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Country-level correlates of e-cigarette use in the European Union

Giuseppe La Torre · Daniele Mipatrini

Abstract

Objectives The aim of this study was to assess the relationship between the prevalence of e-cigarette use and country-level factors across 28 European countries.

Methods The study objectives were addressed in an ecological design in which both exposures and outcomes were measured at the country level. Data from the Eurobarometer Report, the Eurostat database and the WHO observatory were analyzed. Bivariate and multivariate analyses were performed considering the rates of current and ever smokers of e-cigarettes as dependent variables, and socio-economic factors, health status and policies against tobacco as independent variables.

Results Both the rate of current smokers and ever smokers of e-cigarette were positively associated to the offer of help to quit tobacco use ($P < 0.01$; $P = 0.04$) and to the raise of taxes on tobacco ($P = 0.01$; $P = 0.01$). The warn on dangers of tobacco negatively correlated with the rate of e-cigarette current smokers. The rate of current e-cigarette smokers correlated with the rate of current smokers and with national Gross Domestic Product, while the rate of ever e-cigarette smokers did not correlate with any socio-economic factor.

Conclusions Our analysis suggests that both policy and non-policy factors are associated with the geographical variability seen in the prevalence of e-cigarette use. Policies against the consumption of conventional tobacco products may lead to an increase of e-cigarette smokers.

Keywords e-Cigarette · Europe · Smoking cessation · Tobacco policy

Introduction

Electronic cigarettes (e-cigarettes) deliver a nicotine-containing aerosol to users by heating a solution containing propylene glycol or glycerol, nicotine and flavoring agents. Use of e-cigarettes since their creation in the early 2000s by Hon Lik, a Chinese pharmacist, has been widespread (Grana et al. 2013). A recent systematic review (Gualano et al. 2014) suggests that e-cigarette use may help reduce the number of cigarettes smoked as well as nicotine withdrawal symptoms. However, current knowledge on possible long-term adverse effects of e-cigarette use remains limited since most studies assess use over short time periods only. As discussed by Famele et al. (2015), there may be harmful substances produced during the heating process, and in-depth chemical analyses of the aerosol are needed to fully assess the chemical consequences of e-cigarette use. Moreover, there is evidence that dual use of conventional and e-cigarettes does not help smokers quit or reduce smoking (Manzoli et al. 2015).

Because of the lack of knowledge on the effectiveness and risks of e-cigarette use, policy makers often adopt a cautious approach (Smith 2014; Kadowaki et al. 2015).

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The American Heart Association (AHA) in a recent policy statement published in *Circulation* (Bhatnagar et al. 2014), considers e-cigarettes containing nicotine as tobacco products. The direct corollary is that their regulation should comply or align with existing laws on the use and marketing of tobacco products. In this statement, the AHA strongly supported laws and regulations that prohibit the sale and marketing of e-cigarettes to young people.

In the European Union, the Tobacco Products Directive (2014/40/EU) establishes rules governing the manufacture and sale of tobacco and related products including e-cigarettes. The Directive sets out safety and quality requirements for tobacco consumers, and e-cigarette users in particular. However, this Directive may not be easy to implement at the national level.
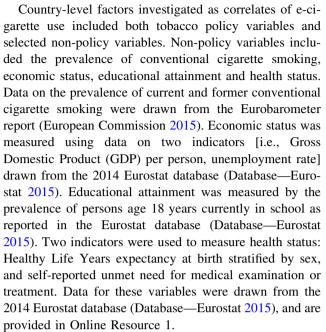
In the absence of evidence-based policy, e-cigarette use must be closely monitored. Vardavas et al. (2014), using data from the 2012 Eurobarometer 385 Survey, reported that e-cigarette users are more likely to be younger, current smokers, or past-year quit attempters. However, their analysis was conducted at the individual level, and no insight was obtained on the possible influence of country-level factors including tobacco control policies. The aim of this study was therefore to assess the association between the prevalence of e-cigarette use and country-level factors across 28 European countries.

