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# **Comparison of e-cigarette use characteristics between exclusive e-cigarette users and dual e-cigarette and conventional cigarette users: an online survey in France**

Running head: Dual users of electronic cigarettes

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## Abstract

**Background and aims:** Completely substituting e-cigarettes (EC) for combustible tobacco cigarettes reduces exposure to toxicants and carcinogens. However, a large proportion of EC users (dual users) continue to smoke conventional cigarettes. This study aimed to compare estimated nicotine intake and e-cigarette use characteristics between exclusive EC users and dual users.

**Design:** Web-based anonymous cross-sectional survey.

**Setting:** France.

**Participants:** 3189 adults, current users of electronic cigarettes (EC). Data collection between 4 October 2014 and 11 November 2014.

**Measurements:** Primary outcome: estimated nicotine intake per day (mg) from participants' reports. Secondary outcomes: duration, frequency of EC use, and nicotine content of e-liquids used/day. Dual use was defined as using at least one cigarette per day while using also EC.

**Findings:** 2836 respondents reported exclusive EC use and 353 reported being dual users. Backward stepwise logistic regression showed that dual users had higher estimated daily nicotine intake from e-liquids and cigarettes [estimate: 2.14 SE: 0.26, adjusted odds ratio (aOR): 8.48, 95% confidence interval (CI)= 5.11 to 14.09,  $P < 0.001$ ], but lower daily nicotine intake from EC [estimate: -2.14, SE: 0.26, aOR: 0.12, CI=0.07 to 0.196,  $P < 0.001$ ] and reported less months of EC use [estimate -0.31, SE: 0.14, aOR: 0.73, CI=0.56 to 0.95,  $P = 0.022$ ] compared with exclusive EC users.

**Conclusion:** Dual e-cigarette users in France may have higher nicotine intake overall than exclusive e-cigarette users but they may take in less nicotine from their e-cigarettes.

Key words: electronic cigarette only users, dual users, nicotine intake from electronic cigarette

## **Introduction**

Electronic cigarettes (EC) are diverse battery-powered devices that produce an aerosol. The battery heats a resistance that allows aerosolisation of the liquid called “e-liquid” which contains humectants (propylene glycol and/or glycerin) along with flavorants and may or may not contain nicotine. The European Union Tobacco Product Directive of April 2014 limited the nicotine content of EC to 20 mg/mL [1]. As of today, in France, ECs are consumer products and sold outside the health care system. It is usually believed that EC help smokers quit smoking; however, observational cohorts have provided conflicting results as an aid to quitting smoking [2, 3, 4] and two randomized studies with early EC did not show a therapeutic efficacy in smoking cessation [5,6]. In the most recently published pragmatic trial the one-year abstinence rate was 18 % among those randomised to receive EC and 9.9 % among those randomised to receive nicotine replacement therapy, a difference statistically significant [7]. A highly exhaustive report concluded that “There is conclusive evidence that completely substituting e-cigarettes for combustible tobacco cigarettes reduces users’ exposure to numerous toxicants and carcinogens present in combustible tobacco cigarettes” [8].

In 2016, 58.8 % of vapers were dual users in France [9], and 63.9 % in New Zealand [10], a prevalence similar to that observed in the USA in 2015 (59%) [11]. According to recent data, dual use is 44 % of vapers in the UK [12].

The individual need of daily nicotine dose is highly variable among smokers; furthermore, individual dose titration of nicotine replacement therapies according to withdrawal symptoms provides similar results to achieve smoking cessation than dose titration according to saliva cotinine [13]. A recent study suggests that progressive nicotine patch up-titration improves cessation rate (14). It is therefore likely that dual users, while reducing their usual cigarette

consumption, remain dual users because their individual nicotine substitution rate is less than needed. The aims of this study were to: (a) estimate the strength of association between demographics, smoking history and EC use characteristics among exclusive EC users and dual users; b) compare characteristics of dual use to exclusive EC use.

