Electronic cigarette use among 14- to 17-year-olds in Europe

Jaana M. Kinnunen [1], Arja H. Rimpelä[1,2,3], Pirjo L. Lindfors [1,3], Luke Clancy[4], Joana Alves[5,6], Laura Hoffmann[7], Matthias Richter[7], Anton E. Kunst[8], Vincent Lorant[9]

1 Faculty of Social Sciences, Unit of Health Sciences, Tampere University, Tampere, Finland
2 Department of Adolescent Psychiatry, Pitkäniemi Hospital, Nokia, Tampere University Hospital, Finland
3 PERLA - Tampere Centre for Childhood, Youth and Family Research, Tampere University, Tampere, Finland
4 TobaccoFree Research Institute Ireland, Dublin, Ireland
5 NOVA National School of Public Health, Public Health Research Centre, Universidade NOVA de Lisboa, Lisbon, Portugal
6 Comprehensive Health Research Center (CHRC), Lisbon, Portugal
7 Institute of Medical Sociology, Medical Faculty, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany
8 Department of Public and Occupational Health, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands
9 Institute of Health and Society, Université catholique de Louvain, Brussels, Belgium

Correspondence: Jaana M. Kinnunen, Faculty of Social Sciences, Unit of Health Sciences, P.O. Box 100, FI-33014, Tampere University, Tampere, Finland, Tel: +358 (0) 40 190 1667, e-mail: jaana.kinnunen@tuni.fi

Background: Studies comparing adolescent e-cigarette use in different countries are scarce. We study students' e-cigarette and conventional cigarette ever-use, their social correlates and e-liquid use in seven EU countries. **Methods:** SILNE-R data (*N*=12 167, response rate 79.4%) of 14–17-year-olds from Amersfoort (NL), Coimbra (PT), Dublin (IR), Hanover (GE), Latina (IT), Namur (BE) and Tampere (FI) were used. E-cigarette and conventional cigarette ever-use, dual-use, type of e-liquid and social correlates were measured with a school survey and analyzed with cross-tabulations and multinomial logistic regression. **Results:** About 34% had tried e-cigarettes, but the variation was large between the cities (Latina 50%; Hanover 23%). Of e-cigarette ever-users, 37% had used nicotine e-liquid, 43% exclusively non-nicotine liquid and 20% did not know the content. Nicotine e-liquid was more prevalent among monthly e-cigarette users and weekly smoking e-cigarette users. The social correlates were mainly the same for exclusive e-cigarette ever-use, exclusive conventional cigarette ever-use and dual-use. Boys had greater odds for exclusive e-cigarette and dual-use compared to girls. Of social correlates, low academic achievement and parental smoking were positively associated with all categories of use, but parental education and immigrant background were not. The strongest association was found between peer smoking (most/all best friends smoke) and dual-use (OR 34.29). **Conclusions:** Students' e-cigarette ever-use varies greatly between EU countries. E-cigarettes seem not to be a substitute for conventional cigarettes but more a complementary product. Tobacco control policies might also prevent e-cigarette use but specific regulations on e-cigarettes are needed to prevent nicotine addiction originating from them.

Introduction

Electronic cigarette (e-cigarette) use has been increasing worldwide among adolescents,[1] but with differences between countries. According to a review with studies from 2013 to 2014, e-cigarette ever-use varied from 4.7% in Germany to 38.5% in Romania,[2] but reliable comparisons of adolescent e-cigarette use between the countries could not be made as the measurements and reporting of e-cigarette use varied considerably between the studies.[3,4] However, in a couple of studies which used comparable survey instruments, large country differences were observed.[5,6] The scarcity of reliable cross-national comparisons is a barrier for assessing effects of e-cigarette and health promotion policies. In this article, we use the same measurement instrument and comparable samples to study adolescent e-cigarette ever-use between seven European Union (EU) countries.

E-cigarettes have been suggested to be a gateway to smoking.[7,8] The liquids used in e-cigarettes to be vaporized (e-liquids) may or may not contain nicotine,[9] which is of importance if the gateway effect is considered. In most e-cigarette studies, the nicotine content of e-liquids has not explicitly been asked.[3] A few studies on adolescents show country differences in the use of e-cigarettes containing nicotine. For example, in Finland, majority of adolescent e-cigarette users reported nicotine e-liquids[10] but in Switzerland, non-nicotine e-liquids were more common.[11] In this article, the content of the e-liquid is studied.

