

Prevalence and correlates of current daily use of electronic cigarettes in the European Union: analysis of the 2014 Eurobarometer survey

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Abstract The study purpose was to analyze current daily and current daily nicotine-containing electronic cigarette (EC) use in the European Union (EU). Special Eurobarometer 429, a cross-sectional survey performed in a representative sample of 28 member states of the EU in November and December of 2014, was analyzed. The prevalence of current daily and current daily nicotine-containing EC use was 1.08% (95% CI 0.95–1.20%) and 1.00% (95% CI 0.88–1.12%), respectively, and was mainly observed in current and former smokers. Minimal current daily (0.08%, 95% CI 0.03–0.12%) and current daily nicotine-containing EC use (0.04%, 95% CI 0.01–0.08%) was observed among never smokers. Smoking cessation with the help of ECs was reported by 47.12% (95% CI 41.28–52.96%) of current daily and 49.14% (95% CI 43.12–55.17%) of current daily nicotine-containing EC users. Additionally, 33.18% (95% CI 27.67–38.69%) and 31.40% (95% CI 25.80–36.99%) reported reduction in smoking consumption, respectively. The strongest

correlates of daily EC use were being current and former smokers. In the EU in late 2014, current daily EC use was predominantly observed in current and former smokers and was associated with high self-reported rates of smoking cessation and reduction. Current daily EC use by never smokers was extremely infrequent.

Keywords Electronic cigarettes · Smoking · Eurobarometer · European Union · Smoking cessation · Nicotine

Introduction

Electronic cigarettes (ECs) are a recent addition in tobacco harm reduction. Awareness and use of these products have grown significantly over the past few years, mainly after 2009 [1–4]. From a public health perspective, their intended role is as substitutes to combustible cigarettes, in an effort to reduce or, ideally, quit smoking. Several surveys of EC users have attempted to evaluate the effects of ECs on users' smoking status [5–10]. Despite finding that users consistently reported ECs helped them quit smoking, the samples were self-selected, and, thus, not representative of the population. Two randomized controlled trials show only modest smoking cessation efficacy of ECs [11, 12], while two Cochranes review verify the modest but statistically significant effects of ECs on smoking cessation [13, 14]. Other systematic reviews of randomized controlled trials and cohort studies show mixed results [15, 16]. The quality of evidence in these reviews is low due to biases observed in the studies analyzed. Moreover, most studies do not assess regular (daily), and nicotine use or whether ECs are used as smoking cessation aids. These factors are important, not only because surveys of

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successful users (smokers who have managed to quit smoking with EC use) show that daily use and nicotine use are important determinants of success [17], but also because it is not expected that occasional use of any smoking cessation aid (whether pharmaceutical products or ECs) would have a significant effect on smoking cessation. The importance of differentiating between ever, or occasional use, and regular (daily) use is shown by recent studies finding that the commonly used definition of current EC use (past 30-day use) includes many infrequent users (mostly experimenters unlikely to continue use), [18] and provides misleading conclusions about the effects of ECs on smoking reduction or cessation [19]. Finally, beyond the evaluation of efficacy, the assessment of current regular use, and the differentiation between nicotine and non-nicotine EC use are determinants of potential harm from EC use, especially for never smokers; it is not expected for occasional use to cause any harm, while nicotine use is probably necessary to create an addiction among never smokers.

The Eurobarometer is a survey performed in a representative sample of the population of European Union (EU) member states. Among other issues, part of the survey is dedicated to tobacco use and perceptions. The latest Eurobarometer (Eurobarometer 429) was performed in November and December 2014 in 28 member states (with the addition of Croatia compared to the previous one in 2012) [20]. Previously, we performed a secondary analysis on the prevalence and correlates of ever and current EC use [21]. The aim of the present study is to examine the prevalence and correlates of current daily EC use in the EU population. Additionally, a separate analysis of current daily use of nicotine-containing ECs was performed.

