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**Electronic cigarette use and its association with smoking in Hong Kong Chinese adolescents**

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## **Abstract**

**Background:** Electronic cigarettes (e-cigarettes) are increasingly used in adolescents with unknown impacts on conventional cigarette smoking. We examined the associations of e-cigarette use with smoking intention, nicotine addiction and smoking cessation in Chinese adolescents.

**Methods:** A total of 45128 students (age  $14.6 \pm 1.9$ ; boys 51.4%) from 75 randomly selected schools in Hong Kong reported e-cigarette use (in the past 30 days), conventional cigarette use and socio-demographic characteristics in an anonymous questionnaire survey. Adjusted odds ratios (AORs) of intention to smoke, morning smoking urge, intention to quit and quit attempts; and beta-coefficient ( $\beta$ ) of cigarette consumption per day were calculated in relation to e-cigarette use.

**Results:** E-cigarette use was associated with intention to smoke with an AOR (95% CI) of 1.74 (1.30-2.31) in all students, 2.18 (1.12-4.23) in never and 2.79 (2.05-3.79) in ever smokers (non-significant interaction by smoking status). The associations were also significant in experimental and former smokers but not in current smokers. In current smokers, e-cigarette use was significantly associated with heavier smoking ( $\beta$  2.54, 95% CI 1.28-3.81) and morning smoking urge (AOR 2.54, 95% CI 1.50-3.11), and non-significantly associated with lower quit intention (0.76, 0.52-1.09) and attempts (0.80, 0.56-1.23).

**Conclusions:** E-cigarette use was associated with smoking intention in never, experimental and former smokers in Hong Kong Chinese adolescents. In current smokers, e-cigarette use was associated with nicotine addiction but not quit intention and attempts. Prospective studies with detailed measurements on e-cigarette use are warranted for further studies.

**Keyword:** E-cigarettes; Chinese; adolescents; smoking

## 1. Introduction

Electronic cigarettes (e-cigarettes) are highly controversial. Apparently, e-cigarettes have less toxicants than conventional cigarettes (Goniewicz, et al., 2014) but acute adverse effects on respiratory function have been reported (Vardavas, et al., 2012) and long-term health effects and abuse liability are uncertain. E-cigarettes are advocated as smoking cessation aids, but conflicting findings have been reported by trials (Bullen, et al., 2013; Caponnetto, et al., 2013), longitudinal (Adkison, et al., 2013; Grana, Popova, & Ling, 2014) and cross-sectional (Brown, Beard, Kotz, Michie, & West, 2014) studies. Some had argued that popular use of e-cigarettes may undermine tobacco control policies and renormalizes smoking (Fairchild, Bayer, & Colgrove, 2014). Young people might be particularly vulnerable to e-cigarette use as it is relatively new and seemingly safe (Durmowicz, 2014).

The prevalence of current e-cigarette use has reached 13.0% in Hungary (children aged 13-15), 8.2% in Poland (high school students), 4.5% in Korea (children aged 13-18) and 1.1% in the US (middle school students). Among smokers, one-fourth (26%) of US and 75% of Korean adolescent smokers were currently using e-cigarettes (Dutra & Glantz, 2014; Lee, Grana, & Glantz, 2014). Cross-sectional studies among adolescents suggested e-cigarette use was linked to heavier cigarette consumption and higher odds of smoking maintenance, but its associations with quit intention and attempts remain unclear (Dutra & Glantz, 2014; Lee, et al., 2014; Lippert, 2014). Some have advocated using e-cigarettes to lower smoking prevalence but the influence on smoking among never-smoking children is causing concern. Hong Kong, the most westernized and urbanized city of China with the strongest tobacco control measures and smoking denormalisation among Chinese cities, has the lowest smoking prevalence in the developed

world (10.7% daily smoking in 2012-13) with decreasing smoking prevalence in adolescence (3.3% smoked in the past 30 days in 2012-13) (Mackay, Ritthiphakdee, & Reddy, 2013). We examined the associations of e-cigarette use with the intention to smoke, nicotine addiction and quitting in Hong Kong Chinese adolescents.