In previous studies, social correlates of adolescent e-cigarette use have resembled those of conventional smoking,[12,13] e.g. male gender,[11,14,15] lower academic achievement,[13,16] peer[14,17] and parental[16,18] smoking and use of other substances.[11,13,14] This is not a surprising finding as most adolescent e-cigarette users also smoke.[1,15,19] However, also never-smokers experiment with e-cigarettes,[1,15] even with nicotine liquids,[8,10,16] and they may differ from those who also smoke, i.e. dual-users. Wills et al.[20,21] showed that exclusive e-cigarette users may be placed between non-users and dual-users when concerning their risk status based on risk and protective factors. Additionally, even though the correlates of only e-cigarette and dual-use have been mainly the same, the effect sizes have been different.[12,20–22] In this study, we compare social correlates of exclusive e-cigarette use, exclusive conventional cigarette use and dual-use. Concerning the gateway from e-cigarettes to conventional cigarettes,[7,8] we also explore whether the social correlates differ between those dual-users who first experimented with e-cigarettes and those who first experimented with conventional cigarettes.

This study aims at offering an overview of e-cigarette use among 14–17-year-old students in seven EU countries each represented by one city. With the same survey instruments, data collection methods and comparable study populations, we address the following questions: how common is e-cigarette ever-use and use of nicotine e-liquid, and whether the use varies between the cities and between smokers and non-smokers? Which are the social correlates of e-cigarette use, and are they the same for exclusive e-cigarette ever-use, exclusive conventional cigarette ever-use and dual-use?

Methods

Participants and study procedure

We use school survey data from the SILNE-R study (Enhancing the effectiveness of programmes and strategies to prevent youth smoking: a comparative realist evaluation of seven European cities) collected in Namur (Belgium), Tampere (Finland), Hanover (Germany), Dublin (Ireland), Latina (Italy), Amersfoort (the Netherlands) and Coimbra (Portugal). The survey was conducted in the same way as the previous SILNE-survey, and in the same cities. The aim was to select cities with population size, income and employment rate close to the national average ones.[23] Two school grades were selected in each city to cover 14–16-year-old students in schools. All students in these grades were invited to participate (N=16 356) leading to an age range of 12–19 years. For this study, the students aged 13 or younger and 18 or older (n=806) along with the students with missing information on age (n=18) were excluded to keep the age variation more compact. The survey was conducted with paper-and-pencil method during regular school hours during academic school year of 2016–17. Instantly, after completion, the questionnaires were sealed in envelopes and the answers were subsequently entered into a web platform by the responsible organization of each country. The students' overall response rate was 79.4%. The response rate on student level varied from 65.8% in Germany to 87.1% in Finland. The study protocol was approved by the appropriate ethical committee in each survey country.

Measures

E-cigarette ever-use was assessed with a question 'Which one of the following statements concerning electronic cigarettes best describes you?' The options were: 'I have never tried an e-cigarette', 'I have tried an e-cigarette once or twice', 'I have tried e-cigarettes more than twice', 'I use e-cigarettes at least once a month', 'I use e-cigarettes at least once a week', 'I use e-cigarettes every day' and 'I don't know what e-cigarettes are'. Those, who reported trying e-cigarettes, were further asked: 'If you have tried/used e-cigarettes, what substance did they contain?' with the options 'Liquid with nicotine', 'Liquid without nicotine', 'I don't know' and 'I have never tried e-cigarettes'. The respondent could tick one or more option. As 11% of the e-cigarette ever-users had used both nicotine and non-nicotine e-liquids, we classified e-liquid use according to nicotine content: used nicotine e-liquids (=those reporting nicotine or both e-liquids), used exclusively non-nicotine (=those reporting only non-nicotine e-liquids) and does not know. Here, e-cigarette ever-use refers to those adolescents who had at least tried once or twice, and monthly e-cigarette use to those reporting at least monthly use.

Smoking status was based on two questions: 'Have you ever tried cigarette smoking, even just a few puffs?' with options 'No' and 'Yes', and 'How many cigarettes have you smoked during the last 30 days?' with options 'I have never smoked', 'None', '1–2 cigarettes during the last 30 days', '1–2 cigarettes per week', '3–7 cigarettes per week', '1–5 cigarettes per day', '6–10 cigarettes per day (about half a pack)', '11–20 cigarettes per day (about one pack)', '21–30 cigarettes per day' and 'More than 30 cigarettes per day'. Those who answered the first question as 'Yes' were classified as 'Ever-used conventional cigarettes', 'Weekly smokers' were those who reported smoking at least 1–2 conventional cigarettes per week.

A combined variable 'Ever-use of conventional cigarettes and e-cigarettes' was computed combining information from the questions on e-cigarettes and smoking, and a third question: 'When you tried e-cigarettes for the first time, what was your relationship with smoking?' The variable includes five categories: 'Tried neither of the products', 'Tried only conventional cigarettes', 'Tried only e-cigarettes', 'Tried both but e-cigarettes before conventional cigarettes' and 'Tried both but conventional cigarettes before e-cigarettes'. The last two categories together constituted category 'Tried both, i.e. dual-use'.

