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**Electronic cigarette use was not associated with quitting of conventional cigarettes in youth smokers**

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45 **Declaration of Interests**  
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47 None declared.  
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52 **Category of study:** Population study  
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**Abstract**

**Background:** To investigate the association between electronic cigarette (e-cig) use and smoking cessation among smokers who called the Youth Quitline in Hong Kong.

**Methods:** This longitudinal study collected data on youth smokers' (N=189) use and perception of e-cigs, conventional cigarette smoking behavior and socio-demographic characteristics at baseline. Self-reported past 7-day point prevalence of abstinence (PPA) was assessed at the 6-month telephone follow-up. Linear and logistic regressions were used to estimate the association of e-cig use with quitting cigarette and other cessation related outcomes.

**Results:** E-cig users were younger, more addicted to nicotine, and less ready to quit (all  $p < 0.05$ ) at baseline. The PPA rate was lower in e-cig users (13.4% vs. 20.8%) at follow-up. E-cig use was not associated with PPA at the 6-month follow-up (odds ratio: 0.56, 95% CI 0.24 to 1.35) but it was non-significantly related to more cessation attempts (raw coefficient: 1.26, 95% CI -0.13 to 2.66). Among those who still smoked, e-cig use was non-significantly associated with intention to quit smoking (odds ratio: 0.55, 0.15 to 2.05), nicotine dependence (Fagerström score, raw coefficient: 0.75, -0.39 to 1.90) and perceptions on quitting cigarette.

**Conclusion:** E-cig use was not associated with successful smoking cessation among Youth Quitline smokers.

## Introduction

Electronic cigarettes (e-cigs) are popular worldwide, especially in the youth. A population survey in 2012 showed Europeans aged 15–24 years had 230% higher odds of having ever used e-cigs. (1) The prevalence of e-cig use even approached that of conventional cigarettes. A recent study among high school students in the US reported that the prevalence of e-cig use in the past 30 days increased from 1.7% in 2011 to 7.7% in 2013, while the proportion of current conventional cigarette smokers dropped from 15.1% to 13.1%. (2) E-cig use in Asian countries is emerging with 9.4% and 4.7% Korean adolescents ever tried and used it in the past 30 days, respectively. (3) In Hong Kong, the prevalence of past 30-day e-cig use in adolescents is relatively low (1.1% in 2012–2013) but it is gradually approaching that of conventional cigarette use (3.3%). (4)

E-cig use is more prevalent in current adolescent smokers. (1,3,4) Smoking cessation is one of the main reasons reported for the use of e-cigs. (5) The effects of e-cigs on smoking cessation among adolescents are uncertain because only 2 cross-sectional studies have reported results on successful abstinence. (3,6) Both ever and past 30-day e-cig use were associated with lower abstinence rate at 30-day, 6-month and 1-year follow-ups among ex-smokers from a representative sample of US secondary students. (6) Similar results were found in Korean adolescents using e-cigs in the past 30 days. (3) Prospective studies are needed to better assess the effects of e-cigs on quitting cigarette smoking among adolescents. Adult studies found inconclusive evidence on the effectiveness of e-cigs as a smoking cessation aid. (7) A recent meta-analysis concluded that e-cig users had 28% lower odds of quitting (8) but the designs of the studies included varied, which rendered this result less convincing. Meanwhile, positive associations were also reported by a paper

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3 that included 3 cross-sectional studies among US young adult smokers (aged 18–25 years),  
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5 in which 1 study found that past-month e-cig use was positively related to past-year  
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7 quitting attempts and another found a positive association with the desire to quit. (9)  
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11 E-cig may affect the cessation of cigarette smoking differently between adolescents and  
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13 adults as similar phenomena were observed with reference to the use of medications for  
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15 smoking cessation (e.g. nicotine replacement therapy (NRT) and varenicline). A recent  
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17 systematic review failed to find the long-term beneficial effects of smoking medication use  
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19 among adolescents. (10) The e-cig was widely promoted as a smoking cessation tool  
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21 worldwide and in Hong Kong, and it is available on the internet and in some local shops.  
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23 The nicotine containing e-cig is required to register according to the Pharmacy and Poisons  
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25 Ordinance, but none has done so as of December 2016. Additionally, the use of e-cigs,  
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27 irrespective of whether it contains nicotine, is prohibited in smokefree areas under the  
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29 comprehensive smokefree legislation. We investigated the prospective associations of e-cig  
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31 use with smoking cessation behaviors, level of nicotine dependence, and perceived self-  
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33 efficacy on quitting cigarette smoking in youth smokers in Hong Kong.  
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## 42 **Methods**