## **2. Methods**

### *2.1 Study design and participants*

A cross-sectional Youth Smoking Survey was conducted in 2012-13 in Secondary 1 (US grade 7) to 6 students (student response rate 96%) from 75 randomly selected schools (school response rate 20%). School sampling was stratified by district, mixed/single sex education, financial support, and school type. School non-responses were typically due to time and administrative issues, and the included schools were similar to all Hong Kong schools in district (Cohen's effect size 0.44), mixed/single sex education (0.13) and financial support (0.26). Sample representativeness was also supported by the small differences in sex (Cohen's effect size 0.04) and grade (0.01) distributions compared with the corresponding population in Hong Kong. Ethical approval was granted by a local institutional review board. An anonymous, self-administered questionnaire in Chinese adapted from the Global Youth Tobacco Survey (GYTS) (The GTSS Collaborative Group, 2006) was distributed to all classes in the selected schools. Completed answer sheets were collected by research staff immediately and sealed in opaque envelopes.

### *2.2 Measurement*

As the first territory-wide school-based smoking survey to explore e-cigarette use, only one question on e-cigarettes use in the past 30 days (yes vs no) was used. No levels of use were specified and students were expected to report any use including even 1 puffs. Students were asked to select their smoking status which was categorized as never smokers (even 1 puff), experimenters (ever smoked once or a few times), former smokers (smoked but quit) and current smokers (currently smoke non-daily or daily). Students reported whether they would smoke in the next 12 months, and when cigarettes were offered by one of their good friends in 2 separate items each with 4 response options of “definitely not”, “probably not”, “probably yes” and “definitely yes” (Sterling, Ford, Park, & McAlister, 2014). Those who chose “definitely not” for both questions were regarded as having no intention to smoke and otherwise as having an intention to smoke.

Nicotine addiction was assessed by 2 items. First, early morning smoking urge (morning smoking) was assessed with the question “Have you smoked or wanted to smoke first thing in the morning?” with 3 responses of “no”, “sometimes” and “always” with the latter two denoted morning smoking (Wang, Ho, Lo, & Lam, 2012). This single-item was accepted as a valid indicator of nicotine dependence (Baker, et al., 2007). Second, students reported the number of cigarettes consumed in a day when smoking occurred in the past 30 days. Consuming more cigarettes (heavier smoking) is an essential feature of nicotine addiction (O'Loughlin, et al., 2003). Quit attempts in the past 12 months (yes vs no), intention to quit (yes vs no), parental and peer smoking, sex, age, and proxies of socioeconomic status including perceived family affluence (Ho, et al., 2010), and parental education attainment were also reported by the students.

### *2.3 Statistical analysis*

A total of 45128 students remained after excluding 729 (1.6%) poorly answered questionnaires typically with over 50% missing data and dubious response patterns on the answer sheets.

Descriptive data were weighted by sex and age distribution of the corresponding general population. Adjusted odds ratios (AORs) for intention to smoke by e-cigarette use in students with various smoking status were calculated using logistic regression adjusting for potential confounders and clustering effect of schools (to correct intra-class correlation errors). Similar methods were used for current smokers except linear regression was used to study the association between e-cigarette use and heavier smoking.

## **3. Results**

Among 45128 students, 51.4% were boys, mean age was 14.6 ( $\pm 1.9$ ), 30.4% perceived family affluence as below average and 19.8% had paternal education below secondary school (data not shown in tables). The prevalence of e-cigarette use (past 30 days) was low overall (1.1%, 95% CI 1.0%-1.2%), but increased sharply with cigarette smoking status: never smokers 0.13%, experimenters 2.02%, former smokers 9.60% and current smokers 9.62% (Table 1). E-cigarette use was also more prevalent in students who reported an intention to smoke (4.1% vs 0.3%) and morning smoking (11.9% vs 6.0%) (both  $p < 0.001$ ). However, the prevalence of e-cigarette use was similar by intention to quit and quit attempt.

In all students, e-cigarette use was associated with intention to smoke with an AOR (95% CI) of 1.74 (1.30-2.31) adjusting for potential confounders and smoking status (Table 2). The

corresponding AORs (95% CI) remained significant in never smokers (2.18, 1.12-4.23) and ever-smokers (2.79, 2.05-3.79) with non-significant interaction with smoking status ( $p=0.45$ ). Further breakdown of ever-smoking status found significant AORs of smoking intention in experimenters (2.17, 1.32-3.62) and former smokers (1.48, 1.02-2.13) but a non-significant AOR in current smokers (1.25, 0.58-2.72). In current smokers, e-cigarette use was associated with higher levels of nicotine addiction with adjusted  $\beta$ -coefficient (95% CI) of 2.54 (1.28-3.81) for heavier smoking and AOR (95% CI) of 2.16 (1.50-3.11) for morning smoking. E-cigarette users were apparently less likely to have an intention to quit at present (AOR 0.76, 95% CI 0.52-1.09) and quit attempts in the past 12 months (0.80, 0.56-1.23), although the associations were non-significant.