Academic achievement was assessed by asking 'Which of the following best describes your school marks during the past year?' The measurement instrument was adjusted for each country, but it separated students into three categories: 'High', 'Average' and 'Low'. Parents' educational level was asked for father and mother separately. The question was adapted for each country. For the analyses, the answers were combined as the highest educational level of either father or mother, and a common four categories was used: 'High', 'Average', 'Low' and 'Do not know/other'. The student was defined as having immigrant background if at least one of the parents was born in another country.

Parents' smoking was asked for mother and father separately but combined with categories of 'Neither of them smoke' and 'At least one of them smokes'. Peer smoking was asked with a question 'Do any of your best and closest friends smoke cigarettes?' and the options were: 'None of them', 'Some of them', 'Most of them' and 'All of them'. Categories 'Most of them' and 'All of them' were combined due to small frequencies.

Data analysis

Descriptive statistics were first computed for all data and by city. Use of e-liquids was calculated for those who had tried or used e-cigarettes. The associations between social correlates and exclusive e-cigarette, and exclusive conventional cigarette ever-use, and their dual-use were calculated first with cross-tabulations and then with multivariate multinomial logistic regression with all the variables in the same model to explore which of the variables were associated with the outcome. The multinomial logistic regression was conducted with generalized linear mixed models, which takes the school clustering into account. City was also one variable in the model with Hanover as the reference category, as the proportion of 'tried neither of the products' was the largest there. Pearson's X^2 test was used to test for statistical significance. IBM SPSS Statistics, V.25 was used for all data analyses.

Results

Prevalence of e-cigarette ever-use

The descriptive statistics of the study population (N=12 167) including the distribution of e-cigarette use are presented in table 1. About 34% of the students had tried e-cigarettes and 37% conventional cigarettes, and most of the students who had tried e-cigarettes or conventional cigarettes had tried both products (figure 1). The proportions of students who had tried e-cigarettes varied between the cities: the highest prevalence was in Latina (IT) (50%) and in Namur (BE) (48%). The lowest prevalence was in Hanover (GE), 23%. The proportions of conventional cigarette ever-use mainly followed the proportions of e-cigarette ever-use (figure 1). Weekly smoking was more common (11%) than weekly use of e-cigarettes (4%) (table 1). Approximately half of the students had tried neither conventional nor e-cigarettes with large differences between the cities: lowest in Latina (IT), 39%, and highest in Hanover (GE), 67% (Supplementary figure S1).