### 43 44 45 46 *Design*

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48 We analyzed the longitudinal data from the Youth Quitline (YQL), which provides a free  
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50 smoking cessation service (counseling without pharmacological intervention) for 6 months.  
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52 This quitline is funded by the Tobacco Control Office, Department of Health, Government  
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54 of Hong Kong SAR and is operated by the School of Nursing, University of Hong Kong.  
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Details of this quitline have been reported elsewhere. (11) Smokers who initiated a call to the YQL were screened, and those who could speak Cantonese, smoked at least 1 cigarette in the past 30 days, and were aged  $\leq 25$  years were eligible to receive the service. Those unable to communicate or those who were undergoing other smoking cessation programs were excluded. Smokers completed the assessment questionnaire on the phone at baseline, and at the 3-day, 1-week, 2-week and 1-month follow-ups. Counseling was provided after each assessment, based on the smoker's smoking behaviors, using the "five A's" strategy (ask about smoking status, advise to quit, assess readiness to quit, assist to quit, and arrange follow-up contact). (12) Smoking cessation outcomes were assessed at the 6-month follow-up using self-reported abstinence, which was also validated by a salivary cotinine level of  $< 10$  ng/ml as an indicator of successful cessation. (13) Ethical approval was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority West Cluster. Oral informed consent was obtained from all participants.

During 2014–15, a baseline questionnaire with added questions on e-cig were administered among 224 smokers and 190 replied to the question on e-cig use (27 had never heard of e-cig and 7 did not answer the questions on e-cig). Follow-up were successfully conducted with 189 smokers, who were included in the current study. The smokers were asked whether they had ever tried e-cig even a single puff, and whether they perceived that an e-cig could help them quit smoking. Those who had ever used an e-cig further reported details about its taste (e.g. menthol, fruit, and coffee) and the nicotine concentration of the e-cigs. Socio-demographic characteristics, including age, sex, education, and employment

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3 were recorded. The smoking behaviors assessed included number of smoking friends,  
4 smokers lived with, and number of quitting attempts in one's lifetime, whether the smokers  
5 wanted to quit (measuring intention to quit, yes/no), planned method, and day determined  
6 for quitting cigarette smoking. The Fagerström score, including number of cigarettes  
7 consumed per day (weekday and weekend) and time to first cigarette after waking (14) was  
8 calculated. Perceived importance, confidence, and difficulties in successfully quitting  
9 cigarette smoking were measured as they predicted abstinence of cigarette use. (15)  
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11 Similar questions on smoking and cessation behaviors were measured at the 6-month  
12 follow-up, except the question on e-cig use.  
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### 29 *Measures*

30 Smokers who had tried the e-cig at least once were classified as "ever user". Participants  
31 rated the perceived effectiveness of an e-cig as a smoking cessation aid on a 5-point scale  
32 ranging from strongly agree to strongly disagree. Readiness to quit was classified into the  
33 following stages with reference to when the respondent planned to quit: action/preparation  
34 (already started to quit or planned to quit within 1 month, which indicated a higher  
35 readiness to quit) and contemplation/pre-contemplation (planning to quit since longer than  
36 1 month or not yet decided, which indicated a lower readiness to quit), based on the  
37 Transtheoretical Model of change. (16) Level of nicotine dependence was assessed by the  
38 Fagerström test and the number of cigarettes consumed per day on weekends because the  
39 most of the participants were students, who spent most of the weekdays at school, and thus  
40 could not smoke *ad libitum*. Perceived importance, confidence and difficulties in  
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4 successfully quitting cigarette smoking were measured on a scale of 0–10, (15,17)  
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6 indicating self-efficacy on quitting (higher scores indicated better perceived self-efficacy).  
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8 Abstaining from smoking for more than 24 hours (18) (yes/no) was considered a serious  
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10 quit attempt and the main outcome used was self-reported point prevalence of abstinence  
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12 (PPA) (19) for the past 7-days at the 6-month follow-up.  
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### 18 *Analysis*