## **Methods**

*Design.* A cross-sectional survey was launched to assess the association of demographic, smoking and EC characteristics among current EC users. Individuals who currently used EC (vapers) were eligible and asked to participate in this French language survey.

*Participants/Procedures.* On October 4<sup>th</sup>, 2014, an advertisement was posted in a local daily newspaper, on its website, on the TV channel “France 3”, and on a the Facebook wall page explaining that a survey aiming to evaluate the characteristics of EC use on tobacco consumption was to be conducted on-line during the following month. Repeat advertisements were posted two weeks later in the same media outlets. The survey ran from October 4<sup>th</sup> to November 11<sup>th</sup>, 2014. The questionnaire was managed and hosted by a company dedicated to on-line surveys ([www.sondageonline.com](http://www.sondageonline.com)®). An integrated control checked IP addresses and did not authorize two answers from the same computer. When the survey was conceived, very little was known about EC and in particular about the nicotine amount in EC between exclusive vapers and dual users. Because this lack of previous data, power calculation could not be undertaken. It was simply stated in the survey’s protocol that at least 1000 responders would be needed to make some meaningful conclusions.

*Measures.*

*Key predictors*

Nicotine consumption by e-liquids was calculated as follows: “How much e-liquid do you vape per day?” Answers: 0 to ≤ 2 mL; 2 to ≤ 4 mL; 4 to ≤ 6 mL; more than 6 mL The question as to the nicotine strength was : “Do you use currently an e-liquid only without nicotine? Or only with nicotine?” For this second question the answers were as follows: 1 to 6 mg ; 8 to 12 mg ; 16 to 19 mg. These categories followed the strengths available in 2014 in the e-liquid market. We used the formula proposed by Goniewicz et al. [15]: e-liquid nicotine concentration (mg/mL) x amount of e-liquid used/day (mL) x percent of nicotine vaporized.

We considered, according to Goniewicz et al. [15], that 60% of nicotine from a cartridge was aerosolized. When the responder could not provide the amount of e-liquid he/she used per day, he/she could report how long a vial's use could last; thus, we divided the vial volume by the number of days of use. It is notable that in 2011, that is before the study was run, the French national medication agency (Agence nationale de sécurité du médicament (ANSM)) stated that the nicotine content for individual cartridges cannot be higher than 10 mg and for refill vials should be less or equal to 20 mg/mL [16].

### *Covariates.*

Age, sex, daily tobacco consumption, previous tobacco use history, duration of vaping, its frequency, the nicotine concentration, and the quantity of e-liquid used per day were recorded. Previous quit attempts referred to smoking prior EC use. A question about checking for his/her EC when leaving was added as a control variable. This question, as a measure of adherence to EC use, was included since one of the simplest reasons not to use EC is having forgotten it at home when leaving. EC make/type was not recorded because of the large number of available models. Dependence on EC was measured by the modified Fagerström Test for Cigarette Dependence (FTCD) [17] replacing questions about cigarettes by “vaping” and number of cigarettes by amount of e-liquid used. As with FTCD, we created a total score that could range from 0 to 10. The frequency of EC use was assessed by the question: “How frequently do you vape ?” The answer was conditional. The first level was: « not every day » OR « everyday ». If « everyday » was selected, then the participant had to choose between “not very often”, “often”, “very often”. Nicotine consumption through cigarette smoking was assessed by multiplying the cigarettes/day by 1 mg, considered as an acceptable approximation of the nicotine amount delivered by a cigarette [15,18].

*Ethics.* Because this was an anonymous survey, according to French law, approval from an ethics committee was not required. However, the aims and the methodology of the survey were explained on the home page of the survey and participants provided informed consent before completing the survey.

