective cohort studies were conducted at the smoking cessation clinic of Beijing Chaoyang Hospital from May 2022 to April 2024, as part of the public welfare initiative "You Quit, I Support" program. These cohorts were initiated at different times, and tailored to specific smoking cessation services. Current smokers (aged≥18) intending to quit within a month were recruited online, excluding those with mental or psychological conditions. All eligible participants provided either electronic or printed consent forms. These studies received approval from the Institutional Review Board of Beijing Chao-Yang Hospital, Capital Medical University (IRB# 2022-ke-394, 2020-ke-545-3).

Participants were enrolled to receive one of the following free-of-charge services based on the cohort they participated in: the WQ modality (WQ group), the WQ modality supplemented with mailed NRT (WQ+ mailed NRT group), or traditional clinic-delivered treatment (SCC group). The WQ modality

provided two months of three WeChat-based interventions (*2*). The WQ+ mailed NRT modality consisted of the WQ interventions plus a four-week supply of nicotine gum (2 mg/piece, McNeil Sweden AB, Inc., Helsingborg, Sweden) for on-demand use (*3*). Traditional clinic-delivered treatment included varenicline (Sinobiopharma, Inc., Jiangsu, China) for up to 12 weeks and 6 standardized counseling sessions (*4*). Participants who did not utilize any of the cessation services offered were classified as the control group (none use group).

Baseline data were collected through an online questionnaire, which included demographic characteristics, smoking history, previous quit attempts, and comorbidities. The Fagerstrom Test for Nicotine Dependence (FTND) was employed to assess nicotine dependence. Follow-up data were obtained via phone or online using WenJuanXing (https://www.wjx.cn/) at 1 and 3 months post-baseline, covering changes in smoking behavior, cessation service utilization, and other relevant factors. Data regarding the usage of the WeChat-based interventions were extracted from the WeChat app platform. Participants self-reported their medication use. The primary outcome was the self-reported prolonged abstinence rate over 1 to 3 months (*5*). Secondary outcomes included the self-reported 7-day point prevalence of abstinence rate (PPAR) (*5*), the quit attempt rate, and the smoking reduction rate (≥50% daily smoking reduction from baseline) at the 1-month follow-up.

All statistical analyses were conducted using SPSS software (version 22.0; SPSS, Inc., Chicago, IL, USA). Descriptive data were presented as mean (standard deviation, SD) for continuous variables with normal distribution, median (interquartile range, IQR) for continuous variables without normal distribution, and proportions for categorical variables. Baseline characteristics of participants across the four groups were compared using analysis of variance (ANOVA) for continuous variables and Fisher's exact test or Kruskal-Wallis test for categorical variables. To adjust for confounding factors, logistic regression was employed to calculate odds ratios (*OR*s) and 95% confidence intervals (*CI*s) for the effectiveness of different modalities and the relationship between treatment adherence and prolonged abstinence. Participants lost to follow-up were classified as continuous smokers. Statistical significance was set at a level of 0.05 (two-tailed).

A total of 2,194 individuals were recruited, of which 1,498 met the eligibility criteria. Ultimately, 1,107 eligible participants who completed at least one follow-up were included in the final analysis (Figure 1). These participants were distributed as follows: 378 in the non-use group (354 from the cohort 1 and 24 from the cohort 2), 368 in the WQ group, 264 in the WQ+ mailed NRT group, and 97 in the SCC group. The majority of participants were male (95.8%; *n*=1,061), had a college degree or higher (81.3%; *n*=900), and had comorbidities (39.2%; *n*=434). On average, participants smoked 17.4±8.2 cigarettes per day for 18.3±8.7 years. Additionally, most participants attempted to quit smoking (70.1%; *n*=776) using the cold turkey method (62.3%, *n*=561) (Table 1).

