E-cigarettes Associated With Depressed Smoking Cessation: A Cross-sectional Study of 28 European Union Countries

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Introduction: Electronic cigarettes (e-cigarettes) are often promoted to assist with cigarette smoking cessation. In 2016–2017, the relationship between e-cigarette use and having stopped smoking among ever (current and former) smokers was assessed in the European Union and Great Britain by itself.

Methods: Cross-sectional logistic regression of the association between being a former smoker and e-cigarette use was applied to the 2014 Eurobarometer survey of 28 European Union countries controlling for demographics.

Results: Among all ever smokers, any regular ever use of nicotine e-cigarettes was associated with lower odds of being a former smoker (unadjusted OR=0.34, 95% CI=0.26, 0.43, AOR=0.43, 95% CI=0.32, 0.58) compared with smokers who had never used e-cigarettes. In unadjusted models, daily use (OR=0.42, 95% CI=0.31, 0.56); occasional use (OR=0.25, 95% CI=0.18, 0.35); and experimentation (OR=0.24, 95% CI=0.19, 0.30) of nicotine e-cigarettes were associated with lower odds of being a former smoker compared with having never used nicotine-containing e-cigarettes. Comparable results were found in adjusted models. Results were similar in Great Britain alone. Among current smokers, daily cigarette consumption was 15.6 cigarettes/day (95% CI=14.5, 16.7) among those who also used e-cigarettes versus 14.4 cigarettes/day (95% CI=13.4, 15.4) for those who did not use them ($p<0.05$).

Conclusions: These results suggest that e-cigarettes are associated with inhibiting rather than assisting in smoking cessation. On the population level, the net effect of the entry of e-cigarettes into the European Union (and Great Britain) is associated with depressed smoking cessation of conventional cigarettes.
Am J Prev Med 2018;∎(∎):∎∎∎–∎∎∎. © 2018 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

INTRODUCTION

Electronic cigarettes (e-cigarettes) are promoted to assist with cigarette-smoking cessation, including by the National Health Service in England,[1] by Public Health Wales,[2] and, more tentatively, by NHS Health Scotland,[3] and cessation is one of the major reasons smokers use them.[4,5] Public health institutions in other European Union (EU) countries do not endorse e-cigarettes as cessation devices. RCTs on efficacy for smoking cessation are limited, and their results have been equivocal.[6,7] Most studies have been based on e-cigarette use in the real world, which, taken together, show that e-cigarettes are associated with significantly less quitting.[8–11] Some studies, however, suggest that intensive use of e-cigarettes (daily use of tank systems,[12] daily use for at least 1 month,[13] long-term use,[14] and use among established current smokers and recent quitters[15]) is associated with more quitting. E-cigarettes are mass-marketed consumer products, not medicines

administered as part of a medically supervised cessation attempt. Thus, rather than asking the clinically relevant question "Are e-cigarettes effective when used as part of an organized cessation attempt?" this paper asks, "What effect is use of e-cigarettes having on smoking cessation in the real world as they are actually used?"

One limitation of the available literature is that the sample sizes are relatively small and often do not have detailed assessment of e-cigarette use patterns. Filippidis et al.[16] used the Eurobarometer, a cross-sectional household survey performed in a representative sample of the population of the EU, to assess increases in e-cigarette use between 2012 and 2014, and Farsalinos and colleagues[17] used the 2014 Eurobarometer[18] to assess cigarette smoking behavior among e-cigarette users. As Farsalinos and colleagues noted, the Eurobarometer survey is useful for evaluating e-cigarette use by the EU population because it is representative of the entire EU region (28 countries), and the 2014 Eurobarometer makes a clear distinction between regular and occasional use and between nicotine-containing and nicotine-free e-cigarettes. Using the Eurobarometer, they found that 35% of current e-cigarette users reported smoking cessation. Although Farsalinos and colleagues[17] specifically examined the relationship between intensity of e-cigarette use and being a former smoker among e-cigarette users, they did not include people who did not use e-cigarettes as the control group, so they did not estimate the effect of e-cigarette use on smoking cessation. This is a major shortcoming as their study did not assess the association of any e-cigarette use with cigarette smoking status. The same dataset is used to assess the relationship between e-cigarette use and having stopped smoking among all ever (current and former) smokers.