20 Stata (Release 13, College Station, TX: StataCorp LP) was used for the analyses. We  
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22 adopted a pairwise deletion approach and used a 2-tailed  $\alpha = 0.05$  as the significance level.  
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24 The relationship of socio-demographic characteristics with smoking behaviors and e-cig  
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26 use were examined. Adjusted odds ratios (AORs) for self-reported past 7-day PPA and  
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28 intention to quit, and raw coefficients (b) from a linear regression for quit attempts, level of  
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30 nicotine dependence, number of cigarettes consumed per day, and perceived self-efficacy  
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32 on quitting cigarette smoking in relation to e-cig use were calculated, adjusting for baseline  
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34 respective levels of smoking behaviors and socio-demographic characteristics, when  
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36 applicable. The effect size was measured by the Cohen's d and Cohen's w.  
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### 46 **Results**

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50 The participants included in the study shared similar socio-demographic characteristics  
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52 with excluded smokers, except that they were younger (18.1 years vs. 19.6 years,  $p < 0.01$ )  
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54 (data not shown in the tables). Most participants (82.0%) were male, with a mean age of  
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3 18.1 ( $\pm$  2.7) years, and 75.7% had an education level of high school or above (Table 1).  
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6 The average number of cigarettes consumed per day on weekends was 11.5 ( $\pm$  9.6) and  
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8 level of nicotine dependence was mild (Fagerström score:  $2.8 \pm 2.4$ ). As expected, nearly  
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10 all smokers (94.7%) had an intention to quit and over half of the smokers (51.4%) were  
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12 more ready to abstain from smoking. Smokers generally perceived successful quitting as  
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14 important ( $7.3 \pm 2.2$ ), not difficult ( $3.6 \pm 2.3$ ), and they were confident in their ability to  
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16 quit ( $6.1 \pm 2.3$ ). A total of 112 smokers (59.3%, 95% CI 51.9% to 66.3%) had ever tried ab  
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18 e-cig and they were younger (17.5 years vs. 18.9 years), more addicted to nicotine  
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20 (Fagerström score: 3.3 vs. 2.2), less ready to quit (44.8% vs. 60.8%) and consumed more  
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22 cigarettes daily on weekend (12.9 vs. 9.4), compared with non-users (all  $p < 0.05$ ).  
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31 Table 2 shows that 31 (16.4%, 95% CI 11.1% to 21.7%) participants reported abstinence at  
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33 the 6-month follow-up with a lower PPA for the past 7 days for e-cig users than that for  
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35 non-users (13.4% vs. 20.8%). E-cig users had non-significant lower odds of quitting (AOR:  
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37 0.56, 95% CI 0.24 to 1.35), although they appeared to have tried quitting more frequently  
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39 (b: 1.26, 95% CI -0.13 to 2.66). Among those who remained smokers at the 6-month  
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41 follow-up, ever e-cig use was non-significantly associated with lower intention to quit  
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43 (AOR: 0.55, 95% CI 0.15 to 2.05) (Table 3); higher level of nicotine dependence (b: 0.75,  
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45 95% CI -0.39 to 1.90); more cigarette consumption (b: 1.47, 95% CI -2.21 to 5.15); and  
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47 lower perceived importance (b: -0.76, 95% CI -2.01 to 0.49), confidence (b: -0.13, 95% CI  
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49 -1.80 to 1.54), and difficulties (b: -0.75, 95% CI -2.38 to 0.88) pertaining to quitting  
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cigarette smoking.

## Discussion

To the best of our knowledge, this is the first report on prospective associations of e-cig use on quitting cigarette smoking in youth quitline smokers. Among these motivated youth smokers, ever e-cig use did not predict abstinence from cigarette smoking. However, the finding of non-significant negative associations with nicotine dependence, intention to quit, number of cigarettes consumed per day, and perceived self-efficacy among non-quitters were consistent with those on quitting cigarette smoking. The result on quitting cigarette smoking was consistent with that reported in American and Korean cross-sectional adolescent studies. (3,6) Such negative or null associations between e-cig use and intention to quit were also reported by cross-sectional studies among US and Hong Kong adolescents. (2,4,20,21) E-cig users appeared to have more quit attempts than non-users did in our study, which was similar to the positive association between e-cig use and quit attempts in a convenient sample of US young adults (9) and a representative sample of Korean adolescents. (3)