Methods

Survey design

Information on the Special Eurobarometer 429 (82.4) has been presented elsewhere [21, 22]. In brief, the survey was conducted by TNS Opinion & Social at the request of the Directorate-General for Health and Food Safety. A total of 27,801 respondents aged ≥ 15 years were interviewed face-to-face at home in their native language. A number of sampling points were drawn in each country, with probability proportional to population size (for a total coverage of the country) and to population density. The EU sample is derived from Eurostat population data or from national statistics offices. For all countries surveyed, a national weighting procedure, using marginal

and intercellular weighting, was carried out. For international weighting (i.e. EU averages), TNS Opinion & Social applied the official population figures as provided by Eurostat or national statistic offices. More information about the weighting methodology is available through GESIS-Leibniz Institute for Social Sciences (<http://www.gesis.org>). In the present analysis, participants responding ‘Do not know’ to the questions about smoking status and e-cigarette use were excluded from the analysis.

Measures

The questions used in the Eurobarometer survey and the definitions of EC use used in this study are presented in Supplementary File 1. Smoking status is defined as current smoking, former smoking and never smoking. EC use pattern is defined as current use, past use, past trial (experimentation) and never use. A specific question requested information about frequency of use (every day, weekly, monthly, less than monthly, only tried once or twice), separately for nicotine-containing and non-nicotine ECs. Current daily EC users are defined as those responding they are current EC users and use nicotine or non-nicotine ECs every day. Current daily nicotine-containing EC users are defined as those responding they are current EC users, and use nicotine-containing ECs every day. The survey included a question about whether EC use helped them to stop or reduce their tobacco consumption. The response options were: ‘Yes, you stopped smoking tobacco completely’, ‘Yes, you stopped smoking tobacco for a while but started again’, ‘Yes, you reduced your tobacco smoking but did not stop’, ‘No, you did not reduce your tobacco smoking at all’, and ‘No, and actually you increased your tobacco smoking’. In the current analysis, the prevalence of each response among current and former smokers who report current daily and current daily nicotine-containing EC users is measured.

Statistical analysis

Estimates for use of ECs and effects on smoking status are calculated with 95% CI. Comparison in use prevalence between current, former and never smokers is performed with χ^2 test. Multivariate logistic regression analysis is performed to determine the correlates of current daily EC use. In the multivariate model, age, gender, residence, age when finished education, social class, marital status, economic status, perceived harmfulness of ECs and exposure to EC advertisements are entered into the model as covariates. A separate model is applied for current daily

and current daily nicotine-containing EC use. A P value of ≤ 0.05 is considered statistically significant. All analyses (besides multivariate regression analyses) are weighted using probability weights in the Eurobarometer dataset and performed with commercially available software (SPSS v.22.0, Chicago, IL, USA). The methodology for the multivariate logistic regression analysis is consistent with a secondary analysis of the same survey evaluating ever and current EC use [21] and the analysis of the Eurobarometer 2012 survey for ever EC use [22].