*Data analysis.* Data for continuous variables are presented as means and standard deviations; frequencies by numbers and percent. Exploratory analysis by ANOVA was used for univariate comparisons. Stepwise descendent logistic regression (Wald's method) was used to test the variables' association with groups. Variables with a p value  $\leq 0.01$  in the univariate analyses were included in the regression model. In the final regression model only variables

with a p value of  $\leq 0.05$  were considered as significantly associated with the type of EC users. All analyses were run using SPSS V22 software (IBM SPSS Inc, Armonk, NY, USA).

## Results

Among the 3189 responders, 2836 reported exclusive EC use and 353 (11 %) reported dual use. Among the exclusive vapers 1634 (58 %) reported having stopped conventional cigarettes “the day I started using EC”; 61 (2 %) reported being free of tobacco when starting EC and 1138 (40 %) after having started EC. Thus, individuals of this latter group, exclusive vapers, at the time of the survey were previously dual users at some point.

All recorded variables showed significant differences between the two groups of vapers (Table 1). There were more women among dual users than among exclusive vapers. Dual users were younger, reported more previous quit attempts and checked more frequently if their EC was with them when leaving home; used somewhat more nicotine in e-liquids but vaped for a shorter period than exclusive vapers. The modified Fagerström Test for EC total score was higher among exclusive vapers probably because they reported more e-liquid use (exclusive vapers: 3.0 (1.9), 3.4 (1.7), 3.6 (1.9); dual users: 2.4 (1.1), 2.8 (1.3), 3.2 (1.4) mL during the first 6 months, 6 to 12 months and more than 12 months of vaping, respectively,  $p < 0.001$ ). Shorter time to first EC use after awakening was more frequent among dual users than among EC only users:  $\leq 5$  min.: 13.3 vs 7.9%; 6 to 30 min.: 20.4 vs 19%; 31 to 60 min.: 41.6 vs 38%  $> 60$  min.: 30.2 vs 29.7%,  $p = 0.007$ ). We calculated that dual users reported taking 11.7 (9.6) mg nicotine from conventional cigarettes along with vaping leading to a higher total nicotine intake in dual users compared with exclusive vapers.

Stepwise backward elimination logistic regression showed that only three variables differentiated dual users from exclusive vapers. Dual users reported a shorter duration of vaping than exclusive vapers; they had higher daily total nicotine intake but lower nicotine intake from EC. Compared to the univariate comparison, the direction of this latter association was reversed by adjustment for variables included in the model (Table 2). Replacement of the total score of the Fagerström Test for EC dependence by time to first EC use did not change these results.

## Discussion

In this Internet sample of 3189 vapers, most of the vapers (89 %) reported exclusive use of EC. Multivariable logistic regression showed that although dual users use less nicotine from

e-liquids they concurrently smoke probably in order to satisfy their nicotine need by getting nicotine from conventional cigarettes. It is likely that dual users are more highly nicotine dependent than exclusive EC users. In line with this is the finding that they reported using EC earlier after awakening than exclusive vapers. Moreover, dual users reported shorter duration of EC use. These results may suggest that dual users should increase their nicotine substitution dose from e-liquid to suppress their need to smoke also conventional cigarettes. It is also likely that dual users can suppress smoking conventional cigarettes if they use EC for a longer period.

To the best of our knowledge, only one paper compared dual users and EC only users in terms of characteristics and consumption [19]. Questionnaires were completed in nine vape shops in Louisville, Kentucky (67 EC only users, 11 dual users). Exclusive EC users consumed higher levels of nicotine in e-liquids and more nicotine per month. Dual users started EC earlier after awakening than EC only users. The current survey, with a larger sample size shows similar results.

Daily use of EC while smoking is associated with increased number of cessation attempts but not with successful cessation [20]. Dual use can be understood as insufficient nicotine intake from EC by individuals who intend to stop conventional cigarette smoking. Dual use does not seem to improve the likelihood of quitting tobacco and some dual users return to smoking [21]. On the other hand, switching from dual use to exclusive EC use by increasing nicotine intake from EC may result in quitting conventional cigarettes.