Methods

The study objectives were addressed in an ecological design in which both exposures and outcomes were measured at the country level. Specifically, we examined the association between the prevalence of current and ever e-cigarette use in 28 European Union countries and selected country-level factors.

Study variables

Data on the prevalence of current and ever e-cigarette use were drawn from the Eurobarometer "Attitudes of Europeans towards tobacco and electronic cigarettes" report published in May 2015 (European Commission 2015). This report summarizes data collected in 1000 interviews conducted in each of the 28 countries of the European Union in 2014. We defined "current e-cigarette users" as those who answered "yes" to the question: "Are you currently smoking electronic cigarettes or similar devices?" "Ever e-cigarette users" included current smokers, former smokers and participants who had tried e-cigarettes in the past, but no longer used them. Data on the prevalence of e-cigarette users and conventional cigarette smokers are provided in Online Resource 1.

Country-level factors investigated as correlates of e-cigarette use included both tobacco policy variables and selected non-policy variables. Non-policy variables included the prevalence of conventional cigarette smoking, economic status, educational attainment and health status. Data on the prevalence of current and former conventional cigarette smoking were drawn from the Eurobarometer report (European Commission 2015). Economic status was measured using data on two indicators [i.e., Gross Domestic Product (GDP) per person, unemployment rate] drawn from the 2014 Eurostat database (Database—Eurostat 2015). Educational attainment was measured by the prevalence of persons age 18 years currently in school as reported in the Eurostat database (Database—Eurostat 2015). Two indicators were used to measure health status: Healthy Life Years expectancy at birth stratified by sex, and self-reported unmet need for medical examination or treatment. Data for these variables were drawn from the 2014 Eurostat database (Database—Eurostat 2015), and are provided in Online Resource 1.

To measure country-level tobacco control policies, we drew data on policies in Europe in 2014 from the WHO Global Health Observatory Data Repository (Global Health Observatory Data Repository 2015). Seven policies were retained: presence of an active monitoring system of smokers indicators, the active protection from tobacco smoke (ban on smoking in public settings), help to quit tobacco smoke, the warn on dangers of tobacco (health warnings on tobacco products), the presence of anti-tobacco mass media campaigns, the enforcement of bans on tobacco advertising, and the raise of taxes in the retail price of tobacco products. Each policy in each country was scored according to a "best practice ranking" of the policy. Countries were scored 1 if data on policy implementation at the national level were not available or if the anti-tobacco policy was not present in the country, 2–4 if the country was active in the area, but did not implement or only partially implemented the best practice, and 5 if the country fully implemented the best policy in the area. For example, a score of 5 on the policy offering help to quit tobacco smoke indicated that the country fully implemented a national quit line, and both nicotine replacement therapy and cessation services available in hospitals or the community were cost covered. Detailed explanations of the seven indicators and their scoring are presented in Table 1. Data are available in Online Resource 1.

Data analysis

Spearman rank correlation coefficients were computed to describe the correlation between current and ever e-cigarette use and each potential correlate of interest. We then undertook two multivariable analyses for each outcome

Table 1 Explanation of the scoring for tobacco control policies according to the WHO Global Health Observatory Data Repository

