


# Electronic cigarette use among adolescents in 17 European study sites: findings from the Global Youth Tobacco Survey

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**Background:** As new findings on public health implications of electronic cigarette (e-cigarette) use emerge, its surveillance remains of utmost importance. This study examined the latest state of e-cigarette use in youth in 17 European study sites (i.e. 16 countries and the Federation of Bosnia and Herzegovina) using the Global Youth Tobacco Survey (GYTS). **Methods:** This was an observational study. Cross-sectional data on students aged 11–17 years from the latest available GYTS round completed in 17 study sites were used to estimate crude and adjusted prevalence of e-cigarette use by sex and pocket money. Panel GYTS data from five countries were used for the trend analyses. All analyses were weighted to account for the survey design and non-response. **Results:** Compared to 2014, the age-adjusted prevalence of e-cigarette use more than doubled in Georgia and Italy, and nearly doubled in Latvia. Significantly more male than female students aged 11–17 years reported use of e-cigarettes, with little to no confounding by age, grade and pocket money across countries. Youth with medium or higher amount of pocket money was 20–200% more likely to use e-cigarettes than those with fewer to no pocket money in 14 study sites. **Discussion:** As e-cigarette use is becoming widespread throughout the world, there is variation in use among and between countries. Expanded and consistent surveillance of e-cigarette use by all World Health Organization member states is essential to generate data on the extent and correlates of youth e-cigarette use for evidence-based planning and evaluation of the electronic nicotine delivery systems and electronic non-nicotine delivery systems national and global control programmes.

## Introduction

Electronic cigarettes (e-cigarettes) are part of the heterogeneous class of products that heat a solution (also known as e-liquid) in an electrically powered device turning it into an aerosol which the user then inhales. The main constituents of the solution, in addition to nicotine when it is present, are propylene glycol, with or without glycerol, water and flavouring agents.<sup>1–4</sup>

Depending on the presence of nicotine in the solution, e-cigarettes can be attributed to either a group of products known as electronic nicotine delivery systems (ENDS) or electronic non-nicotine delivery systems (ENNDS).<sup>1–3</sup> However, several products labelled as not containing nicotine have been shown to have nicotine of measurable level or concentration (or volume), which can reach 36 mg/ml or more in marketed e-liquids.<sup>3</sup> A study of e-cigarette sales data from convenience stores and mass market channels in the USA has found a significant increase in the average nicotine concentration in e-cigarettes and the proportion of total dollar sales comprised of e-cigarettes with higher nicotine concentration (>4% mg/ml) from 12.3% in March 2013 to 74.7% in September 2018. Five per cent or more of nicotine products examined in the study accounted for over 66% of market share in 2018. Zero-nicotine

containing e-cigarettes accounted for < 1% of dollar market share across all study years.<sup>5</sup>

Regulation of nicotine concentration in e-liquids differs across 53 countries of the World Health Organization (WHO) European Region. For example, the European Union (EU) Member States must follow a Council Directive 2014/40/EU, which prohibits placement of e-liquids exceeding nicotine concentration of the 20 mg/ml on the market and regulates maximum sizes for refill containers (max 10 ml), tanks and cartridges (max 2 ml).<sup>6</sup> Few non-EU countries, including the Russian Federation,<sup>7</sup> Georgia and recently Kyrgyzstan, adopted the same requirement for nicotine volume and concentration. To reduce appeal of e-cigarettes, some countries in the Region, such as Finland, Hungary and Montenegro, have banned flavours, with exception of tobacco flavours. Denmark, Estonia and Germany ban or permit specific flavours.<sup>8</sup> Armenia, Tajikistan and Turkey mandated large graphic warnings for ENDS, and Israel implemented the plan packaging.<sup>2</sup> Turkmenistan is the only country with a ban on sale of e-cigarettes in the WHO European Region.<sup>8,9</sup>