The lack of prospective association between e-cig use and smoking cessation may be explained by the fact that only a few smokers (15.5%) used nicotine containing e-cigs in our study. Although e-cig use can mimic smoking behaviors, the effect of nicotine-free e-cigs on quitting cigarette is weaker than that of e-cigs containing nicotine in adults. (22–24)

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New generation e-cigs, which have improved nicotine delivery systems, (25) have been found to be more effective in relieving cravings (26) and promoting cessation (27) in adults. However, nicotine-containing e-cigs may not be effective in adolescents even if such products could indeed help adults quit cigarette smoking, as corroborated by NRT studies. (10,28) However, no study has investigated the cessation effect of nicotine-containing e-cigs in adolescents. In this regard, a subgroup analysis on nicotine e-cig use is not feasible in the present study because few smokers used such e-cigs.

Another explanation may be that the participants did not engage in e-cig use for aiding smoking cessation because 55.9% of the smokers in this study planned to quit smoking just by themselves or without a specific method, and only 6 planned to use e-cigs for quitting cigarette. Many smokers (67.8%) did not perceive e-cigs as an effective tool for smoking cessation. Other studies found that non-cessation-oriented e-cig users usually stopped using e-cigs after trying them or used them infrequently. (5,29) Cessation-oriented users may be more willing to practice e-cig use for a longer period, which may facilitate learning on how to inhale a satisfactory level of nicotine,(30) and may lead to a higher chance of quitting cigarette smoking.

This study has several limitations. More in depth analysis was restricted by the lack of detailed use pattern (e.g. number of use days in the past 30 days, number of puffs/sessions per day, reason for use). Due to the small sample size, a post priori analysis showed that the statistical power was 0.27 for the detection of a significant association, if the true effect

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3 of ever e-cig use on quitting conventional cigarette was assumed to be OR = 0.59, as found  
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6 in this study. Smoking abstinence was self-reported because biochemical validation of  
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9 quitting cigarette smoking remained low (58.1% of all quit), mostly due to participants'  
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11 busy schedule. As an observational study, unmeasured confounders could not be  
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13 eliminated, which preclude drawing a causal inference.  
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19 Our findings showed that e-cig use was not associated with successful abstinence and it  
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21 appeared to increase difficulties in quitting cigarette smoking in Youth Quitline smokers.  
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24 Given the prevalent e-cig use in the youth and other evidence on the adverse effects on  
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26 smoking initiation and respiratory health, (31,32) further public health action should be  
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28 taken against the promotion, sales and use of e-cigs.  
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38 Government of Hong Kong SAR.  
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### 43 **Declaration of Interests**

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Table 1. Baseline socio-demographic characteristics and smoking behaviors by ever e-cig use in all participants (N=189)

	All (%)	E-cig use		P value
		Non-user (%)	User (%)	
Male	82.0	79.2	83.9	0.41
Age (mean ± SD), years	18.1 ± 2.7	18.9 ± 2.7	17.5 ± 2.6	<0.001
Highest education				<0.01
Junior second or below	24.3	12.5	32.7	
Senior second or diploma	57.2	59.7	55.5	
Sub-degree/higher diploma or above	18.5	27.8	11.9	
Work/study status				0.49
Full-time student	74.6	69.3	78.3	
Employed or self-employed	16.6	18.7	15.1	
Unemployed	1.7	2.7	0.9	
Others	7.2	9.3	5.7	
Number of cigarettes consumed per day <sup>a</sup> (mean ± SD)	11.5 ± 9.6	9.4±8.1	12.9±10.3	0.02
Nicotine dependence <sup>b</sup> (mean ± SD)	2.8 ± 2.4	2.2 ± 2.2	3.3 ± 2.4	<0.01
Readiness to quit smoking				0.03
Action/preparation	51.4	60.8	44.8	
Contemplation/pre-contemplation	48.6	39.2	55.2	
Intention to quit	94.7	96.1	93.8	0.48
Lifetime quit attempts (mean ± SD)	3.3 ± 5.3	3.2 ± 5.3	3.3 ± 5.3	0.91
Perceived self-efficacy in quitting smoking <sup>c</sup> (mean ± SD)				
Importance in successfully quitting cigarette smoking	7.3 ± 2.2	7.6 ± 2.2	7.2 ± 2.3	0.25
Confidence in successfully quitting cigarette smoking	6.1 ± 2.3	6.2 ± 2.4	6.0 ± 2.2	0.56
Difficulties in successfully quitting cigarette smoking	3.6 ± 2.3	3.6 ± 2.6	3.5 ± 2.1	0.72

<sup>a</sup> Cigarettes consumed per day on weekends.