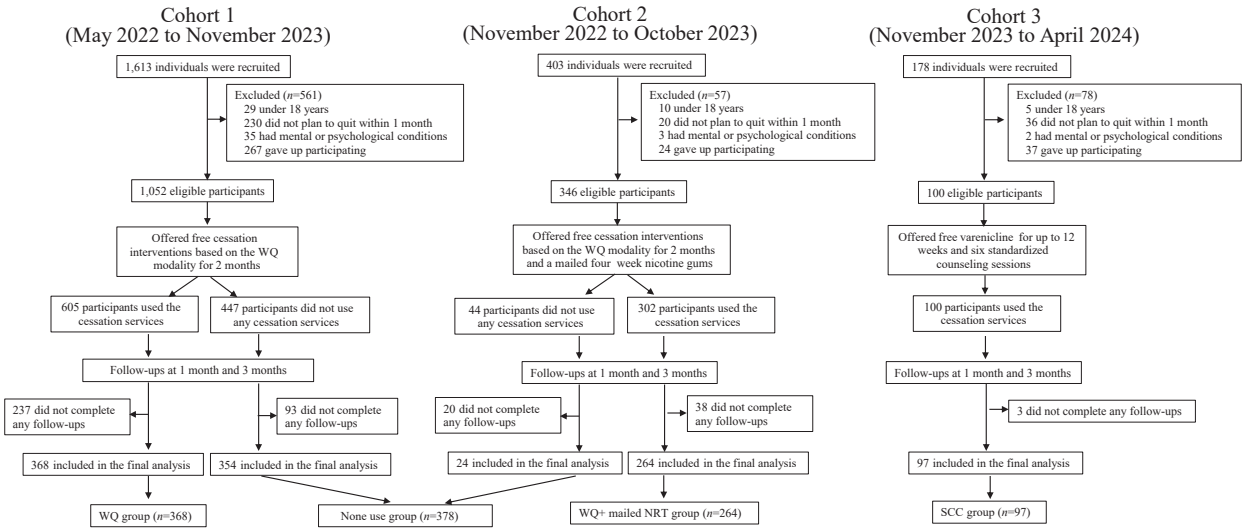

FIGURE 1. Flowchart of screening and enrolling the participants.
Abbreivation: WQ=Way to Quit modality; NRT=nicotine replacement therapy; SSC=smoking cessation clinic.

TABLE 1. Baseline characteristics of participants.

Characteristics	Total (*n*=1,107)	None use group* (*n*=378)	WQ group (*n*=368)	WQ+ mailed NRT† group (*n*=264)	SCC group (*n*=97)	*P* value
Sex, *n* (%)						
Male	1,061 (95.8)	361 (95.5)	355 (96.5)	254 (96.2)	91 (93.8)	0.668
Female	46 (4.2)	17 (4.5)	13 (3.5)	10 (3.8)	6 (6.2)	
Age (years), mean±SD	38.9±9.4	38.1±9.1	40.5±9.8	37.1±8.9	40.8±8.3	<0.001
Education, *n* (%)						
High school and below	207 (18.7)	75 (19.8)	60 (16.3)	58 (22.0)	14 (14.4)	0.138
College	809 (73.1)	280 (74.1)	289 (78.5)	171 (64.8)	69 (71.1)	
Graduate	91 (8.2)	23 (6.1)	19 (5.2)	35 (13.3)	14 (14.4)	
Comorbidities, *n* (%)	434 (39.2)	140 (37.0)	154 (41.8)	75 (28.4)	35 (36.1)	0.007
Risk factors for CVD§						
Hypertension	159 (14.4)	57 (15.1)	60 (16.3)	27 (10.2)	15 (15.5)	0.168
Hyperlipidemia	168 (15.2)	57 (15.1)	55 (14.9)	32 (12.1)	24 (24.7)	0.032
Diabetes	76 (6.9)	23 (6.1)	30 (8.2)	17 (6.4)	6 (6.2)	0.692
CVD	53 (4.8)	23 (6.1)	21 (5.7)	8 (3.0)	1 (1.0)	0.067
Respiratory diseases¶	66 (6.0)	12 (3.2)	24 (6.5)	19 (7.2)	11 (11.3)	0.011
Daily smoking consumption, mean±SD	17.4±8.2	18.2±8.8	17.1±7.9	16.4±7.1	18.3±8.9	0.023
Smoking duration (years), mean±SD	18.3±8.7	17.7±8.2	19.6±9.2	16.5±8.4	20.5±8.3	<0.001
Previous quit attempt, *n* (%)	776 (70.1)	250 (66.1)	246 (66.8)	205 (77.7)	75 (77.3)	0.003
Number of attempts, *n* (%)						
1–2	427 (55.0)	151 (60.4)	141 (57.3)	107 (52.2)	27 (36.0)	<0.001
3–5	258 (33.2)	73 (29.2)	71 (28.9)	74 (36.1)	41 (54.7)	
≥6	91 (11.7)	26 (10.4)	34 (13.8)	24 (11.7)	7 (9.3)	
Quit methods, *n* (%)						
Cold turkey	561 (72.3)	177 (70.8)	171 (69.5)	159 (77.6)	54 (72.0)	0.040
Medication	128 (16.5)	40 (16.0)	46 (18.7)	31 (15.1)	11 (14.7)	0.002
Counseling	60 (7.7)	17 (6.8)	16 (6.5)	22 (10.7)	5 (6.7)	0.534
Quitline	12 (1.5)	4 (1.6)	5 (2.0)	3 (1.5)	0 (0.0)	0.722
e-cigarette	267 (34.4)	86 (34.4)	70 (28.5)	92 (44.9)	19 (25.3)	0.023
others	79 (10.2)	17 (6.8)	25 (10.2)	22 (10.7)	15 (20.0)	0.008
FTND score						
0–3	289 (26.1)	86 (22.8)	118 (32.1)	60 (22.7)	25 (25.8)	0.028
4–6	488 (44.1)	167 (44.2)	152 (41.3)	124 (47.0)	45 (46.4)	
7–10	330 (29.8)	125 (33.1)	98 (26.6)	80 (30.3)	27 (27.8)	