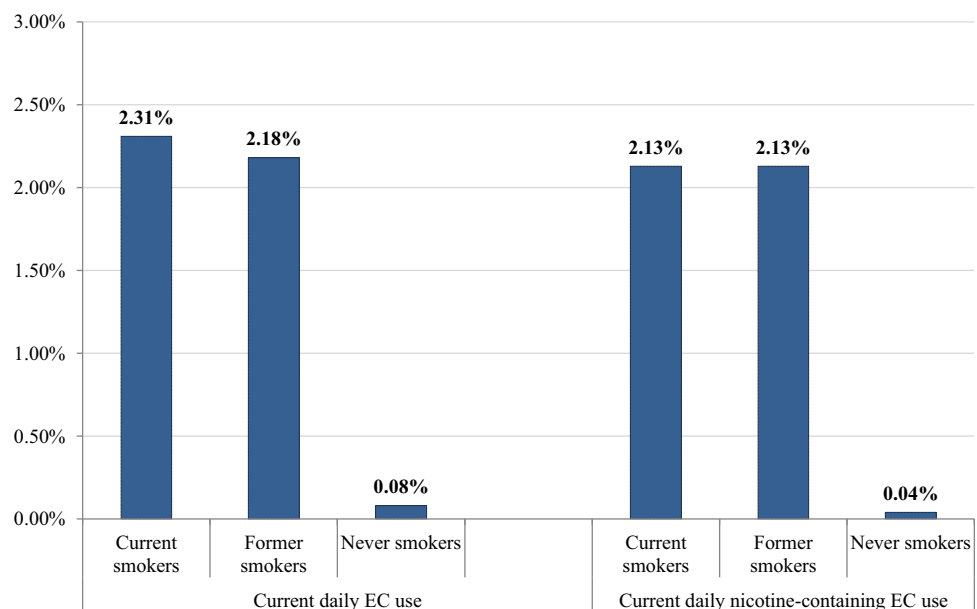
Results

Current daily EC use in the EU

Current daily use of ECs is reported by 1.08% (95% CI 0.95–1.20%) of participants. That represents 9.29% (95% CI 8.28–10.30%) of ever users. Figure 1 displays current daily EC use according to smoking status. Current and former smokers have higher rates of daily EC use (2.31%, 95% CI 1.96–2.65% and 2.18%, 95% CI 1.79–2.57%, respectively), compared to never smokers (0.08%, 95% CI 0.03–0.12%, χ^2 test $P < 0.001$).

Current daily nicotine EC use is reported by 1.00% (95% CI 0.88–1.12%) of participants. That represents 8.64% (95% CI 7.66–9.62%) of ever EC users and 92.96% (95% CI 90.03–95.90%) of current daily EC users. Current and former smokers have higher rates of current daily nicotine-containing EC use (2.13%, 95% CI 1.80–2.46% and 2.13%, 95% CI 1.74–2.51%, respectively), compared to never smokers (0.04%, 95% CI 0.01–0.08%, χ^2 test $P < 0.001$).

Fig. 1 Current daily and current daily nicotine-containing electronic cigarette (EC) use according to smoking status in the European Union in 2014



Current daily EC use and change in smoking status

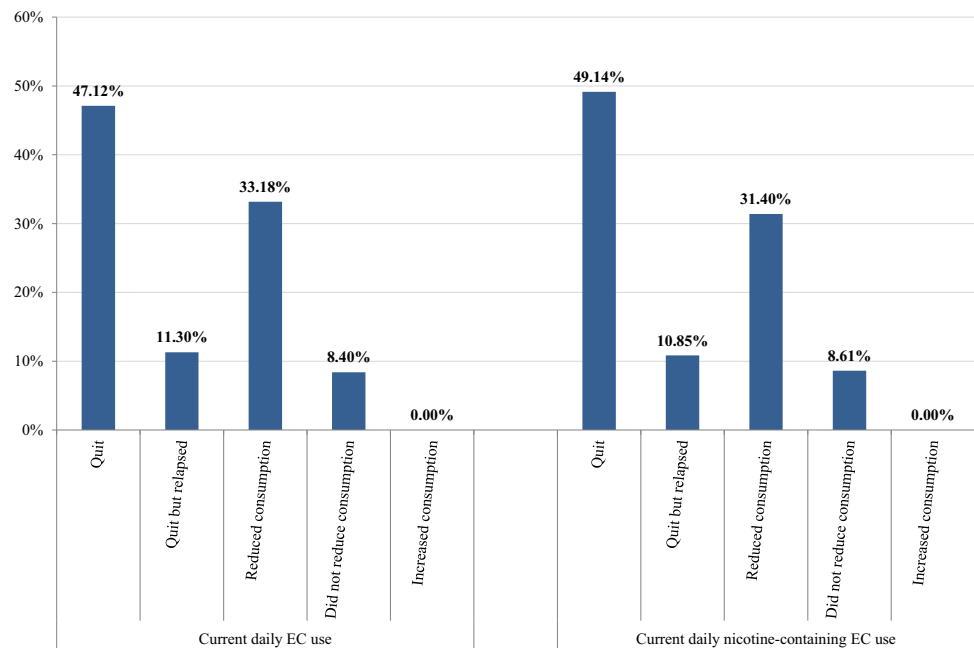
Figure 2 shows the prevalence of each response option of the question whether EC use helps current and former smokers stop or reduce their tobacco consumption. For current daily EC use, 11 subjects are classified as “inappropriate responses” in the original dataset because they responded to the question despite not complying with the criteria of being current or former smokers or reporting EC use. These subjects (3.8% of the total sample of current daily EC users) are excluded from the estimations. From the remaining subjects, 47.12% (95% CI 41.28–52.96%) report quitting smoking, 11.30% (95% CI 7.59–15.00%) quitting but relapsing, 33.18% (95% CI 27.67–38.69%) reducing smoking consumption and 8.40% (95% CI 5.15–11.65%) no change in consumption. No subject reports increasing smoking consumption.