<sup>b</sup> Fagerström score: 0–3 mild, 4–5 moderate, 6–10 severe.

<sup>c</sup> Score: 0–10, higher scores indicate better perceived self-efficacy.

Table 2. Association between ever e-cig use and quitting cigarette smoking and quit attempts in all participants at the 6-month follow-up

	N	Outcome <sup>a</sup>		Effect size <sup>b</sup>	Raw coefficient (95% CI) <sup>c</sup>	
		No EC use	EC use		Model 1	Model 2 <sup>d</sup>
Quitting cigarette	189	20.8 %	13.4 %	0.10	0.59 (0.27 to 1.28)	0.56 (0.24 to 1.35) <sup>e</sup>
Quit attempts	89	2.1 ± 2.4	3.1 ± 3.2	0.35	1.32 (0.05 to 2.60) <sup>f</sup>	1.26 (-0.13 to 2.66)

<sup>a</sup> Percentage for quitting cigarette smoking and mean for quit attempts.

<sup>b</sup> Cohen's d/Cohen's w: 0.10, small; 0.30, medium; 0.50, large.

<sup>c</sup> Odds ratio for quitting cigarette smoking and raw coefficients from the linear regression for quit attempts.

<sup>d</sup> Model 2: Adjusting for Model 1 variables and sex, age, smoking friends, and smoking family members.

<sup>e</sup> Adjusting for Model 2 variables, and for baseline quit attempts and nicotine dependence level.

<sup>f</sup> Adjusting for lifetime quit attempts reported at baseline.

Table 3. Association between ever e-cig use and quitting related outcomes in non-quitters at the 6-month follow-up

	N	Outcome (mean $\pm$ SD) <sup>a</sup>		Effect size <sup>b</sup>	Raw coefficient (95% CI) <sup>c</sup>	
		No EC use	EC use		Model 1 <sup>d</sup>	Model 2 <sup>e</sup>
Intention to quit	61	80.8 %	68.6 %	0.14	0.51 (0.15 to 1.72)	0.55 (0.15 to 2.05)
Nicotine dependence <sup>f</sup>	57	1.5 $\pm$ 1.6	2.6 $\pm$ 2.1	0.61	1.02 (0.00 to 2.04)	0.75 (-0.39 to 1.90)
Number of cigarettes consumed per day <sup>g</sup>	65	7.2 $\pm$ 6.4	8.7 $\pm$ 6.9	0.22	1.38 (-1.98 to 4.73)	1.47 (-2.21 to 5.15)
Perceived self-efficacy in quitting smoking <sup>h</sup>						
Importance in successfully quitting cigarette smoking	56	7.9 $\pm$ 1.9	6.6 $\pm$ 2.3	0.59	-0.85 (-1.93 to 0.24)	-0.76 (-2.01 to 0.49)
Confidence in successfully quitting cigarette smoking	55	5.0 $\pm$ 2.8	5.3 $\pm$ 2.5	0.09	0.06 (-1.49 to 1.62)	-0.13 (-1.80 to 1.54)
Difficulties in successfully quitting cigarette smoking	50	3.8 $\pm$ 2.9	3.2 $\pm$ 2.5	0.25	-1.06 (-2.69 to 0.56)	-0.75 (-2.38 to 0.88)

<sup>a</sup> Mean of outcome for all variables except % for intention to quit.

<sup>b</sup> Cohen's d/Cohen's w: 0.10, small; 0.30, medium; 0.50, large.

<sup>c</sup> All are raw coefficients from the linear regression except for intention to quit, which are odds ratios.

<sup>d</sup> Model 1: Adjusting for baseline respective level.

<sup>e</sup> Model 2: Adjusting for Model 1 variables and for sex, age, smoking friends and smoking family members.

<sup>f</sup> Fagerström score: 0–3 mild, 4–5 moderate, 6–10 severe.

<sup>g</sup> Cigarettes consumed per day on weekends.

<sup>h</sup> Score: 0–10, higher scores indicate better perceived self-efficacy.