### *Strength and Limitations*

The strength of this survey is the large sample size. Limitations include: cross sectional, observational study based on self-reports; lack of biochemical verification of self-report of not smoking conventional cigarettes; and unknown level of intention to quit conventional cigarettes. Although in 2014, all EC devices were performing less well in terms of nicotine delivery, it cannot be excluded that more dual users used low nicotine delivery devices. The data were collected in 2014 and may not therefore be representative of current usage patterns. Non-recording of potential confounders as is always the case in non-randomized studies could also have contributed to the observed findings. It cannot be excluded that successful quitters of conventional cigarettes that is exclusive EC users were more likely to complete the survey than dual users leading to a selection bias.



## Conclusions

The current results suggest that dual users take up insufficient amount of nicotine from EC than needed and use EC for a shorter period than exclusive EC user former smokers. Dual users should be encouraged to self-titrate their daily nicotine intake until no conventional cigarette is needed. Further prospective studies should confirm the current findings.

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Table 1. Characteristics of exclusive electronic cigarette (EC) users and dual users.

	Exclusive EC users (vapers)	Dual users	OR (95% CI)	p-value
<b>N</b>	2836	353		
<b>Age (years)</b>	39.5 (10.2)	37.3 (10.6)	1.02 (1.01-1.03)	0.000
<b>Sex (M/W) %</b>	73/27	65/35	1.46 (1.15-1.85)	0.002
<b>Duration of EC use (months)</b>	10.8 (4.2)	9.2 (4.8)	1.08 (1.05-1.11)	0.000
<b>Frequency of EC use (%) N=3179</b>			1.22 (1.05-1.41)	0.000
Not every day n=72	1.6	6.3		
Every day, sometimes, n=248	7.4	10.8		
Every day, often, n=1412	45.5	35.9		
Every day, very often, n=1447	45.3	47.0		
<b>Check when leaving home (%) N=3189</b>			1.16 (1.05-1.29)	0.005
Never, n= 37	1.0	2.8		
Rarely, n=135	4.1	5.7		
Often, n=451	14.1	14.4		
Very often, n =238	7.2	9.3		
Always, n=2326	73.6	67.7		
<b>E-liquid nicotine content (mg/mL, %) N=3189</b>			0.79 (0.71-0.87)	0.000

1-6, n=1401	46.0	27.5		
7-12, n=1057	37.3	40.8		
13-19, n=437	11.7	30.0		
No nicotine, n=150	5.1	1.7		
<b>Amount of nicotine (mg) from EC/day</b>	28 (16.7)	30.6 (18.7)	0.992 (0.98-0.99)	0.008
<b>Nicotine (mg) from cigarettes/day, N=352</b>		11.7 (9.6)		
<b>Total nicotine intake /day (mg)</b>	28.0 (16.7)	40.9 (19.4)	0.965 (0.960-0.971)	0.000
<b>Previous quit attempt (%) N=3189</b>			0.63 (0.50-0.79)	0.000
Yes, n=1067	32.3	43.1		
No, n=2122	67.7	56.9		
<b>Fagerström Test for EC dependence, total score</b>	3.82 (2.05)	3.41 (1.96)	1.11 (1.05-1.17)	0.000

Data are means and (SD) if otherwise not indicated.

Table 2. Variables in the final model of backward elimination stepwise logistic regression. EC: electronic cigarette. aOR: adjusted odds ratio. Coding: exclusive EC users: 0, dual users 1.

	<b>Estimate</b>	<b>Standard error</b>	<b>Wald statistic</b>	<b>aOR</b>	<b>95% Confidence Interval</b>	<b>p value</b>
<b>Amount of nicotine from EC/day (mg)</b>	-2.144	0.263	66.497	0.117	0.070 to 0.196	<0.001
<b>Total nicotine intake/day (mg)</b>	2.138	0.259	68.228	8.483	5.107 to 14.088	<0.001
<b>Duration of EC use (months)</b>	-0.312	0.136	5.277	0.732	0.561 to 0.955	0.022