Score	Policies						
	Monitoring smokers indicators	Protect from tobacco smoke	Offer help to quit tobacco use	Warning on dangers of tobacco	Anti-tobacco mass media campaign	Enforce ban on tobacco advertising	Raise taxes on tobacco
1	Data not reported	Data not reported	Data not reported	Data not reported	Data not reported	Data not reported	Data not reported
2	Recent and representative data for adults OR youth	Up to two public places completely smoke-free	none	None or less than 30 %	No national campaigns	Complete absence of OR soft ban	≤25 % of retail price is tax
3	Recent and representative data for both adults and youth	Three to five public places completely smoke-free	NRT[a] and/or some cessation services[b] (not covered)	≥30%[c], but no pictures or pictograms and/or other appropriate characteristics	National campaign conducted with 1–4 appropriate characteristics	Ban on national TV, radio and print media only	26–50 % of retail price is tax
4	Recent, representative and periodic data for both adults and youth	Six to seven public places completely smoke-free	NRT[a] and/or some cessation services[b] (cost covered)	31–49 %[c] including pictures or pictograms and other appropriate characteristics	National campaign conducted with 5, 6 appropriate characteristics, or with 7 characteristics excluding airing on TV and/or radio	Ban on national TV, radio and print media as well as on some, but not all other forms of direct and/or indirect advertising	51–75 % of retail price is tax
5	– (For this indicator 4 is the highest possible score)	All public places completely smoke-free (or at least 90 % of the population covered smoke-free legislation)	National quit line, and both NRT[a] and some cessation services[b] cost covered	≥50 %[c] including pictures or pictograms and appropriate characteristics	National campaign conducted with at least seven appropriate characteristics including airing on TV and/or radio.	Ban on all forms of direct and indirect advertising	>75 % of retail price is tax

[a] Nicotine replacement therapy

[b] Smoking cessation support available in any of the following places: health clinics or other primary care facilities, hospitals, office of a health professional, the community

[c] Average of the front and back of the cigarette pack

(current e-cigarette use; ever e-cigarette use) adopting a stepwise approach with backwards elimination. The first model included only the non-policy potential correlates. To avoid multicollinearity in this model, we selected only one indicator for each of use of conventional cigarettes (i.e., either current or former conventional cigarette smoking), economic status (GDP per person or unemployment rate) and health status (Healthy Life Years expectancy at birth in males and females, or unmet need for medical examination or treatment).

The second model included all the policy variables except presence of an active monitoring system of tobacco consumption, which was viewed as a method to monitor changes due to the other six policies. The analyses of the first two models were performed using a stepwise approach with backwards elimination. A third model included variables retained in the last step of the backward elimination in the two previous analyses plus one indicator of use of conventional cigarettes and GDP per person if these were not retained in the last step of the backwards elimination. Finally, we produced a model for each outcome with five covariates.

Statistical significance was set at $p < 0.05$. The analysis was conducted using SPSS for Windows, release 22.0

Results

According to the 2014 Eurobarometer report, the average prevalence of current e-cigarette use was 2 % across European countries. The lowest prevalence was less than 1 % in Hungary, Lithuania, Malta, Romania, Slovenia and Sweden while the highest prevalence was 4 % in the UK. The prevalence of ever e-cigarette use was higher—12 % of Europeans reported trying e-cigarettes. Portugal reported the lowest prevalence (6 %) while France reported the highest prevalence (21 %) (European Commission 2015).

Table 2 summarizes the correlations between the country-level potential correlates and the prevalence of current and ever e-cigarette use across the 28 European Union countries.

The only variable that was statistically significantly correlated with the prevalence of current e-cigarette use was the best practice ranking the offer of help to quit tobacco smoke. None of the other potential correlates investigated were statistically significantly correlated with the prevalence of current or ever e-cigarette use at $p < 0.05$.

Multivariately, several policy variables were statistically significantly associated with the prevalence of current and ever e-cigarette use (Table 3).

Specifically, in the third model which included both non-policy and policy variables, the prevalence of current e-cigarette use was associated with the best practice rankings of the offer of help to quit tobacco consumption ($\beta = 0.68$; $P < 0.01$) and the raise of taxes on tobacco ($\beta = 0.39$; $P = 0.01$). The best practice ranking of the warn on dangers of tobacco (health warnings on tobacco products) was negatively associated with the prevalence of current e-cigarette use ($\beta = -0.38$; $P = 0.04$). GDP per person ($\beta = 0.48$; $P = 0.01$) and current use of conventional cigarettes ($\beta = 0.35$; $P = 0.04$) were both associated with the prevalence of current e-cigarette use.