With youth smoking at all-time lows in several nations that have implemented tobacco control programmes, e-cigarettes may stall or reverse achievements in declining tobacco cigarette initiation among

adolescents. Prior research has documented gateway effects of e-cigarette use into smoking and related toxicity.<sup>2,10–13</sup> A systematic review of relevant studies published between 1 January 2005 and 15 April 2019 has concluded e-cigarette use among adolescents in Europe and North America is associated with starting tobacco cigarette smoking.<sup>10</sup> Nicotine is a dependence-producing central nervous system stimulant. Compared with adults, exposure of young people to nicotine may increase their risk for adverse long-term long-lasting effects on brain development, including nicotine addiction (which can develop faster and from nicotine exposure at lower levels in adolescence), mood disorders and permanent lowering of impulse control.<sup>13</sup> Dual- and poly-use of tobacco products are emerging behaviours among youth.<sup>14,15</sup> For instance, a cross-sectional study based on the 2018 Planet Youth survey completed by adolescents aged 15–16 years in the West of Ireland has shown dual-use (i.e. consumption of conventional and e-cigarettes at least once in the past 30 days) was the most prevalent behaviour among adolescent nicotine product users in Ireland.<sup>14</sup> Although there is currently insufficient data to understand the full breadth of e-cigarette use, its patterns, and medium and long-term effects in adolescents globally, the evidence on e-cigarettes harmful health effects is mounting.

To ensure continued progress with reducing use of tobacco products among youths, its epidemiologic surveillance is of utmost importance. Surveillance produces regular, representative and comparable data needed to estimate prevalence and risk factor profiles, and to evaluate measures of tobacco control and its impact across different populations. Yet, monitoring tobacco use and prevention policies, one of the MPOWER measures from the WHO Framework Convention on Tobacco Control, tends to be deprioritized and underfunded. As of 2016, only one-third of countries have comprehensive monitoring systems in place at best-practice level, requiring recent, representative and periodic surveys of both youth and adults to have taken place.<sup>16</sup> Global Youth Tobacco Survey (GYTS) has proven the feasibility of an economical, standardized, worldwide surveillance system for tobacco use. Since addition of an optional module on e-cigarettes to GYTS in 2014, its implementation has been uneven across countries and years.<sup>17</sup> The purpose of our study was to examine (i) prevalence of e-cigarette use in youth

from 16 European countries and the Federation of Bosnia and Herzegovina (hereinafter, study sites), participating in the latest GYTS round, and (ii) changes in prevalence overtime in a subset of study sites with data from the previous GYTS rounds.

## Methods

The GYTS is a worldwide collaborative surveillance initiative of governments and non-governmental organizations led by the Tobacco Free Initiative, WHO, and the Office on Smoking and Health of the United States Centers for Disease Control and Prevention in all WHO regions. The GYTS' goal is to enhance the capacity of countries to design, implement and evaluate tobacco control and prevention programmes. Since its first implementation in 1999, the GYTS has been serving as a global standard for systematic monitoring of tobacco use among youth and tracking key tobacco control indicators. The GYTS is a nationally representative school-based survey of students aged 13–15 years. In a majority of countries, including our study sites, the GYTS uses a two-stage cluster sampling. Classes are randomly chosen from schools identified using a selection probability proportional to enrolment size. As the classes are carefully identified to ensure sufficient sample size of students aged 13–15 years, students of all ages in the selected classes attending school on the day of the survey are eligible to participate in it. Hence, data from students aged < 13 years or > 15 years are also collected. Students complete a self-administered standard core questionnaire and a set of optional questions adapted by countries depending on their needs and priorities. More details can be found elsewhere.<sup>17</sup>

Given this study focus on current use of e-cigarettes among youth in the WHO European Region, 17 study sites (i.e. 16 countries and the Federation of Bosnia and Herzegovina) were selected because they met the following criteria: (i) availability of national rather than subnational and consistent across countries data or indicators allowing cross-country comparisons and (ii) recency of the latest round of data collection (e.g. during 2017–19) for estimating the most current prevalence of e-cigarette use in youth. Overall sample sizes ranged from 624 students in San Marino to 6145 students in Kyrgyzstan (median = 4065 students corresponding to Ukraine).