#### **4. Discussion**

Although not directly comparable, the prevalence of current e-cigarette use in Hong Kong adolescents (1.1%) was similar to that observed in the US (1.1%) but much lower than that in Korea, Poland and Hungary (4.5%-13.0%) (Durmowicz, 2014). E-cigarettes have been marketed as smoking cessation aids and were subject to regulation for therapeutic purposes in many countries but only few have totally banned e-cigarette sales or marketing (WHO Study Group on Tobacco Product Regulation, 2009). In Hong Kong, e-cigarettes containing nicotine and marketed as nicotine replacement therapy must be registered before sale, and use of e-cigarettes in smoke-free areas is banned (Tobacco Control Office, 2014). To date, no such marketing has been approved by the government. However, nicotine free e-cigarettes are not banned and various flavoured e-cigarettes with or without nicotine can be easily brought through the Internet (e.g. [www.taobo.com](http://www.taobo.com)) at low prices and with speedy delivery as nearly 80% of global e-cigarette



manufacturers are based near Hong Kong in Guangdong province and Shenzhen city (O'Neill, 2014).

Dual use of e-cigarettes and conventional cigarettes was less prevalent in our study (9.6% in current smokers) than in the US (26%) and Korea (75%) (Dutra & Glantz, 2014; Lee, et al., 2014). E-cigarette use in 9.6% former smokers which suggested some smokers may stop smoking and shifted to use e-cigarettes. We found e-cigarettes were used in never smokers (0.2%) and conventional cigarette experimenters (2.1%). Although the prevalence in never smokers was lower than that in the US (1.1%) (Dutra & Glantz, 2014), this still has important implications as the present study found 85% of Hong Kong adolescents were never smokers, resulting in a substantial absolute number of e-cigarette users.

We provided one of the first results on the associations between e-cigarette use and smoking intention in adolescent never smokers and experimenters. Such association has also been reported among never smoking youth in the US (Bunnell, et al., 2015). Other youth studies have found a substantial proportion (22%) of never smokers reporting willingness to use e-cigarettes (Pepper, et al., 2013) and low odds of being abstinent in 30-day, 6-month and 1-year among experimenters using e-cigarettes (Dutra & Glantz, 2014). E-cigarette use may serve as a gateway to initiating or restarting conventional cigarette smoking in never and experimental smokers (Fairchild, et al., 2014). This may particularly be the case in places such as Hong Kong, where the smoking prevalence was low (Census and Statistics Department, 2013) and smoking is highly denormalised. However, this cannot be confirmed in this cross-sectional study, prospective studies are warranted to investigate the effect of e-cigarettes with or without nicotine on inducing

smoking in never and experimental smokers. We also found e-cigarette use in former smokers associated with higher odds of smoking intention, which is a robust predictor of smoking maintenance and relapse in adolescents (Cengelli, O'Loughlin, Lauzon, & Cornuz, 2012). Little is known about the effect of e-cigarettes in former smokers; prospective studies in different populations and age groups are needed.

In current smokers, e-cigarette use was associated with morning smoking and heavier smoking. This was in line with US and Korean studies which found e-cigarette use associated with more cigarettes consumed per day and more frequent smoking in the past 30 days (Dutra & Glantz, 2014; Lee, et al., 2014). The non-significant negative associations of e-cigarette use with quit intention and attempts were consistent with other studies in adolescents and college students (Dutra & Glantz, 2014; Lippert, 2014; Sutfin, McCoy, Morrell, Hoepfner, & Wolfson, 2013), although a positive association with quit attempts was reported in Korean adolescents (Lee, et al., 2014). The accumulated evidence suggested that e-cigarette use may not encourage smoking cessation but could exacerbate nicotine dependence in young smokers. Current evidence on the effectiveness of e-cigarettes on smoking cessation was based on adults and may not be applicable to adolescents, who use e-cigarettes mainly for sensation seeking (Sutfin, et al., 2013).