Abbreviation: SSC=smoking cessation clinic; SD=standard deviation; WQ=Way to Quit modality; FTND=Fagerstrom Test for Nicotine Dependence.

* None use group, participants who did not use any services provided by public welfare activities;

† NRT, nicotine replacement therapy, nicotine gum;

§ CVD, cardiovascular and cerebrovascular diseases, including coronary heart disease and stroke;

¶ Respiratory diseases, including chronic bronchitis, emphysema, chronic obstructive pulmonary disease, and asthma.

The self-reported 1–3 month prolonged abstinence rates were 6.6%, 21.7%, 19.7%, and 29.9% for the control group, WQ group, WQ+ mailed NRT group, and SCC group, respectively. After adjusting for age, sex, education, occupation, comorbidities, smoking duration, daily smoking consumption, FTND score, and previous quit attempts, the likelihood of achieving 1–3 month prolonged abstinence increased by 276% (adjusted *OR*=3.76; 95% *CI*: 2.33, 6.08) in the WQ group, by 230% (adjusted *OR*=3.30; 95% *CI*: 1.95,

5.57) in the WQ+ mailed NRT group, and by 483% (adjusted *OR*=5.83; 95% *CI*: 3.18, 10.65) in the SCC group compared to the control group. Additionally, the self-reported 7-day PPAR at 1 month and 3-month follow-ups for all groups using cessation services was higher than that of the control group. The WQ+ mailed NRT group had higher quit attempt and reduction rates at 1 month follow-up (*P*<0.001) (Table 2).

Intervention adherence significantly increased the participants' likelihood of quitting. In the WQ group, those who used WeChat intervention for more than 10 days quit smoking 7.94 times more likely than those with less than 10 days (adjusted O*R*=7.94, 95% *CI*: 4.45, 14.14). Similarly, in the WQ+ mailed NRT group, participants using WeChat-based intervention for over 10 days and consuming 30+ NRT gum pieces had a 7.29 times higher quit rate than those with lower adherence (adjusted *OR*=7.29, 95% *CI*: 2.44, 21.83). This trend aligns with the SCC group, where varenicline extended use correlated with higher smoking quit rate. (P_{trend}=0.001) (Table 3).

DISCUSSION

The mHealth-based cessation modalities (WQ modality and WQ+ mailed NRT modality) boosted abstinence rates up to twice the success rate of the no-

TABLE 2. Outcomes of different smoking cessation modalities at various time points.