**Table 1** Countries or study sites from the WHO European Region with the latest available data on current use of e-cigarettes from the GYTS and the overall response rates

Countries or study sites, arranged alphabetically	Latest round of GYTS			Previous round of GYTS		
	Year	Number of students-survey participants aged 11–17 years	Overall response rate, %	Year	Number of students-survey participants aged 11–17 years	Overall response rate, %
Albania	2015	4672	89.3		– <sup>a</sup>	
Bulgaria	2015	4042	86.0		– <sup>a</sup>	
Croatia	2016	3250	95.8		– <sup>a</sup>	
Georgia	2017	1345	78.7	2014	1379	75.4
Italy	2018	1680	77.4	2014	1822	77.0
Kyrgyzstan	2019	6145	88.8		– <sup>a</sup>	
Latvia	2019	4226	70.7	2014	4320	79.5
Poland	2016	5154	81.7		– <sup>a</sup>	
Romania	2017	5409	88.6	2013	4801	84.6
San Marino	2018	624	92.0	2014	638	95.7
Serbia	2017	3861	52.2		– <sup>a</sup>	
Slovakia	2016	3997	81.7		– <sup>a</sup>	
The Czech Republic	2016	3926	78.3		– <sup>a</sup>	
The Federation of Bosnia and Herzegovina	2019	5483	83.3		– <sup>a</sup>	
The Republic of Moldova	2019	4717	93.3		– <sup>a</sup>	
The Republic of North Macedonia	2016	5141	86.2		– <sup>a</sup>	
Ukraine	2017	4065	81.6		– <sup>a</sup>	

<sup>a</sup>: Questions on current e-cigarette use were not asked in the previous rounds. Hence, these study sites were not included in trend analysis.

**Table 2** Age-adjusted prevalence of e-cigarette use among students aged 11–17 years in the WHO European Region countries selected based on availability of the two latest rounds of GYTS data: comparison overtime

Countries or study sites	Previous round of GYTS		Latest round of GYTS		P-value
	Unweighted <i>n</i> current use/total responses	Weighted % (95% CI)	Unweighted <i>n</i> current use/total responses	Weighted % (95% CI)	
Georgia 2017 vs. 2014	82/1301	6.1 (3.7–8.6)	162/1305	12.4 (9.0–16.9)	<b>0.020</b>
Latvia 2019 vs. 2014	461/4306	10.3 (8.4–12.2)	739/4221	18.5 (17.0–20.0)	<b>&lt; 0.001</b>
Italy 2018 vs. 2014	162/1656	9.1 (6.9–11.3)	309/1671	18.3 (14.8–21.7)	<b>0.001</b>
Romania 2017 vs. 2013	267/4756	5.7 (4.5–6.8)	409/5359	7.6 (6.5–8.8)	0.113
San Marino 2018 vs. 2014	36/637	5.7 (3.6–7.8)	66/611	10.7 (7.2–14.1)	0.064

Note: P-values indicative of statistically significant differences are in bold.

The overall response rates ranged from 52.2% in Serbia to 95.8% in Croatia (median = 83.3% corresponding to the Federation of Bosnia and Herzegovina). Five countries collected data on current e-cigarette use in previous rounds of GYTS. More details are provided in table 1. For this observational study, we used cross-sectional GYTS data from 17 study sites and panel GYTS data from five countries to assess current e-cigarette use and its trends overtime, respectively, among students aged 11–17 years.

As part of the optional set of questions, students were asked to choose one out of seven response options on how many days they used e-cigarettes during past 30 days. Consistent with the WHO definition of current e-cigarette use (also referred to as ‘past month e-cigarette use’ in some studies), we operationalized it as having used on one or more days in the past 30 days.