Table 1. Descriptive statistics of the study population, all and by city

|	All	Amersfoort (NL)	Coimbra (PT)	Dublin (IR)	Hanover (GE)	Latina (IT)	Namur (BE)	Tampere (FI)
Response rate, %	79.4	84.9	76.2	80.3	65.8	78.9	84.1	87.1
Participants, N	12 167	1828	1731	1990	1169	1936	1796	1717
Gender, %								
Girls	50.2	47.1	50.2	50.9	49.1	55.2	49.8	48.2
Boys	49.8	52.9	49.8	49.1	50.9	44.8	50.2	51.8
Mean age, years	15.04	15.01	15.66	15.15	14.53	14.80	15.28	14.68
Age, %								
14–15 years	72.6	74.4	44.6	67.5	91.2	85.3	59.7	91.4
16–17 years	27.4	25.6	55.4	32.5	8.8	14.7	40.3	8.6
E-cigarette use, %								
Do not know what they are	1.3	3.9	0.5	1.5	1.7	0.4	0.2	0.7
Never tried	64.5	67.4	75.3	68.8	75.4	49.8	51.7	68.3
Tried once/twice	14.9	11.6	11.9	14.7	11.9	16.9	21.1	15.0
Tried over twice	12.7	12.9	10.0	10.7	7.3	17.7	16.6	11.6
Monthly use	2.7	3.1	1.6	1.9	1.8	4.6	3.3	2.0
Weekly use	2.4	0.8	0.3	1.6	1.1	6.7	4.0	1.8
Daily use	1.5	0.4	0.3	0.8	0.7	4.0	3.0	0.7
Smoking, %								
Never tried	63.3	68.1	61.7	72.8	73.7	47.0	51.7	72.0
Tried but do not smoke	19.5	16.7	22.8	16.4	16.9	21.9	23.6	17.6
Occasionally	5.8	5.6	4.1	5.4	3.5	10.2	6.5	4.3
Weekly	4.3	3.9	4.3	2.5	2.3	7.6	6.0	2.5
Daily	7.1	5.6	7.1	2.8	3.6	13.3	12.2	3.7
Academic achievement, %								
High	40.8	30.0	34.4	44.2	37.4	65.8	31.8	37.9
Average	39.3	53.8	42.9	38.8	48.9	29.7	30.9	33.6
Low	20.0	16.1	22.7	17.0	13.7	4.5	37.4	28.5
Highest education of either parent, %								
High	48.5	54.8	45.9	68.9	50.7	33.0	48.1	36.9
Average	30.6	19.0	28.8	19.8	27.6	49.4	33.3	35.3
Low	9.7	10.4	21.7	5.5	5.0	15.0	7.1	2.0
Unknown	11.2	15.8	3.6	5.8	16.8	2.5	11.5	25.8
Immigrant background, %								
No	74.2	78.7	78.5	63.0	55.1	84.3	69.5	85.0
Yes	25.8	21.3	21.5	37.0	44.9	15.7	30.5	15.0
Parental smoking, %								
Neither of them smoke	66.5	74.6	63.3	74.8	59.6	58.6	60.0	72.0
At least one smokes	33.5	25.4	36.7	25.2	40.4	41.4	40.0	28.0
Peer smoking, %								
None of them smokes	41.6	47.9	34.1	54.0	64.1	16.7	26.3	57.1
Some of them smoke	42.4	41.8	51.4	38.0	30.6	44.7	48.3	38.0
Most or all of them smoke	16.0	10.3	14.5	8.0	5.4	38.5	25.4	4.9
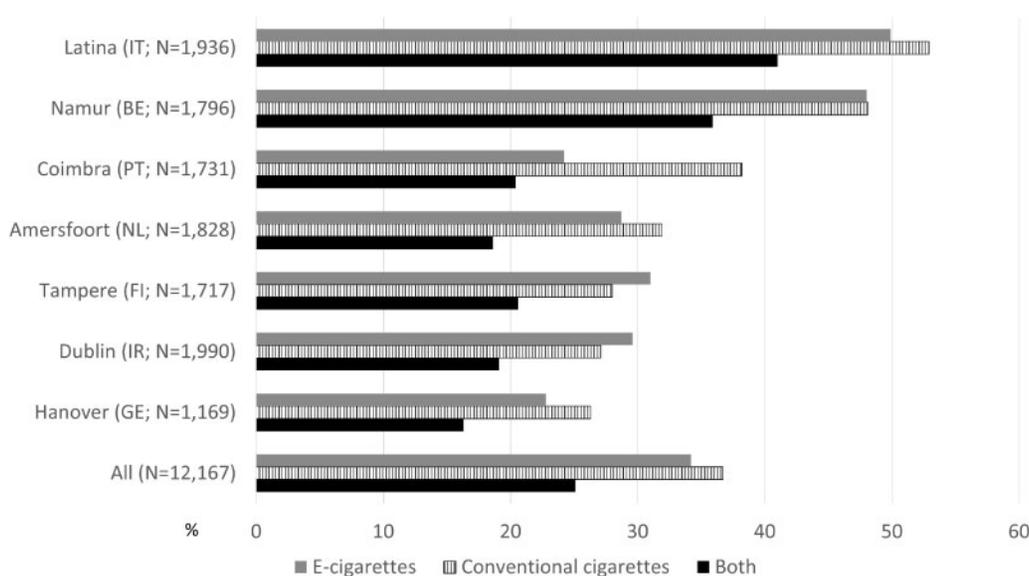
Figure 1 Ever-use of e-cigarettes, conventional cigarettes and both by city

Table 2. Distributions of e-liquid types among all e-cigarette ever-users, among monthly e-cigarette users, and among weekly smoking e-cigarette ever-users

Type of e-liquid	All, %	Amersfoort (NL), %	Coimbra (PT), %	Dublin (IR), %	Hanover (GE), %	Latina (IT), %	Namur (BE), %	Tampere (FI), %
All e-cigarette ever-users	N=4113	N=521	N=416	N=582	N=263	N=957	N=852	N=522
Nicotine[a]	37.2	25.9	36.1	36.0	34.2	35.6	38.6	52.8
Non-nicotine only	43.3	43.7	43.7	32.6	48.1	54.5	40.9	34.8
Do not know	19.6	30.4	20.2	31.4	17.7	9.9	20.5	12.4
P[b]	<0.001							
Monthly e-cigarette users	N=793	N=77	N=39	N=83	N=42	N=294	N=183	N=75
Nicotine[a]	53.8	50.6	50.0	65.4	45.2	41.8	59.1	85.1
Non-nicotine only	39.5	33.8	50.0	19.8	47.6	54.8	32.0	14.9
Do not know	6.8	15.6	0.0	14.8	7.1	3.4	8.8	0.0
P[c]	<0.001	<0.001	0.005	<0.001	0.085	<0.001	<0.001	<0.001
Weekly smoking e-cigarette ever-users	N=1163	N=131	N=149	N=93	N=54	N=364	N=285	N=87
Nicotine[a]	60.4	53.4	51.0	67.0	61.1	55.5	64.9	84.5
Non-nicotine only	27.7	25.2	35.2	9.9	25.9	36.0	24.5	14.0
Do not know	12.0	21.4	13.8	23.1	13.0	8.5	10.6	1.2
P[d]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

a: Includes also use of both nicotine and non-nicotine.
b: Statistical significance of the difference in e-liquid use between cities.
c: Statistical significance of the difference in e-liquid use between monthly users and non-monthly users.
d: Statistical significance of the difference in e-liquid use between weekly and non-weekly smokers.