For current daily nicotine-containing EC use, six subjects are classified as “inappropriate responses” in the original dataset. These subjects (2.4% of the total sample of current daily nicotine EC users) are excluded from the estimations. From the remaining subjects, 49.14% (95% CI 43.12–55.17%) report quitting smoking, 10.85% (95% CI 7.10–14.60%) quitting but relapsing, 31.40% (95% CI 25.80–36.99%) reducing smoking consumption and 8.61% (95% CI 5.23–12.00%) no change in consumption. No subject reports increasing smoking consumption.

Correlates of current daily EC use

The results of multivariate logistic regression analyses are displayed in Table 1. Similar correlates are observed for current daily and current daily nicotine EC use. Smoking

Fig. 2 Changes in smoking status among participants reporting current daily and current daily nicotine-containing electronic cigarette (EC) use in the European Union in 2014



status is the strongest correlate, with current and former smokers having higher odds of being current daily and current daily nicotine-containing EC users compared to never smokers. Age groups <55 years, male gender, higher social class and marital status (divorced, widowed or other) also positively correlate with both current and daily use, while no association with education is observed. Finally, frequency of seeing EC advertisements and perceptions that EC are not harmful are associated with higher odds of both current daily and current daily nicotine EC use.

Discussion

The Eurobarometer represents one of the largest population surveys, assessing smoking behavior in all member states of the EU. EC use was first examined in 2012 [23], and a secondary analysis examined prevalence and correlates of ever EC use [22]. The 2014 survey includes a more comprehensive and detailed assessment of EC use patterns [20]. The study herein expands on a previous analysis of ever and current EC use [21] by examining current daily EC use, including current daily nicotine use. Such an analysis is important for multiple reasons. As expected, studies show that daily, but not occasional EC use is a predictor of smoking cessation [19]. Surveys of smokers who used ECs as a smoking cessation aid, show that the use of nicotine seems to be important in their attempt to quit [8, 9]. Additionally, the assessment of daily use is important when assessing adoption of EC use by non-smokers because such use could continuously expose non-smokers to a new risk

while daily nicotine-containing EC use raises the possibility of dependence.

A small proportion of ever EC users report current daily use. Such use is mostly observed in smokers and former smokers, and is remarkably uncommon in never smokers, as is current daily nicotine use. Combined with the previous finding of minimal initiation with ECs [21], these observations appear reassuring in relation to a potential threat that ECs might engage a new generation of nicotine addicts, at least among adults. It is also clear that it is necessary to determine the frequency of use when assessing prevalence of EC use according to smoking status. Another important finding of this study is that there are substantial differences in the reported change in smoking status among different patterns of EC use. The EU announced that 14% of ever EC users quit smoking with the help of ECs [20]. Herein, it is found that the reported smoking cessation and reduction rates are more prevalent in current daily and current daily nicotine-containing EC users; more than 80% of the latter report smoking reduction or cessation. Therefore, determining frequency of use and nicotine use is important when evaluating the smoking cessation and reduction rates among EC users. Moreover, the findings indicate that current daily use is possibly adopted by smokers because of positive effects on their smoking status (reduction or cessation), since less than one out of ten current daily users reports no reduction, and none reports an increase, in smoking consumption.