As part of the core questionnaire, students reported their age (using one of the seven response options ranging from ‘11 years old or younger’ to ‘17 years old or older’), sex and grade—essential socio-demographic characteristics. In all study sites, students also reported ranges of pocket money in the optional set of questions. We included this variable in our analyses as a proxy of students’ socioeconomic status (SES) and its modifiable nature.<sup>18,19</sup>

The response options for grade and pocket money varied across countries. For example, in Georgia and Albania, there were students from four grades; in Czech Republic—from eight grades, while the rest of the sites had students from three grades. The ranges of pocket money were assessed using four response options in Croatia; five response options in Italy, the Republic of North Macedonia and San Marino; six—in the Federation of Bosnia and Herzegovina and Serbia; seven in Albania, Bulgaria, Georgia, Kyrgyzstan, Latvia, the Republic of Moldova, Poland, Romania, Slovakia and Ukraine; and eight—in the Czech Republic. To enable cross-country comparisons and ensure sufficient number of observations for adjusted analyses, we dichotomized the original variable as having no to less than medium amount of pocket money vs. having medium amount of pocket money to far above.

To examine trends in current e-cigarette use in Georgia, Latvia, Italy, Romania and San Marino, first, age-adjusted prevalence of current e-cigarette use in each country in a given year was estimated as average adjusted predictions using *margins* command following the univariate logistic regression. Next, difference in prevalence estimates between the two rounds of GYTS by country was examined using a z-test.

Associations between current e-cigarette use with age, sex, grade and pocket money in 17 study sites were examined using univariate and multivariable logistic regression models. Crude and adjusted prevalence of e-cigarette use by sex and by pocket money were estimated using *margins* command. Interaction effects of pocket

money and gender on current e-cigarette use were examined by including an interaction term in the logistic regression models. Poisson regression models were used to estimate prevalence ratios of current e-cigarette use among students with at least medium amount of pocket money compared with those with smaller amount to none, controlling for their sex, age and grade. The variance inflation factors, measures of the amount of multicollinearity in a set of multiple regression variables, were low to moderate (< 5).

All analyses were conducted separately for each country and were weighted to account for the survey design and non-response. Statistical significance level was set at 5%. All tests were two-tailed. Stata/SE 14.2 was used for all analyses. Estimates based on unweighted sample sizes < 35 or relative standard error > 0.3 were not reported, because they might not be reliable. For example, survey respondents aged < 12 years were currently using e-cigarettes; however, estimated prevalence could not be reported by age due to very low number of observations (< 5).

## Results

Over time, there has been a significant increase in e-cigarette use among students aged 11–17 years in Georgia, Latvia and Italy. The age-adjusted prevalence of e-cigarette use more than doubled in Georgia between 2014 and 2017 ( $P=0.020$ ): from 6.1% (95% CI: 3.7–8.6) to 12.4% (95% CI: 9.0–16.0), as well as in Italy between 2014 and 2018 ( $P=0.001$ ): from 9.1% (95% CI: 6.9–11.3) to 18.3% (95% CI: 14.8–21.7). In Latvia, the current e-cigarette use nearly doubled between 2014 and 2019 ( $P<0.001$ ): from 10.3% (95% CI: 8.4–12.2) to 18.5% (95% CI: 17.0–20.0), respectively. In Romania and San Marino, the age-adjusted prevalence of current e-cigarette use was 7.6% (95% CI: 6.5–8.8) in 2017 and 10.7% (95% CI: 7.2–14.1) in 2018, respectively, whereas it was 5.7% in both countries 3 or 4 years prior. More details are provided in table 2.

Based on the results of univariate and multivariable logistic regression analyses of the most recent round of GYTS, significantly more male than female students aged 11–17 years reported use of e-cigarettes, suggesting little to no confounding by age, grade and pocket money overall across all countries (table 3). The highest statistically significant difference in the adjusted prevalence of e-cigarette use between male and female students was in Georgia with 10.7 percentage points (pps) ( $P<0.001$ ), the lowest difference—in Serbia with 2.4 pps ( $P<0.023$ ), and the median difference of 7.3 pps in Croatia ( $P<0.001$ ). More specifically, within male study population, the highest percentage of e-cigarette users was in Poland—30.9% (95% CI: 27.6–34.1); the lowest—in Kyrgyzstan: 4% (95% CI: 2.8–5.2), and the median 12% (95% CI: 8.8–15.3%) in Bulgaria. Among the female study population, the