Outcomes	Rate, *n* (%)	Adjusted *OR** (95% *CI*)	*P* value
1-month 7-days PPAR			
None use group† (*n*=378)	50 (13.2)	Ref.	
WQ group (*n*=368)	117 (31.8)	3.03 (2.08, 4.42)	<0.001
WQ+ mailed NRT§ group (*n*=264)	86 (32.6)	3.00 (2.00, 4.52)	<0.001
SCC group (*n*=97)	32 (33.0)	3.19 (1.88, 5.40)	<0.001
3-month 7-days PPAR			
None-use group (*n*=378)	69 (18.3)	Ref.	
WQ group (*n*=368)	117 (31.8)	2.07 (1.47, 2.94)	<0.001
WQ+ mailed NRT group (*n*=264)	76 (28.8)	1.78 (1.20, 2.63)	0.004
SCC group (*n*=97)	49 (50.5)	4.68 (2.88, 7.62)	<0.001
1–3 month prolonged abstinence rate			
None-use group (*n*=378)	25 (6.6)	Ref.	
WQ group (*n*=368)	80 (21.7)	3.76 (2.33, 6.08)	<0.001
WQ+ mailed NRT group (*n*=264)	52 (19.7)	3.30 (1.95, 5.57)	<0.001
SCC group (*n*=97)	29 (29.9)	5.83 (3.18, 10.65)	<0.001
1-month quit attempt rate			
None-use group (*n*=378)	101 (26.7)	Ref.	
WQ group (*n*=368)	141 (38.3)	1.85 (1.35, 2.54)	<0.001
WQ+ mailed NRT group (*n*=264)	143 (54.2)	3.27 (2.31, 4.63)	<0.001
SCC group (*n*=97)	23 (23.7)	0.90 (0.53, 1.15)	0.680
1-month smoking reduction rate			
None-use group (*n*=378)	66 (17.5)	Ref.	
WQ group (*n*=368)	76 (20.7)	1.23 (0.81, 1.87)	0.333
WQ+ mailed NRT group (*n*=264)	103 (39.0)	2.77 (1.79, 4.29)	<0.001
SCC group (*n*=97)	44 (45.4)	4.66 (2.50, 8.66)	<0.001

Abbreviation: Ref.=reference; PPAR=point prevalence abstinence rate; WQ=Way to Quit modality; SSC=smoking cessation clinic; *OR*=odds ratio; *CI*=confidence interval.

* Adjusted odds ratio; *OR* was adjusted for age, sex, education, occupation, comorbidities, smoking duration, daily smoking consumption, FTND score, and previous quit attempts;

† None use group, participants who did not use any services provided by public welfare activities;

§ NRT, nicotine replacement therapy, nicotine gum.

TABLE 3. Relationship between intervention adherence and 1–3 month prolonged abstinence among different smoking cessation modalities.

Modality	Adherence, *n* (%)	1–3 month prolonged abstinence, *n* (%)	Adjusted *OR** (95% *CI*)	*P* value
WQ group (*n*=368)				
Usage duration of WeChat based interventions				
<10 days	242 (65.8)	20 (8.3)	Ref.	
≥10 days	126 (34.2)	40 (37.3)	7.94 (4.45, 14.14)	<0.001
WQ+ mailed NRT† group (*n*=264)				
Adherence§ to WQ and NRT				
Low adherence to WQ and NRT	74 (28.0)	7 (9.5)	Ref.	
Low adherence to WQ and high adherence to NRT	98 (37.1)	19 (19.4)	2.61 (0.99, 6.87)	0.052
High adherence to WQ and low adherence to NRT	61 (23.1)	13 (21.3)	2.60 (0.92, 7.38)	0.072
High adherence to WQ and NRT	31 (11.7)	13 (41.9)	7.29 (2.44, 21.83)	<0.001
P_{trend}				0.005
SCC group (*n*=97)				
Varenicline treatment duration				
<1 month	35 (36.1)	3 (8.6)	Ref.	
1–2 months	27 (27.8)	8 (29.6)	5.67 (1.16, 27.59)	0.032
2–3 months	35 (36.1)	18 (51.4)	14.7 (3.36, 64.13)	<0.001
P_{trend}				0.001