Although reassuring for never smokers, the low adoption of daily EC use among current smokers as an aid to quit smoking is a phenomenon that needs to be further

Table 1 Multivariate logistic regression analysis of current daily and current daily nicotine-containing electronic cigarette (EC) use in the European Union in 2014

Correlates	Current daily EC use		Current daily nicotine EC use	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Smoking status				
Never smokers (referent)				
Current smokers	28.65 (14.55–56.44)	<0.001	35.98 (16.27–79.57)	<0.001
Ex-smokers	38.80 (19.54–77.06)	<0.001	52.07 (23.40–115.88)	<0.001
Age				
55 and older (referent)				
15–24 years	3.14 (1.88–5.24)	<0.001	3.44 (2.06–5.74)	<0.001
25–39	2.01 (1.37–2.94)	<0.001	1.93 (1.31–2.84)	0.001
40–54	2.38 (1.68–3.38)	<0.001	2.14 (1.49–3.07)	<0.001
Gender				
Female (referent)				
Male	1.51 (1.18–1.95)	0.001	1.70 (1.31–2.22)	<0.001
Residence				
Rural (referent)				
Small/middle town	0.87 (0.65–1.17)	0.359	0.89 (0.65–1.20)	0.437
Large town	1.37 (1.00–1.88)	0.050	1.34 (0.96–1.85)	0.082
Age when finished education				
No full-time education or ≤15 years (referent)				
16–19 years	1.07 (0.72–1.60)	0.740	1.18 (0.77–1.81)	0.438
≥20 years	1.17 (0.76–1.81)	0.478	1.37 (0.87–2.18)	0.176
Still studying	0.73 (0.35–1.53)	0.405	0.61 (0.27–1.36)	0.225
Social class				
Working class (referent)				
Lower middle class	1.11 (0.81–1.51)	0.525	1.10 (0.80–1.53)	0.560
Middle class	0.75 (0.55–1.02)	0.066	0.79 (0.58–1.08)	0.140
Upper middle class	0.56 (0.29–1.07)	0.080	0.61 (0.32–1.19)	0.146
Higher class	2.43 (1.16–5.12)	0.019	2.56 (1.21–5.42)	0.014
Marital status				
Married or living with partner (referent)				
Single	1.07 (0.78–1.47)	0.687	1.12 (0.81–1.54)	0.497
Divorced, widowed or other	1.57 (1.12–2.20)	0.009	1.48 (1.04–2.12)	0.014
Difficulty paying bills				
Most of the time (referent)				
From time to time	0.79 (0.51–1.21)	0.274	0.76 (0.49–1.16)	0.203
Almost never/never	1.08 (0.74–1.58)	0.700	0.97 (0.65–1.43)	0.861
Seeing e-cigarette advertising in past 12 months				
Never (referent)				
Often	4.79 (3.47–6.60)	<0.001	4.38 (3.13–6.13)	<0.001
Occasionally	2.21 (1.64–2.98)	<0.001	2.24 (1.65–3.04)	<0.001
Rarely	1.02 (0.66–1.58)	0.02	0.95 (0.60–1.50)	0.826
Perceived harmfulness of e-cigarettes				
Yes or do not know (referent)				
No	3.01 (2.36–3.83)	<0.001	3.19 (2.48–4.10)	<0.001

explored. Potential explanations are that experimenters have no real intention to quit, or that smokers find ECs unsatisfactory, and thus very quickly abandon their use [24]. However, other reasons also need to be considered. A

recent survey by Action on Smoking and Health UK tried to identify reasons why current smokers have not tried ECs [25]. The most prevalent reason is that they did not consider them safe enough. Herein, perception of harmfulness

is a significant negative correlate of EC use. Misperceptions about the harm potential of ECs, considering them equally or even more harmful than smoking, have been observed in other studies [26] and is growing [25, 27]. A recent study identifies that these misperceptions are growing within the EU too [28]. Finally, a survey comparing EC users who report smoking cessation with dual users identifies perceptions of harm as the strongest predictor of dual use [29].