**Table 3** Prevalence of e-cigarette use in male and female students aged 11–17 years in the WHO European Region study sites with the latest available data from GYTS

Countries or study sites, arranged alphabetically	Boys			Girls		
	Unweighted <i>n</i>	Crude weighted % (95% CI)	Adjusted weighted % (95% CI)	Unweighted <i>n</i>	Crude weighted % (95% CI)	Adjusted weighted % (95% CI)
Albania	230	9.9 <sup>a</sup> (7.9–12.0)	9.3 <sup>a</sup> (7.5–11.2)	84	3.2 <sup>a</sup> (2.1–4.3)	3.4 (2.3–4.5)
Bulgaria	236	12.6 <sup>a</sup> (9.1–16.0)	12.0 <sup>a</sup> (8.8–15.3)	190	8.9 <sup>a</sup> (6.3–11.6)	9.3 <sup>a</sup> (6.8–11.8)
Croatia	282	14.7 <sup>a</sup> (10.3–19.1)	14.2 <sup>a</sup> (10.8–17.6)	144	6.8 <sup>a</sup> (4.6–9.1)	6.9 <sup>a</sup> (5.0–8.8)
Georgia	114	17.5 <sup>a</sup> (12.5–24.0)	17.1 <sup>a</sup> (11.6–22.7)	43	6.4 <sup>a</sup> (4.4–9.2)	6.4 <sup>a</sup> (4.1–8.7)
Italy	187	22.5 <sup>a</sup> (17.5–27.5)	22.6 <sup>a</sup> (17.4–27.8)	122	13.6 <sup>a</sup> (11.4–15.8)	13.3 (11.1–15.6)
Kyrgyzstan	141	4.1 <sup>a</sup> (2.8–5.4)	4.0 <sup>a</sup> (2.8–5.2)	59	1.6 <sup>a</sup> (1.0–2.3)	1.5 <sup>a</sup> (0.9–2.2)
Latvia	468	23.0 <sup>a</sup> (20.7–25.2)	22.8 <sup>a</sup> (21.0–24.6)	269	13.9 <sup>a</sup> (11.5–16.3)	14.0 <sup>a</sup> (11.6–16.4)
Poland	736	31.5 <sup>a</sup> (28.2–34.9)	30.9 <sup>a</sup> (27.6–34.1)	560	21.8 <sup>a</sup> (19.0–24.7)	22.2 <sup>a</sup> (19.3–25.1)
Romania	252	9.6 <sup>a</sup> (7.8–11.5)	9.4 <sup>a</sup> (7.6–11.2)	154	5.5 <sup>a</sup> (4.4–6.5)	5.5 <sup>a</sup> (4.4–6.5)
San Marino	42	12.2 (8.1–16.3)	11.7 (7.6–15.8)	– <sup>b</sup>	– <sup>b</sup>	– <sup>b</sup>
Serbia	159	8.4 <sup>a</sup> (6.2–10.6)	8.2 <sup>a</sup> (6.5–10.0)	103	5.6 <sup>a</sup> (4.2–7.1)	5.8 <sup>a</sup> (4.3–7.3)
Slovakia	189	9.7 <sup>a</sup> (7.2–12.3)	9.3 <sup>a</sup> (6.9–11.8)	121	6.2 <sup>a</sup> (4.3–8.0)	6.4 <sup>a</sup> (4.6–8.3)
The Czech Republic	230	12.4 (9.3–15.6)	11.8 (9.1–14.5)	181	9.7 (7.7–11.7)	10.3 (8.6–12.0)
The Federation of Bosnia and Herzegovina	488	16.9 <sup>a</sup> (14.8–19.1)	16.5 <sup>a</sup> (14.6–18.4)	172	6.5 <sup>a</sup> (5.1–7.9)	6.7 <sup>a</sup> (5.3–8.2)
The Republic of Moldova	397	17.1 <sup>a</sup> (14.7–19.5)	16.8 <sup>a</sup> (14.8–18.8)	209	8.4 <sup>a</sup> (6.0–10.8)	8.5 <sup>a</sup> (6.2–10.7)
The Republic of North Macedonia	158	6.0 <sup>a</sup> (4.0–7.9)	5.8 <sup>a</sup> (4.1–7.4)	50	2.1 <sup>a</sup> (1.4–2.8)	2.1 <sup>a</sup> (1.5–2.8)
Ukraine	396	21.7 <sup>a</sup> (17.4–26.1)	21.1 <sup>a</sup> (17.0–25.2)	221	12.8 <sup>a</sup> (9.7–15.9)	13.3 (10.3–16.3)