Abbreviation: Ref.=reference; WQ=Way to Quit modality; SSC=smoking cessation clinic; *OR*=odds ratio; *CI*=confidence interval.
* Adjusted *OR*: *OR* was adjusted for age, sex, education, occupation, comorbidities, smoking duration, daily smoking consumption, FTND score, and previous quit attempts;
† NRT, nicotine replacement therapy, nicotine gum;
§ Low adherence to WQ, usage duration of WeChat based interventions <10 days; High adherence to WQ, usage duration of WeChat based interventions ≥10 days; Low adherence to NRT, number of gums <30 pieces; High adherence to NRT, number of gums ≥30 pieces.

services group, however, slightly lower than traditional clinic-based treatments. Participants' adherence to smoking cessation interventions significantly influenced intervention effectiveness.

Approximately one-third of smokers using mHealth-based cessation modalities quit at the 1-month follow-up, slightly higher than that reported in studies using standalone WeChat mini programs (26.1%) (*6*) and the WeChat app for sending text messages (10.3%) (*7*). Several factors likely contributed to these positive outcomes. First, the WQ modality was grounded in behavioral change theories and followed clinical practice guidelines to ensure evidence-based interventions. Second, it incorporated three mHealth-based interventions, enhancing intervention intensity with comprehensive monitoring and real-time feedback. Furthermore, smokers using online cessation services made more quit attempts, which may be linked to higher future quit success. Thus, even if online cessation services do not immediately help smokers quit, they still contribute to increased quit success over time. However, our study revealed comparable abstinence rates between the WQ modality and the WQ+ mailed NRT modality. This similarity may be attributed to lower medication adherence in the WQ+ mailed NRT group, where nearly 50% non-adherence. This finding indidated that medication adherence management is crucial in maximizing benefits of mailed medications.

The quit rates of the SSC group outperformed both mHealth-based interventions and traditional smoking cessation clinics in China (*8*). This can be attributed to the comprehensive cessation program offered by the hospital involved in this study, which holds the first smoking cessation clinic in China with exemplary clinical and research capabilities. The program included a intensive counseling session and five brief counseling sessions over six months. This extended intervention helped achieve higher medication adherence rates. Additionally, varenicline, the most effective cessation medication currently available (*9*), played a significant role in these outcomes. We also found that providing medication, either through the clinic or by mail, contributed to reduced smoking consumption, thereby increasing future quitting success.

Across all smoking cessation modalities evaluated, higher intervention adherence was associated with higher prolonged abstinence. In this study, adherence to mHealth-based interventions was notably low. Specifically, only 34.2% of participants in the WQ group and 34.8% in the WQ+ mailed NRT group engaged with WeChat-based interventions for 10 or more days. Despite these lower adherence rates, adherent participants demonstrated significantly higher rates of prolonged abstinence for 1–3 months. Consistent results were observed in clinic-delivered treatments. These findings align with clinical smoking cessation guidelines, which recommend that higher intensity and longer duration of interventions increase the likelihood of quitting (*10*). To address the lower adherence rates, it is crucial to conduct in-depth, qualitative interviews with targeted participants. Understanding and identifying barriers can provide valuable insights into enhancing the effectiveness of mHealth interventions.

This study is subject to some limitations. First, being a real-world study, the effectiveness of the two mHealth-based smoking cessation modalities requires further validation through randomized controlled trials. Second, participants exhibited low adherence to the mHealth-based interventions, which may understate their effectiveness. Third, abstinence rates were self-reported and not biologically validated, which may affect the accuracy of the results. Finally, the short-term outcomes restrict our understanding of the long-term effectiveness of these smoking cessation modalities.

In conclusion, mHealth-based smoking cessation modalities present a promising approach for improving access to cessation services, particularly in China. This study provides crucial insights for public welfare activities focused on smoking cessation, especially in enhancing awareness and utilization of cessation services. To foster broader adoption and implementation of mHealth-based approaches nationwide, it needs to develop a standardized online smoking cessation intervention toolkit.

Conflicts of interest: No conflicts of interest.

