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Short Communication

A longitudinal study of electronic cigarette users

Jean-François Etter [a,*], Chris Bullen [b]

[a] Institute of Social and Preventive Medicine, Faculty of Medicine, University of Geneva, Switzerland
[b] National Institute for Health Innovation, School of Population Health, University of Auckland, New Zealand

HIGHLIGHTS

- Little is known about change in the behaviour of users of electronic cigarettes over time.
- We followed 477 users of electronic cigarettes during one month and 367 users over one year.
- We found that electronic cigarette use had no deleterious effects on smoking behaviour.

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ABSTRACT

Objective: To assess behavior change over 12 months in users of e-cigarettes ("vapers").
Methods: Longitudinal Internet survey, 2011 to 2013. Participants were enrolled on websites dedicated to e-cigarettes and smoking cessation. We assessed use of e-cigarettes and tobacco among the same cohort at baseline, after one month ($n = 477$) and one year ($n = 367$).
Results: Most participants (72%) were former smokers, and 76% were using e-cigarettes daily. At baseline, current users had been using e-cigarettes for 3 months, took 150 puffs/day on their e-cigarette and used refill liquids containing 16 mg/ml of nicotine, on average. Almost all the daily vapers at baseline were still vaping daily after one month (98%) and one year (89%). Of those who had been vaping daily for less than one month at baseline, 93% were still vaping daily after one month, and 81% after one year. In daily vapers, the number of puffs/day on e-cigarettes remained unchanged between baseline and one year. Among former smokers who were vaping daily at baseline, 6% had relapsed to smoking after one month and also 6% after one year. Among dual users (smokers who were vaping daily at baseline), 22% had stopped smoking after one month and 46% after one year. In dual users who were still smoking at follow-up, cigarette consumption decreased by 5.3 cig/day after one month (from 11.3 to 6.0 cig./day, $p = 0.006$), but remained unchanged between baseline and 1-year follow-up.
Conclusions: E-cigarettes may contribute to relapse prevention in former smokers and smoking cessation in current smokers.

1. Introduction

Electronic cigarettes (e-cigarettes) are increasingly popular and the prevalence of e-cigarette use increases sharply every year (ASH, 2013). Sales of e-cigarettes have tripled every year since 2007 in the U.S. (Koch, 2012) and part of the recent decrease in cigarette sales in the U.S. is attributable to smokers switching to e-cigarettes (Kell, 2013). Some analysts even predict that within a decade, sales of electronic cigarettes will surpass sales of tobacco cigarettes (Wells, 2013). The spectacular success of e-cigarettes is a game-changing event in the field of tobacco control. Yet, relatively little research has been published on e-cigarettes and on "vapers" (e-cigarette users). Several observational studies (Caponnetto, Polosa, Russo, Leotta, & Campagna, 2011; Farsalinos & Romagna, 2013; Schneiderhan, 2012) and two randomized trials suggest that e-cigarettes help smokers quit or reduce smoking (Bullen et al., 2013; Caponnetto, Campagna, et al., 2013). Outside these clinical studies, only a few longitudinal studies of vapers have been published (Adkison et al., 2013; Vickerman, Carpenter, Altman, Nash, & Zbikowski, 2013), and it is still unclear how the behavior of vapers evolves over time. This is important information to obtain because the effects of e-cigarettes on health and on smoking behavior will be more evident if vaping is an ongoing, rather than temporary behavior. The safety and toxicity of e-cigarettes will also largely depend on how long vapers use these products. Vapers' behavior may also change over time, in particular because this technology evolves

* Corresponding author at: Institute of social and preventive medicine, University of Geneva, CMU, case postale, CH-1211 Geneva 4, Switzerland. Tel.: +41 22 379 04 59; fax: +41 22 379 04 52.
E-mail address: Jean-Francois.Etter@unige.ch (J.-F. Etter).

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rapidly, and because with time, they acquire more experience or may otherwise modify their behavior. Thus, the objective of this study was to assess change over time in the behavior of e-cigarette users.

2. Material and methods

Because e-cigarettes are purchased largely on the Internet, online registration is an appropriate method to recruit vapers. We posted a questionnaire in English and French on the smoking cessation website Stop-Tabac.ch, and asked websites informing about e-cigarettes or selling them and specialized discussion forums to publish links to the questionnaire. Starting in 2010, the baseline questionnaire included a detailed assessment of vaping and smoking behaviors, which has been previously reported. From August 2011 until January 2013, we collected e-mail addresses for those who agreed to participate in a follow-up study. Only data collected in this period were used in the current study. One month and one year after baseline data collection, we e-mailed all participants who had provided their e-mail address an invitation to answer the follow-up questionnaires. These covered e-cigarette use, current smoking, use of tobacco in the previous 7 days, cigarettes per day (in smokers), puffs/day on e-cigarettes (1-year only) and quit date (in former smokers). Participants were >18 years and the study was approved by the ethics committee of the Geneva University Hospitals.

We used chi^2 tests to compare proportions, *t* tests to compare means and Wilcoxon signed rank tests to compare medians. A *P* value of 0.05 was used as the cut-off to categorise results as statistically significant or not.