The prevalence estimates are adjusted by age, grade and pocket money.

<sup>a</sup>: Statistically significant difference between the estimates,  $P < 0.005$ .

<sup>b</sup>: The unweighted sample size was  $< 35$ , resulting in unstable estimates.

highest percentage of e-cigarette use was in Poland: 22.2% (95% CI: 19.3–25.1), and the lowest in Kyrgyzstan: 1.5% (95% CI: 0.9–2.2). The median prevalence of current e-cigarette use in female study population was 6.8%, with the Federation of Bosnia and Herzegovina and Croatia being around this estimate: 6.7% (95% CI: 5.3–8.2) and 6.9% (95% CI: 5.0–8.8), respectively. Further details are provided in [table 3](#).

In both univariate and multivariable analyses, students aged 11–17 years with medium or higher amount of money to spend on themselves ‘however they want’ were significantly more likely to use e-cigarettes compared with their counterparts with fewer to no pocket money in all study sites, except The Republic of North Macedonia ( $PR_{adj} = 1.2$ ; 95% CI: 0.9–1.7). In the Czech Republic ( $PR_{adj} = 2.1$ ; 95% CI: 1.7–2.6) and Republic of Moldova ( $PR_{adj} = 2.0$ ; 95% CI: 1.7–2.2), students with medium amount of pocket money or more were at least two times as likely to use e-cigarettes than students with less than medium amount ( $P < 0.001$ ). In Latvia and Poland, students with at least medium amount of pocket money were 30% more likely (95% CI: 1.1–1.6 and 1.2–1.5, respectively) to use e-cigarettes compared with their counterparts with fewer pocket money, adjusting for age, sex and grade ( $P = 0.001$  and  $< 0.001$ , respectively). The unweighted sample sizes were insufficient to

produce stable prevalence estimates of e-cigarette use by amount of pocket money in San Marino and Kyrgyzstan. More details can be found in [table 4](#).

## Discussion

In light of the growing concerns of increasing e-cigarette use among children and adolescents and the mounting evidence on the health risks associated with the use of these products,<sup>4,10,11</sup> we examined the current prevalence of e-cigarette use and changes overtime in youth aged 11–17 years in 17 European study sites. We found in the last 4–6 years, the percentage of students aged 11–17 years currently using e-cigarettes had doubled in Georgia and Italy, and nearly doubled in Latvia. The prevalence of current e-cigarette use increased in Romania and San Marino. The finding of upward trend is similar to reports from other countries. A systematic review and meta-analyses of 27 publications (36 surveys) from 13 countries has shown ENDS ever use among youth aged  $< 20$  years increased in New Zealand, Poland, the Republic of Korea and the USA.<sup>20</sup> In the UK, 4.9% of youth aged 11–18 years were currently using e-cigarettes in 2019 vs. 2.4% in 2015.<sup>21</sup>

**Table 4** Association between pocket money and current e-cigarette use among students aged 11–17 years in the WHO European Region study sites with the latest available GYTS data