The content of the e-liquid

Non-nicotine e-liquids (43%) were slightly more commonly used than nicotine e-liquids (37%) among all e-cigarette users but there were differences ($P < 0.001$) between cities (table 2). In Amersfoort (NL), Coimbra (PT), Hanover (GE) and Latina (IT), non-nicotine e-liquids were used more often, in Namur (BE) and Dublin (IR), both liquids were used equally and in Tampere (FI), nicotine e-liquids were reported more often. When e-cigarette use was more regular or was related to smoking, the proportion of nicotine e-liquid was higher; among monthly users, 54% and among weekly smokers, 60% reported nicotine e-liquid use. About 20% of the students did not know whether the e-liquid had contained nicotine or not (table 2).

Supplementary table S1 shows that nicotine e-liquid use was more common among dual-users who had first tried conventional cigarettes (49%) than among dual-users who had first tried e-cigarettes (29%), while among those who had tried exclusively e-cigarettes, only 16% reported nicotine e-liquid use ($P < 0.001$).

Correlates of e-cigarette and conventional cigarette ever-use, and dual-use

Table 3 presents the associations between the correlates and ever-use of e-cigarette, conventional cigarette and their dual-use with the 'tried neither of the products' group as the reference category. Boys had greater odds for exclusive e-cigarette and dual-use, and girls for exclusive conventional cigarette ever-use. Older adolescents were less susceptible to exclusive e-cigarette use but more susceptible to conventional cigarette ever-use and to dual-use when compared to younger ones. Parental smoking was positively associated with use of all products, but more strongly with dual-use. The strongest association was found between peer smoking (most or all of best friends smoke) and dual-use [odds ratios (OR) 34.29, 95% confidence intervals (95% CI) 28.39–41.40]. Average and low academic achievement were positively associated with all categories of use, but parental education and immigrant background were not (table 3).

Supplementary table S2 shows the distributions of different categories of use within correlates. There were differences between groups; e.g. among tried neither group, the proportion of most or all of friends smoking was 4.6%, while the corresponding proportion among dual-users was 39.7%, among exclusive e-cigarette users 12.8%, and among exclusive conventional cigarette users it was 20.1% (Supplementary table S2).

Supplementary table S3 presents the cross-tabulations and Supplementary table S4 presents the associations between the correlates and ever-use of e-cigarette, conventional cigarette and their dual-use separated by the first product tried. Of all study population, tried neither group constituted 54.7% but of high academic achievers 63.6%, while the corresponding proportions for exclusive e-cigarette users were 8.8% and 7.6%, and for exclusive conventional cigarette users they were 11.4% and 9.3% (Supplementary table S3). The associations between the correlates and both categories of dual-use were similar but slightly stronger for dual-use with conventional cigarettes as the first product, e.g. the OR of low academic achievement was 2.04 for dual-users with e-cigarettes first, and 2.89 for dual-users with conventional cigarettes first (Supplementary table S4).

Discussion

Prevalence of e-cigarette use

This is the first study on students' e-cigarette ever-use in different European countries with the same survey. Approximately one-third of students had tried e-cigarettes, and one-third conventional cigarettes, but regular use of e-cigarettes was less common than regular use of conventional cigarettes (4% vs. 11% weekly). The city variation in e-cigarette ever-use was large, the highest prevalence in Latina (IT) and in Namur (BE), and the lowest in Hanover (GE). Majority of e-cigarette ever-users had also tried conventional cigarettes, which shows how

Table 3. Adjusted OR and 95% CI from multinomial logistic regression[a] for exclusive e-cigarette use, exclusive conventional cigarette use and dual-use by correlates (reference category: tried neither, *n*=6521)