3. Results

The baseline survey was answered by 1329 participants, of whom 773 provided an e-mail address (58%). Of these 773 people, 477 answered the follow-up survey after one month, a 62% response rate (36% of 1329) and 367 after **one year**, a 47% response rate (28% of 1329). Table 1 shows that participants in the follow-up surveys were more likely than non-respondents to be daily users of e-cigarettes and former smokers, were older than non-respondents and their income was slightly higher, and among daily smokers, respondents were more motivated to quit than non-respondents. There were no differences between respondents and non-respondents for education, reasons for using e-cigarettes, puffs per day on e-cigarettes, duration of e-cigarette use and among smokers, cigarettes per day. In former smokers, the correlation between cigarettes per day before they quit smoking and puffs per day on e-cigs per day was $r = 0.30$ ($p < .001$) and the correlation between cigarettes per day before they quit and nicotine concentration in e-liquids was 0.12 ($p = 0.3$).

All further analyses were limited to people who answered the follow-up surveys. Distribution of respondents by country was: U.S. (34%), France (24%), U.K. (8%), Switzerland (6%) and other countries (28%). Most participants were former smokers, and they had been abstinent for a median of 10 weeks. Most participants (76%) were using e-cigarettes daily (2% occasionally, 5% past users, 17% never users), and current users had been vaping for 3 months on average. The most used e-cigarette brands were *Joye* ($n = 105$, 22%), *Ego* ($n = 50$, 11%), and *Provape* ($n = 23$, 5%). The most used models, sold under different brand names, were *Ego* ($n = 104$, 22%) and *510* ($n = 24$, 5%). "Dual users" (those who smoked daily and used e-cigarettes daily at baseline) reduced cigarette consumption by 10.5 cigarettes per day since they started vaping: from 24.3 cigarettes per day before they started to vape to 13.8 cigarettes per day at baseline (paired samples *t*-test: $t = 4.5$, $p < 0.001$).

3.1. Change between baseline and follow-up

Almost all (98%) the daily vapers at baseline were still vaping daily after one month and after one year (89%). Of recent vapers (those who had been vaping daily for less than one month at baseline) 93% were still vaping daily after one month and 81% after one year. Of those who were not vaping at baseline, 15% had started to use e-cigarettes (daily or occasionally) after one month and 13% after one year. In the 229 participants who were vaping daily at both time points, the number of puffs per day on e-cigarettes remained

Table 1
Baseline characteristics of e-cigarette users enrolled on the Internet, 2011–2013.

At baseline:	Took part in 1-month survey			Took part in 1-year survey		
	Yes	No	*p*-value	Yes	No	*p*-value
N participants (%)	477 (62%)	296 (38%)		367 (47%)	406 (53%)	
Age, median	42	38	0.032	43	38	0.002
(25th and 75th percentiles)	(33, 51)	(27, 47)		(34, 51)	(28, 48)	
Men (%)	59	48	0.003	58	52	0.08
Have a diploma giving access to university (%)	59	65	0.16	59	63	0.21
Household income above average (%)	38	30	0.007	37	33	0.04
Use e-cig to quit smoking or avoid relapse (%)	92	93	0.64	90	94	0.46
Former smokers (the rest were daily and occasional smokers) (%)	72	53	<.001	76	53	<.001
Former smokers: days since quit smoking, median (25th, 75th centiles)	72	67	0.69	87	53	0.007
	(24, 194)	(18.239)		(28,242)	(18,189)	
Former smokers: cigarettes per day before they quit, median (25th, 75th centiles)	25	20	0.16	25	20	0.55
	(18, 30)	(18, 30)		(18, 30)	(18, 30)	
Use e-cigarettes daily (%)	76	58	<.001	79	58	<.001
Duration of current episode of e-cigarette use, days, median (25th, 75th centiles)	91	49	0.43	91	49	0.24
	(21, 152)	(14,274)		(21, 274)	(21,152)	
Puffs per day on e-cigarette, median (25th and 75th centiles)	150	150	0.87	150	120	0.40
	(90, 250)	(80,250)		(90, 275)	(80,250)	
Use nicotine-containing e-cigarettes (%)	95	95	0.77	96	93	0.25
Number of refills per day, median (25th, 75th centiles)	2	2	0.88	2	2	0.47
	(1, 4)	(1, 4)		(1, 4)	(1, 4)	
Duration of use for one refill or cartridge, hours, median (25th, 75th centiles)	6	8	0.02	6	6	0.40
	(3, 12)	(3, 17)		(3, 12)	(3, 15)	
Concentration of nicotine in liquid, mg/ml, median (25th, 75th centiles)	16	18	0.05	16	18	0.74
	(11, 18)	(12, 24)		(11, 18)	(12, 18)	
Daily smokers: cig. per day	18.2	17.3	0.88	16.3	18.4	0.07
Daily smokers: plans to quit smoking in next 6 month (%)	90.1	72.6	0.006	88.5	76.9	0.014
Daily smokers: currently trying to quit (%)	61.6	68.9	0.04	60.7	67.8	0.04