Countries or sites	Less than medium amount		At least medium amount		Adj. PR <sup>a</sup> (95% CI)	P-value
	Unweighted <i>n</i>	Weighted % (95% CI)	Unweighted <i>n</i>	Weighted % (95% CI)		
Albania	102	4.8 (3.4–6.1)	212	8.5 (6.9–10.0)	1.4 (1.0–2.0)	<b>0.025</b>
Bulgaria	250	9.3 (6.9–11.7)	178	14.4 (9.0–19.8)	1.5 (1.1–2.0)	<b>0.007</b>
Croatia	60	5.7 (3.5–7.9)	362	12.3 (9.0–15.5)	1.8 (1.4–2.4)	<b>&lt;0.001</b>
Georgia	77	9.4 (6.7–12.2)	82	17.7 (12.2–23.1)	1.8 (1.4–2.5)	<b>0.001</b>
Italy	102	12.8 (9.5–16.1)	207	23.1 (18.4–27.9)	1.7 (1.3–2.3)	<b>&lt;0.001</b>
Latvia	323	15.7 (13.5–18.0)	414	21.6 (19.6–23.5)	1.3 (1.1–1.6)	<b>0.001</b>
Poland	606	22.5 (19.9–25.2)	692	32.3 (29.7–35.0)	1.3 (1.2–1.5)	<b>&lt;0.001</b>
Romania	259	6.7 (5.4–8.0)	147	10.1 (8.1–12.1)	1.4 (1.1–1.7)	<b>0.004</b>
Serbia	149	5.5 (4.2–6.7)	116	11.6 (9.1–14.1)	1.9 (1.5–2.5)	<b>&lt;0.001</b>
Slovakia	161	6.2 (4.6–7.9)	150	11.7 (8.4–15.0)	1.6 (1.3–2.0)	<b>&lt;0.001</b>
The Czech Republic	321	9.7 (7.6–11.7)	88	22.5 (18.5–26.5)	2.1 (1.7–2.6)	<b>&lt;0.001</b>
The Federation of Bosnia and Herzegovina	270	9.4 (7.8–11.0)	402	15.7 (13.6–17.8)	1.6 (1.3–1.9)	<b>&lt;0.001</b>
The Republic of Moldova	165	8.3 (7.0–9.5)	434	17.7 (15.0–20.3)	2.0 (1.7–2.2)	<b>&lt;0.001</b>
The Republic of North Macedonia	53	3.5 (2.4–4.6)	152	4.4 (2.8–5.9)	1.2 (0.9–1.7)	0.263
Ukraine	322	13.5 (10.0–16.9)	293	25.7 (21.1–30.4)	1.8 (1.4–2.3)	<b>&lt;0.001</b>
San Marino <sup>b</sup>	16	—	50	16.8 (12.9–20.7)	2.9 (1.8–4.8)	–
Kyrgyzstan <sup>b</sup>	82	1.9 (1.2–2.6)	116	5.1 (3.4–6.7)	–	–

Notes: P-values in bold represent statistically significant differences between prevalence of e-cigarette use among students, aged 11–17 years, who reported having at least medium amount of pocket money vs. no to less than medium amounts.

a. Adjusted by student's age, sex and grade.

b. The insufficient sample size; hence, the resulting estimates may be unstable and are therefore, not reported. The regression coefficients for sex, pocket money and the interaction term between sex and pocket money were statistically significant suggesting differences in statistical effects of having at least medium amount of pocket money on prevalence of e-cigarette use between male and female students compared with having less than medium amount of pocket money.

Our finding of increasing trend in e-cigarette use is of particular concern as they suggest initiation of e-cigarette use at as little as 11 years of age. In a US study using data from five cohorts of the National Youth Tobacco Survey, over three-fold increase in e-cigarette use among youth aged 14 years or younger was mirrored by lowering the initiation age between 2014 and 2018.<sup>22</sup> Of note, similar changes in initiation ages were not observed for cigarettes, cigars and smokeless tobacco among lifetime users of each of these products.<sup>22</sup>