	Only e-cigarette use	Only tobacco us	Dual-use
Intercept	0.024 (0.016–0.034)	0.060 (0.044–0.081)	0.032 (0.024–0.043)
City			
Hanover (GE)	1.00	1.00	1.00
Amersfoort (NL)	1.67 (1.07–2.60)	1.32 (0.91–1.91)	1.06 (0.75–1.51)
Coimbra (PT)	0.66 (0.40–1.07)	1.05 (0.72–1.52)	0.70 (0.49–0.99)
Dublin (IR)	1.92 (1.27–2.91)	0.67 (0.47–0.97)	1.04 (0.74–1.46)
Latina (IT)	1.71 (1.09–2.68)	1.16 (0.79–1.69)	1.94 (1.38–2.74)
Namur (BE)	2.08 (1.35–3.20)	0.92 (0.64–1.33)	1.42 (1.01–2.00)
Tampere (FI)	1.70 (1.12–2.56)	0.78 (0.54–1.13)	1.49 (1.07–2.07)
Gender			
Girl	1.00	1.00	1.00
Boy	2.79 (2.40–3.26)	0.73 (0.64–0.83)	1.51 (1.35–1.68)
Age			
14–15 years	1.00	1.00	1.00
16–17 years	0.77 (0.64–0.93)	1.54 (1.33–1.79)	1.38 (1.21–1.57)
Academic achievement			
High	1.00	1.00	1.00
Average	1.36 (1.16–1.61)	1.49 (1.28–1.73)	1.61 (1.41–1.83)
Low	1.79 (1.46–2.19)	2.16 (1.80–2.60)	2.69 (2.31–3.14)
Highest education of either parent			
High	1.00	1.00	1.00
Average	1.36 (1.15–1.61)	1.05 (0.90–1.22)	1.12 (0.99–1.27)
Low	0.84 (0.63–1.13)	1.05 (0.84–1.30)	1.05 (0.87–1.27)
Unknown/other	0.91 (0.72–1.16)	0.79 (0.62–0.99)	0.68 (0.56–0.82)
Immigrant background			
No	1.00	1.00	1.00
Yes	1.18 (0.99–1.38)	1.02 (0.87–1.18)	1.00 (0.88–1.14)
Parental smoking			
Neither of them smoke	1.00	1.00	1.00
At least one of them smokes	1.28 (1.10–1.50)	1.54 (1.35–1.76)	1.74 (1.55–1.94)
Peer smoking			
None of them smokes	1.00	1.00	1.00
Some of them smoke	2.33 (1.99–2.71)	3.44 (2.96–4.00)	6.53 (5.68–7.50)
Most or all of them smoke	4.62 (3.56–5.98)	8.37 (6.72–10.44)	34.29 (28.39–41.40)

a: All the variables in the same model.

experimenting with these two products go hand in hand in adolescence.

The close connection of conventional and e-cigarette ever-use was not seen only on the individual level but also on the city level. When the use of conventional cigarettes was high in the city, so was the use of e-cigarettes. Similar result was shown in a study of La Torre and Mipatrini[24] on country-level correlates of adult e-cigarette use in EU countries: the prevalence of current e-cigarette use correlated positively with the prevalence of current smoking. At the time of our data collection, the implementation of the new Tobacco Product Directive[25] had not reached the national levels and e-cigarettes were available quite freely. This means that the policy environment concerning e-cigarettes in the studied EU countries was approximately similar while anti-smoking activities measured by the Tobacco Control Scale[26] varied a lot. The correlation of e-cigarette and conventional cigarette use both on the individual and on city level suggests that e-cigarettes seem to be complementary to, and not a substitute for, conventional cigarettes.

Reliable previous country comparisons on adolescent e-cigarette use are lacking but in a review of Greenhill et al.,[2] similar differences were noticed as in our study: e-cigarette ever-use was lower in Germany compared to Finland and Ireland. Large country differences have also been observed in two non-European studies but in very different policy environments.[5,6] In our study, the lowest prevalence of smoking and e-cigarette use in Germany is interesting as Germany had nearly the lowest score (37/100) in the Tobacco Control Scale[26] in Europe. This shows that the country-level correlates of adolescent e-cigarette use, which go beyond relevant policies, should be identified in future studies.

The content of the e-liquid

Non-nicotine e-liquid was used more often than nicotine e-liquid among all e-cigarette users in all cities except Tampere (FI) and Dublin (IR). A comparison with previous studies can be made only from Finland where a national study in 2015 showed a corresponding figure of nicotine e-liquid use as in our study.[16]

In our study, the proportion of nicotine e-liquid was higher among adolescents who used e-cigarettes more regularly than among e-cigarette experimenters. Correspondingly among smoking e-cigarette users, nicotine e-liquid was used more than among non-smokers. This finding coincides with previous findings from the USA, where adolescent smokers and heavier e-cigarette users consumed nicotine e-liquids more often.[27,28] These findings also support the view of e-cigarettes as a complementary product and as a complementary source of nicotine to, and not a substitute for, conventional cigarettes. In our study, those e-cigarette ever-users who later had also tried smoking, had used nicotine e-liquid more often than exclusive e-cigarette users. This hints that nicotine may play a role in the transition from never-smoking to smoking after e-cigarette experimentation. One previous follow-up study[8] has confirmed nicotine's role in this transition, and as nicotine is a highly addictive drug,[29] this is also very plausible.