Table 2 Correlation between potential correlates of the prevalence of ever and current e-cigarette use among European Union countries in 2014

	Current e-cigarette use		Ever e-cigarette use	
	Spearman correlation	P	Spearman correlation	P
Prevalence of conventional cigarette smokers	0.12	0.56	0.01	0.99
Prevalence of conventional cigarette ex-smokers	0.12	0.53	0.25	0.19
Gross Domestic Product (GDP) per person	0.35	0.07	0.16	0.43
Unemployment rate	0.16	0.43	−0.06	0.75
18 year-olds enrolled in education	−0.07	0.72	−0.08	0.68
Female life expectancy in good health	0.09	0.65	0.25	0.20
Male life expectancy in good health	0.15	0.45	0.20	0.31
Unmet medical needs	−0.12	0.56	0.02	0.92
Monitoring smokers indicators	−0.01	0.94	0.01	1.00
Protect from tobacco smoke	0.01	0.95	0.03	0.90
Offer help to quit tobacco use	0.42	**0.03**	0.35	0.06
Warn about the dangers of tobacco	0.05	0.80	0.18	0.37
Mass media campaigns against tobacco	−0.01	0.95	0.24	0.22
Enforce bans on tobacco advertising	−0.05	0.80	−0.07	0.72
Raise taxes on tobacco products	0.25	0.19	0.34	0.08

Table 3 Beta coefficients from multivariate analyses of the determinants of the prevalence of current and ever e-cigarette use among European Union countries in 2014

	Current e-cigarette use			Ever e-cigarette use		
	Beta	P	Adjusted R^2	Beta	P	Adjusted R^2
Model 1: socio-economic factors						
Conventional cigarette smokers	0.37	0.09	0.19	[a]	[a]	0.01
Gross Domestic Product (GDP) per person	0.57	0.01		[a]	[a]	
Model 2: policies						
Offer help to quit tobacco use	0.79	<0.01	0.40	0.37	0.03	0.30
Warn on dangers of tobacco	−0.38	0.07		[a]	[a]	
Anti-tobacco mass media campaigns	[a]	[a]		0.36	0.04	
Raise taxes on tobacco	0.31	0.06		0.36	0.04	
Model 3: socio-economic factors + policies						
Conventional cigarette smokers	0.35	0.04	0.53	N.I.		0.38
Conventional cigarette ex-smokers	N.I.			0.33	0.07	
Gross Domestic Product (GDP) per person	0.48	0.01		[a]		
Offer help to quit tobacco smoke	0.68	<0.01		0.34	0.04	
Warnings on dangers of tobacco	−0.38	0.04		N.I.		
Anti-tobacco mass media campaigns	N.I.			0.38	0.03	
Raise taxes on tobacco	0.39	0.01		0.46	0.01	

N.I. not included

[a] Not present at the last step of backward elimination process

The prevalence of ever e-cigarette use was associated with the best practice rankings of the offer of help to quit tobacco consumption [(i.e., cost coverage of nicotine replacement therapy cost covered, availability of a national help-line) ($\beta = 0.34$; $P = 0.04$)], anti-tobacco mass media campaigns ($\beta = 0.38$; $P = 0.03$), and with the raise of taxes on tobacco ($\beta = 0.46$; $P = 0.01$). None of the other variables investigated were significantly associated with the prevalence of ever e-cigarette use.

Discussion

The debate on e-cigarettes has escalated in the past few years. In a recent commentary, Martin McKee highlighted three critical gaps in our knowledge about e-cigarettes: are they safe, do they work as a quit aid, and are young people who would not otherwise smoke take up e-cigarettes or conventional cigarettes (McKee 2014). Evidence informing these issues would help researchers and decision-makers clarify the potential of e-cigarettes as a quit aid and whether they should be subject to the same regulations as conventional cigarettes (McKee et al. 2014).