The vast proportion of current daily EC users report using nicotine-containing ECs. This is consistent with observations from surveys of dedicated daily users [5, 8, 9]. A recent study of 8 months follow-up of EC users finds that nicotine levels are reduced over time, but daily nicotine intake (assessed by measuring salivary cotinine levels) remain constant by increasing liquid consumption [30]. The present analysis verifies previous findings, and shows that ECs do not eliminate nicotine use for the majority of daily users.

Age <55 years is a significant correlate of EC use. This is not surprising, considering that ECs are technology products, and has been observed in the 2012 Eurobarometer survey [22, 31]. Male gender and higher social class are associated with current daily EC use. This is not observed when assessing ever EC use in the 2012 and 2014 Eurobarometer surveys [21, 31], but higher socio-economic status is a correlate of EC use among current and recent former smokers in the UK [26]. Seeing EC advertisements is also associated with current daily EC use. Although it is reasonable to expect that receiving information about ECs would motivate smokers to use them, it is possible that exposure to advertisements is the result of EC use, due to the higher interest of users to learn about new products. Further assessment through longitudinal studies is needed to understand these associations.

An expected limitation of this study is that causation cannot be determined by a cross-sectional study. Other limitations related to any cross-sectional study, such as accuracy of responses and no objective assessment of the smoking status are also applicable to this study. Therefore, the study is not designed to assess the effectiveness of ECs in smoking cessation. It is possible that the success in reducing or quitting smoking is the driving factor resulting in current daily EC use. Moreover, it is not clear if other confounding factors are related to the study findings. For example, smokers who find ECs more appealing and satisfactory, or manage to reduce or quit smoking would be more motivated to become current daily users compared to those who find ECs less satisfactory, or fail to change their smoking status. A recent longitudinal study finds that long-term dual use is associated with a higher rate of subsequent quitting smoking compared to short-term dual use or non-use [32], but again it is possible that smokers became long-

term dual users because they find ECs more satisfactory, or had an initial reduction in smoking consumption that subsequently led to cessation. Although the finding that the majority of current daily EC users report smoking cessation and reduction is by itself reassuring, and indicative of positive population effects, the current study cannot examine if some of the smokers who report quitting with the help of ECs might have quit with other methods if ECs did not exist. Also, the transition timeline between current daily use and changes in smoking status cannot be evaluated. Finally, the findings represent the situation in the EU in late 2014; continuous monitoring is warranted to identify any changes in the patterns of EC use and the smoking status of EC users. These limitations are not specific to this survey, but are inherent to cross-sectional population surveys in general.

Conclusions

The main conclusion of this secondary analysis of the Eurobarometer survey is that daily EC use is predominantly observed in current and former smokers but is very rare among never smokers. Most current daily EC users use nicotine-containing ECs. Daily use is associated with high rates of self-reported smoking cessation and reduction, especially among current daily users who use nicotine-containing ECs. Differentiating between experimentation and regular use, and determining frequency of use in future longitudinal studies is important in estimating the population effects and the effectiveness of ECs as smoking substitutes.

Compliance with ethical standards

Funding No funding was provided for this study.

Conflict of interest For KF and VV, their institution was remunerated by two e-cigarette companies for two unpublished studies in 2013 (>36 months ago), while two studies were funded by the non-profit association AEMSA in 2013 and one by the non-profit association Tennessee Smoke-Free Association in 2015. JLH has received speaker honorarium and consultancy fees from Johnson & Johnson, Novartis, Pfizer, and Pierre Fabre.

Statement of human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study formal consent is not required.

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