Acknowledgements: The Beijing Municipal Commission of Health and Prevention and the Beijing Center for Disease Prevention and Control for their support of this program.

Funding: Supported by Beijing Key Specialists in Major Epidemic Prevention and Control from the Beijing Municipal Health Commission and Capital's Funds for Health Improvement and Research (CFH 2024-1G-1062).

doi: 10.46234/ccdcw2024.099

[#] Corresponding author: Lirong Liang, llrcruie@163.com.

[1] Department of Research on Tobacco Dependence Therapies, Beijing Institute of Respiratory Medicine and Beijing Chao-Yang Hospital, Capital Medical University, Beijing, China; [2] Beijing Center for Disease Prevention and Control, Beijing, China; [3] Tobacco Control Office, Chinese Center for Disease Control and Prevention, Beijing, China; [4] Department of Respiratory and Critical Care Medicine, Beijing Institute of Respiratory Medicine and Beijing Chao-Yang Hospital, Capital Medical University, Beijing, China.

Submitted: April 17, 2023; Accepted: May 21, 2024

REFERENCES

1. Chinese Center for Disease Control and Prevention. 2018 GATS China report. Beijing: People's Medical Publishing House Co., LTD; 2022. (In Chinese)
2. Chu SL, Jing H, Zhang D, Cao Y, Qian YL, Liu XR, et al. Effectiveness and acceptability of a comprehensive mobile health-based modality for smoking cessation - Beijing municipality, China, 2022. China CDC Wkly 2023;5(21):464 – 8. https://doi.org/10.46234/ccdcw2023.088.
3. Chu SL, Feng L, Zuo YT, Jing H, Zhang D, Tong ZH, et al. Evaluation of an innovative mHealth-based integrated modality for smoking cessation in Chinese smokers: protocol for a randomized controlled trial. BMC Public Health 2023;23(1):561. https://doi.org/10.1186/s12889-023-15448-7.
4. Chu SL, Liang LR, Jing H, Zhang D, Tong ZH. Safety of varenicline as an aid to smoking cessation in professional drivers and its impact on driving behaviors: an observational cohort study of taxi drivers in Beijing. Tob Induc Dis 2020;18:45. https://doi.org/10.18332/tid/120935.
5. Hughes JR, Keely JP, Niaura RS, Ossip-Klein DJ, Richmond RL, Swan GE. Measures of abstinence in clinical trials: issues and recommendations. Nicotine Tob Res 2003;5(1):13-25. https://pubmed.ncbi.nlm.nih.gov/12745503/.
6. Xie JH, Qiu YF, Zhu L, Hu YN, Chang XC, Wang W, et al. Evaluation of the smoking cessation effects of QuitAction, a smartphone WeChat platform. Tob Induc Dis 2023;21:49. https://doi.org/10.18332/tid/161257.
7. Lin HX, Liu YH, Zhang H, Zhu ZJ, Zhang XY, Chang C. Assessment of a text message-based smoking cessation intervention for adult smokers in China: a randomized clinical trial. JAMA Netw Open 2023;6(3):e230301. https://doi.org/10.1001/jamanetworkopen.2023.0301.
8. Liu Z, Qin R, Hu XJ, Liu LJ, Xu SQ, Shi GC, et al. Real-world tobacco cessation practice in China: findings from the prospective, nationwide multicenter China National Tobacco Cessation Cohort Study (CNTCCS). Lancet Reg Health West Pac 2023;39:100826. https://doi.org/10.1016/j.lanwpc.2023.100826.
9. Cahill K, Stevens S, Perera R, Lancaster T. Pharmacological interventions for smoking cessation: an overview and network meta-analysis. Cochrane Database Syst Rev 2013;2013(5):CD009329. https://doi.org/10.1002/14651858.CD009329.pub2.
10. The Clinical Practice Guideline Treating Tobacco Use and Dependence 2008 Update Panel, Liaisons, and Staff. A clinical practice guideline for treating tobacco use and dependence: 2008 update. A U.S. Public Health Service report. Am J Prev Med 2008;35(2):158 – 76. https://doi.org/10.1016/j.amepre.2008.04.009.