Correlates of ever-use of e-cigarette and conventional cigarette and dual-use

The correlates were mainly the same for exclusive e-cigarette ever-use, exclusive conventional cigarette ever-use and dual-use with some differences, and the magnitudes of OR varied. Comparison with other studies concerning the correlates is challenging as they

have previously been studied mainly for e-cigarette use, and the group may have included dual-users. However, our results coincide those of Wills et al.[20] where the correlates of exclusive e-cigarette and exclusive conventional cigarette ever-use were mainly the same as of dual-use. Our results also confirm the previous results that male gender and older age,[12,22] and parental and peer smoking[12] are risk factors for e-cigarette use and especially for dual-use.

Younger students had greater odds for having tried exclusively e-cigarettes. This result is logical, as smoking experimentations and regular smoking become more frequent during adolescence.[30] Friends and peers, and their behaviour, are a major factor in adolescent e-cigarette use[16,31] as supported also by our results. As e-cigarettes may increase smoking also among those adolescents who are not originally susceptible to conventional cigarettes,[32] it is important to concentrate also on preventing e-cigarette use. The same strategies that are used for smoking prevention might work also for e-cigarettes as the correlates are mainly the same.

Strengths and limitations

A major strength of our study is that in each city, we used the same school survey design and the same instruments in the same age groups, and that the survey was conducted during the same academic year. However, we cannot exclude the possibility that there have been some minor differences in the data collection, in the selection of respondents or in the instruments between cities. Although the selected cities were average ones in terms of population size, income and employment rate,[23] we cannot exclude the possibility that the survey cities' prevalence do not represent the prevalence of the whole country.

The overall response rate was high, but it varied between the cities. In Hanover (GE) and Latina (IT), active parental consents were required, which may have resulted in lower response rates. We also used self-reported data, which may have led to misreporting on e-cigarette and conventional cigarette ever-use. However, adolescents' self-reporting on smoking has been shown to be accurate and to correspond to biochemical measures.[33–35] Adolescents' reports on e-liquids may have been more inaccurate, and a considerable proportion of students did not know whether the e-cigarette contained nicotine or not.

Conclusions

Student e-cigarette ever-use in 2016–17 varied strongly between EU countries even though the policy environment of e-cigarettes was similar. Students' experimentations with e-cigarettes were as frequent as their experimentations with conventional cigarettes. Most e-cigarette ever-users had also tried smoking or were smokers. Use of nicotine containing e-liquid was more frequent among those students who used e-cigarettes more frequently. E-cigarettes seem to be complementary to conventional cigarettes meaning that they are primarily another nicotine product additional to conventional cigarettes, and not a replacement for them. Although tobacco control policies might also prevent e-cigarette use to some extent, specific regulations on e-cigarettes are needed to prevent nicotine addiction originating from e-cigarette use.

Supplementary data

Supplementary data are available at *EURPUB* online.

Acknowledgements

Funding

Key points

- Student e-cigarette ever-use varies largely between EU countries and follows the variation in conventional cigarette ever-use.
- Non-nicotine e-liquid use is somewhat more common than nicotine e-liquid use among all e-cigarette ever-users.
- Nicotine e-liquid use is more common than non-nicotine e-liquid use among monthly e-cigarette users and weekly smoking e-cigarette users.
- The social correlates are mainly the same for exclusive e-cigarette ever-use, exclusive conventional cigarette ever-use and dual-use.
- The same strategies that are used for smoking prevention might work also for e-cigarettes.

References

1   Glasser AM, Collins L, Pearson JL, et al. Overview of electronic nicotine delivery systems: a systematic review. *Am J Prev Med* 2017;52:e33–66.

2   Greenhill R, Dawkins L, Notley C, et al. Adolescent awareness and use of electronic cigarettes: a review of emerging trends and findings. *J Adolesc Health* 2016;59:612–19.

3   Echevarria C, Sinha IP. Heterogeneity in the measurement and reporting of outcomes in studies of electronic cigarette use in adolescents: a systematic analysis of observational studies. *Tob Control* 2017;26:247–53.

4   Pearson JL, Hitchman SC, Brose LS, et al. Recommended core items to assess e-cigarette use in population-based surveys. *Tob Control* 2018;27:341–6.

5   Hammond D, Reid JL, Rynard VL, et al. Prevalence of vaping and smoking among adolescents in Canada, England, and the United States: repeat national cross sectional surveys. *BMJ* 2019;365:l2219.

6   Cho HJ, Dutra LM, Glantz SA. Differences in adolescent e-cigarette and cigarette prevalence in two policy environments: South Korea and the United States. *Nicotine Tob Res* 2018;20:949–53.

7   Soneji S, Barrington-Trimis JL, Wills TA, et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: a systematic review and meta-analysis. *JAMA Pediatr* 2017;171:788–97.

8   Kinnunen JM, Ollila H, Minkkinen J, et al. Nicotine matters in predicting subsequent smoking after e-cigarette experimentation: a longitudinal study among Finnish adolescents. *Drug Alcohol Depend* 2019;201:182–7.