Adolescents should be reminded about the potential adverse effects on health and nicotine addiction. This is important as big tobacco companies are expanding their e-cigarette markets and targeting youth (McCarthy, 2014).

Our study has several limitations. First, the cross-sectional design, as in similar studies (Dutra & Glantz, 2014), limits causal inference thus only associations can be drawn for e-cigarette use

with smoking intention and tobacco addiction. Second, more detailed information was not collected about e-cigarette use such as types (nicotine content, flavour), frequency and intensity of use, intention to use, and knowledge and perceptions towards e-cigarette use. E-cigarette use was measured using a simple question with unknown validity and reliability, which needs to be assessed in future studies. Third, all data were self-reported, although self-reporting of conventional cigarette smoking was found to be valid and reliable (Patrick, et al., 1994). Validity of self-reported e-cigarette use was supported by the very strong associations (AORs of 15.5 to 52.5) with various smoking status.

E-cigarette use was associated with smoking intention in never, experimental and ex-smokers in Hong Kong Chinese adolescents. In current smokers, e-cigarette use was associated with nicotine addiction but not quit intention and attempts. Prospective studies with detailed measurements on e-cigarette use are warranted for further studies.

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Table 1. Prevalence of e-cigarette use by smoking-related variables <sup>a</sup>

	N (%)	E-cigarette use	
		% (95% CI)	$\chi^2$ P
All	45128 (100%)	1.13 (1.04-1.23)	
Smoking status			
Never smokers	38398 (85.0)	0.13 (0.10-0.17)	<0.001
Experimenters	3418 (7.6)	2.02 (1.54-2.55)	
Former smokers	1781 (3.9)	9.60 (8.27-11.06)	
Current smokers	1560 (3.5)	9.62 (8.20-11.18)	
Smoking intention			<0.001
No	36541 (79.8)	0.34 (0.29-0.41)	
Yes	9238 (20.2)	4.12 (3.72-4.54)	
Current smokers			
Morning smoking urge			<0.001
No	597 (38.3)	5.98 (4.26-8.25)	
Yes	961 (61.7)	11.86 (9.89-14.08)	
Intention to quit			0.07
No	582 (48.0)	9.13 (6.90-11.74)	
Yes	631 (52.0)	7.20 (5.25-9.43)	
Quit attempts			0.17
No	533 (41.9)	9.29 (7.04-12.18)	
Yes	741 (58.1)	9.0 (7.00-11.19)	

<sup>a</sup> Weighted by sex and age distribution of the corresponding population

Table 2. Associations of e-cigarette use with intention to smoke, tobacco addiction and quit.

Outcomes	% outcome <sup>a</sup>		OR (95% CI) <sup>b</sup>	
	E-cig use	No E-cig use	Crude	Adjusted <sup>c</sup>
Intention to smoke				
All	72.8	20.3	10.56 (8.75-12.75)***	1.74 (1.30-2.31)***
Never smokers	23.4	11.8	1.30 (1.29-4.10)***	2.18 (1.12-4.23)*
Ever-smokers	83.3	62.6	2.97 (2.28-3.87)***	2.79 (2.05-3.79)***
Experimenters	64.9	44.7	2.29 (1.42-3.68)**	2.17 (1.32-3.62)**
Former smokers	77.6	70.5	1.45 (0.98-2.16)	1.48 (1.02-2.13)*
Current smokers	96.1	95.0	1.27 (0.58-2.80)	1.25 (0.58-2.72)
Heavier smoking	7.4	4.5	2.90 (1.98-3.83)***	2.54 (1.28-3.81)***
Morning smoking	72.1	46.1	2.25 (1.57-3.21)***	2.16 (1.50-3.11)***
Quit intention	57.8	72.7	0.72 (0.50-1.03)	0.76 (0.52-1.09)
Quit attempts	79.0	83.3	0.78 (0.55-1.11)	0.80 (0.56-1.23)

<sup>a</sup> All are % except average cigarette consumed per day of smoking cigarettes for heavier smoking

<sup>b</sup> All are odds ratios except  $\beta$  coefficient for heavier smoking

<sup>c</sup> Adjusting for sex, age, perceived family affluence, peer smoking, parental smoking and school clustering effect

\* $p < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$