The current investigation is the first European study to provide evidence on country-level correlates of e-cigarette use. Among non-policy variables, the findings suggest that e-cigarette use does not relate to country-level indicators of educational attainment or health, but is associated with the prevalence of current conventional cigarette smoking and with GDP per person. These results are consistent with previous reports showing that former smokers and smokers who tried to quit in the last year are more likely to have used e-cigarettes (Vardavas et al. 2014). Our results, however, contrast with those suggesting that people with higher education attainment are more likely to try e-cigarette (Ramo et al. 2015). Moreover, the international literature suggests that socioeconomic status might be associated with e-cigarette use (Brown et al. 2014).

Importantly, policies controlling conventional tobacco products were associated with both current and ever e-cigarette use. Current e-cigarette use was positively associated with the best practice ranking of national quit smoking services (i.e., cost coverage of nicotine replacement therapy, availability of a national quit line), and the percentage of taxes in the retail price of tobacco products. Higher use of e-cigarettes in countries with higher taxes, and thus higher prices of tobacco products, supports the premise that economic factors play a role in whether people choose to smoke and which products they choose to use (Bader et al. 2011). On the other hand, increased e-cigarette use in countries with higher best practice rankings for national quit smoking services policy, suggests that smokers may try e-cigarette to stop smoking.

The effectiveness of e-cigarettes in helping smokers quit is highly debated at the international level. Several investigations support their usefulness (Pokhrel et al. 2015; Kaplan 2015a, b; Ben Taleb et al. 2015), while others focus on the lack of evidence on safety and effectiveness in supporting quitting (Levitz 2015a, b). At least one observational study suggests that e-cigarettes support smokers in their quit attempts, (Manzoli et al. 2015) while the randomized controlled trials to date report that "E-cigarettes, with or without nicotine, were modestly effective at helping smokers to quit" (Bullen et al. 2013). Our data suggest that people living in countries with policies that combat tobacco consumption are more likely to smoke or to have ever tried e-cigarettes. We can thus hypothesize that smokers who are more sensitized to tobacco risks across Europe try, or have at least tried in the past, e-cigarettes, which are probably viewed as a helpful way to quit regardless of safety or effectiveness (Vardavas et al. 2014).

Our findings suggest that anti-tobacco mass media campaigns are associated with ever, but not current e-cigarette use. A Cochrane Systematic Review claimed that mass media interventions are useful tools in tobacco control (Bala et al. 2013). Again this evidence suggests that smokers who are aware of tobacco risks may try e-cigarettes to quit smoking.

The only policy that was negatively associated with current e-cigarette use was the warn on dangers of tobacco (health warnings on tobacco products). There is substantial evidence on the effectiveness of pictorial warnings (Fong et al. 2013; Hammond et al. 2013; Mannocci et al. 2013), but relatively little is known about whether such warnings influence e-cigarette use.

Limitations of this study include the ecological design which is subject to the ecologic fallacy, that few covariates at national level were investigated and that the goodness of fit of some models was low (although it was higher in the combined model for both current and ever e-cigarette use).

Conclusion

Our analysis suggests that both policy and non-policy factors are associated with geographical variability in the prevalence of e-cigarette use. Specifically, among non-policy factors, economic factors and the prevalence of conventional cigarette use are directly associated with e-cigarette use. Among tobacco control policies, three were associated with current and ever e-cigarette use including national quit smoking services, mass media campaigns and taxes on the retail price of tobacco products. The presence of health warnings on tobacco products (i.e., pictorial and percentage of packaging covered) was inversely associated with current e-cigarette use. The debate on e-cigarettes is ongoing and there is no consensus on whether they help smokers quit or on the danger to public health (McKee and Capewell 2015). However, the data presented herein suggest that policy makers should be aware that country-level factors may influence e-cigarette use.

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