9   World Health Organization, WHO Framework Convention on Tobacco Control. *Electronic Nicotine Delivery Systems and Electronic Non-Nicotine Delivery Systems (ENDS/ENNDS)*. Geneva: World Health Organization, 2016.

10 Kinnunen JM, Ollila H, El-Amin SE-T, et al. Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study. *Tob Control* 2015;24:e264–70.

11 Surís JC, Berchtold A, Akre C. Reasons to use e-cigarettes and associations with other substances among adolescents in Switzerland. *Drug Alcohol Depend* 2015;153:140–4.

12 Hanewinkel R, Isensee B. Risk factors for e-cigarette, conventional cigarette, and dual use in German adolescents: a cohort study. *Prev Med* 2015;74:59–62.

13 Kinnunen JM, Ollila H, Minkkinen J, et al. A longitudinal study of predictors for adolescent electronic cigarette experimentation and comparison with conventional smoking. *IJERPH* 2018;15:305.

14 White J, Li J, Newcombe R, Walton D. Tripling use of electronic cigarettes among New Zealand adolescents between 2012 and 2014. *J Adolesc Health* 2015;56:522–8.

15 Babineau K, Taylor K, Clancy L. Electronic cigarette use among Irish youth: a cross sectional study of prevalence and associated factors. *PLoS One* 2015;10:e0126419.

16 Kinnunen JM, Ollila H, Lindfors PL, Rimpelä AH. Changes in electronic cigarette use from 2013 to 2015 and reasons for use among Finnish adolescents. *IJERPH* 2016;13:1114.

17 Barrington-Trimis JL, Berhane K, Unger JB, et al. Psychosocial factors associated with adolescent electronic cigarette and cigarette use. *Pediatrics* 2015;136:308–17.

18 Rennie LJ, Bazillier-Bruneau C, Rouëssé J. Harm reduction or harm introduction? Prevalence and correlates of e-cigarette use among French adolescents. *J Adolesc Health* 2016;58:440–5.

19 Wang M, Wang JW, Cao SS, et al. Cigarette smoking and electronic cigarettes use: a meta-analysis. *IJERPH* 2016;13:120.

20 Wills TA, Knight R, Williams RJ, et al. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics* 2015;135:e43–51.

21 Wills TA, Knight R, Sargent JD, et al. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii. *Tob Control* 2017;26:34–9.

22 Chen P-C, Chang L-C, Hsu C, Lee Y-C. Dual use of e-cigarettes and traditional cigarettes among adolescents in Taiwan, 2014–2016. *Nicotine Tob Res* 2019;21:48–54.

23 Lorant V, Soto VE, Alves J, et al. Smoking in school-aged adolescents: design of a social network survey in six European countries. *BMC Res Notes* 2015;8:91.

24 La Torre G, Mipatrini D. Country-level correlates of e-cigarette use in the European Union. *Int J Public Health* 2016;61:269–75.

25 European Union. Directive 2014/40/EU. L 127/1. Official Journal of the European Union 2014. Available at: https://ec.europa.eu/health//sites/health/files/tobacco/docs/dir_201440_en.pdf (16 June 2020, date last accessed).

26 Joossens L, Raw M. The Tobacco Control Scale 2016 in Europe. A report of the Association of European Cancer Leagues. Brussels: Association of European Cancer Leagues, 2017.

27 Morean ME, Kong G, Cavallo DA, et al. Nicotine concentration of e-cigarettes used by adolescents. *Drug Alcohol Depend* 2016;167:224–7.

28 Pepper JK, Farrelly MC, Watson KA. Adolescents' understanding and use of nicotine in e-cigarettes. *Addict Behav* 2018;82:109–13.

29 Benowitz NL. Nicotine addiction. *N Engl J Med* 2010;362:2295–303.

30 Dierker L, Swendsen J, Rose J, et al.; The Tobacco Etiology Research Network (TERN). Transitions to regular smoking and nicotine dependence in the Adolescent National Comorbidity Survey (NCS-A). *Ann Behav Med* 2012;43:394–401.

31 Hammal F, Finegan BA. Exploring attitudes of children 12–17 years of age toward electronic cigarettes. *J Community Health* 2016;41:962–8.

32 Wills TA, Sargent JD, Gibbons FX, et al. E-cigarette use is differentially related to smoking onset among lower risk adolescents. *Tob Control* 2017;26:534–9.

33 Dolcini MM, Adler NE, Lee P, Bauman KE. An assessment of the validity of adolescent self-reported smoking using three biological indicators. *Nicotine Tob Res* 2003;5:473–83.

34 Kentala J, Utriainen P, Pahkala K, Mattila K. Verification of adolescent self-reported smoking. *Addict Behav* 2004;29:405–11.

35 Post A, Gilljam H, Rosendahl I, et al. Validity of self reports in a cohort of Swedish adolescent smokers and smokeless tobacco (snus) users. *Tob Control* 2005;14:114–7.