METHODS

Study Population

Following Farsalinos and colleagues,[17] data from Eurobarometer 82.4 (Special Eurobarometer 429) was used, a survey conducted in all 28 EU states in November and December 2014. Interviews took place in participants' homes in their native language. The multi-stage probability sample of Europeans aged ≥15 years was based on the total population of a country and population density. A weighting procedure was applied for all countries by using official population figures provided by Eurostat or national statistic offices. For the analyses using all the countries, generalizability was achieved using the weighting variable for the full EU population.[18] The total sample size for the survey is 27,801; a total of 12,608 current and former smokers were used for the analyses. Because health authorities have endorsed e-cigarettes in England and Wales, and tentatively in Scotland, a separate analysis for the 411 current and former smokers in Great Britain (GB) was also run. For use with the GB subsample, the weight for the United

Kingdom was adjusted to apply to GB only, excluding Northern Ireland.

Measures

The main outcome variable was being a former smoker, defined by the answer to the question, *Regarding smoking cigarettes, cigars, cigarillos or a pipe, which of the following applies to you?* with the following response options: *you used to smoke, but you have stopped* (former smoker, coded 1) or *you currently smoke* (current smoker, coded 0).

The primary independent variable was nicotine-containing e-cigarette use, quantified in two different ways: (1) nicotine e-cigarette use (dichotomous, excluding experimenters who had only used e-cigarettes once or twice), and (2) intensity of nicotine e-cigarette use. Experimenters were excluded on the assumption that they did not use e-cigarettes enough to have an impact on smoking behavior. Nicotine-containing e-cigarette ever use was measured with the question, *How often do you or did you use the following products: Nicotine-containing electronic cigarettes or similar electronic devices?* after participants previously endorsed using e-cigarettes or similar electronic devices (e-shisha, e-pipe), having used e-cigarettes in the past or having tried e-cigarettes in the past. Those who used e-cigarettes every day, weekly, monthly, or less than monthly were coded as 1. The people who endorsed having never used e-cigarettes were coded as 0 (non-users). The 80 people who responded *don't know* were excluded. Intensity of nicotine e-cigarette use was measured using the same question to create a four-level variable: (1) daily use; (2) occasional use (weekly, monthly, less than monthly); (3) experimentation (used once or twice); and (4) never use (the reference group).

Covariates included age (continuous); sex; cigarettes per day (continuous from the item: *On average, how many cigarettes do you or did you or did you [before you stopped smoking] smoke each day?*); marital status (single, divorced/separated/widowed, with married/living with a partner as reference); and age at which respondents completed their education (16–19 years, ≥20 years, still studying, with no formal education as reference). People who only used non-nicotine e-cigarettes (201/2,430=8% in the EU and 6/118=5% in GB) were coded as never users of nicotine-containing e-cigarettes.

Statistical Analysis

Weighted logistic regression models were run using former smoking as the outcome variable using Mplus, version 8.[19] Predictors included one of two variables: (1) e-cigarette ever use (dichotomous, excluding people who only experimented with e-cigarettes) and (2) intensity of nicotine e-cigarette use. Sensitivity analyses were also run only including current e-cigarette use (not shown), which gave similar results. All models were run using all the countries unadjusted and adjusting for the control variables listed above.

Cigarette consumption was compared among all current smokers who did and did not currently use e-cigarettes using a *t*-test.

Missing data were handled using full-information maximum likelihood, which allows all observations to be used,[20] including those with some missing data. The full-information maximum likelihood method produces more accurate effect size estimates and smaller SEs than listwise deletion by using all the available information, including from incomplete records.[21–23] Country was