Based on descriptive analyses of GYTS data from 22 countries across different WHO regions, current use of ENDS and ENNDs was significantly higher in adolescents than adults. For example, in youth, prevalence ranged from 0.7% in Japan to 23.4% in Poland; whereas in adults, the highest reported prevalence was 16.7% in Brunei Darussalam.<sup>2</sup> Based on the latest Eurobarometer data, in Romania in 2017–18, e.g. the prevalence of current cigarette smoking in adults aged 15 years and older was 3.5 times that of students aged 13–15 years. On the contrary, the prevalence of e-cigarette use in students was 2.4 times that of adults. Similarly, in Ukraine in 2017, the prevalence of current cigarette smoking in adults was 2.5 times that of students, whereas the prevalence of e-cigarette use in students was 10.8 times that of adults.<sup>23</sup> A review of 21 studies published between 2004 and 2013 has indicated a notable proportion of youth

who never smoked cigarettes had ever-used e-cigarettes.<sup>24</sup> Adults most often reported e-cigarettes as a substitute for tobacco, including cessation mechanism. By contrast, among youth, e-cigarette use was not consistently associated with attempting to quit tobacco use. There is also a difference in the pattern of e-cigarette use among young people (e.g. new e-cigarette users who had never used tobacco) vs. adults (e.g. former or current tobacco users).<sup>23</sup> Although research is ongoing, several studies have reported multiple product use as emerging behaviour among young people.<sup>14,15</sup> In a study based on data from the Population Assessment of Tobacco and Health, adolescents aged 12–17 years, who have tried more than one non-cigarette tobacco product, were more likely to smoke in the future than those who ever used a single tobacco product.<sup>25</sup> E-cigarette use alone or in combination with other products among youth poses unique concerns, as the extent of adverse health effects and reasons for use are still open research topics, and therefore, in need of enhanced surveillance.

In addition to the increasing trend in e-cigarette use and initiation as early as 11 years, our study found many more male than female students aged 11–17 years had reported use of e-cigarettes. Adjusting for age, grade and pocket money, the highest difference in prevalence of current e-cigarette use between sexes was over 10 pps in Georgia; the median difference of 7.3 pps was in Croatia, and the lowest difference of 2.4 pps was in Serbia. Prior country-specific

studies have also reported male adolescents are more likely to use e-cigarettes than females.<sup>26–31</sup> However, while sex differences have been identified, few studies have examined them. Based on a review of 652 articles published between 2012 and 2017 in the USA, girls appeared to be at increased risk of using e-cigarettes when those were targeted towards them and were more inclined to obtain e-cigarettes from their peers, whereas boys were more likely to purchase e-cigarettes from online sources.<sup>30</sup> A longitudinal study of Mexican adolescents aged 11–15 years has found a significant predictor of current exclusive e-cigarette use among males at follow-up was having friends who had smoked cigarettes at baseline; among females, the predictors were being a current drinker, having a job, as well as higher technophilia and positive smoking expectancies.<sup>31</sup> Of note, predictors of current exclusive e-cigarette use differed from those of current exclusive smoking and dual use of e-cigarettes and smoking.<sup>31</sup> Explanatory research on sex differences in e-cigarette use in youth is needed, especially as patterns of use evolve with new regulations and alterations in e-cigarette marketing and product features (e.g. flavouring).<sup>32</sup>

Students aged 11–17 years with at least average amount of pocket money were significantly more likely to use e-cigarettes than those with smaller amounts in 14 study sites. The increase in e-cigarette use from larger amount of pocket money ranged from approximately 20 to 200%. While several studies have reported similar positive association of having pocket money with cigarette smoking, explanatory studies are needed to settle the nature of this association for e-cigarette use and develop effective interventions beyond those simply targeting populations of low SES.<sup>33–36</sup> In fact, such policies may be insufficient if young people's disposable income reflects the SES of their family, as commonly assumed (i.e. those better off financially have more pocket money than those who are worse off). Consistent with 'material paradox' young people from lower SES background tend to have more pocket money than their higher SES peers, albeit this association needs to be understood within a context of social class and consumer culture.<sup>33,37</sup> The measurement of SES among adolescents continues to present difficulties and is often omitted from surveys of youth.<sup>38</sup> As researchers tend to use parental smoking status and SES, defined by education level, income or occupation, as independent determinants of adolescents' health and related behaviours, including smoking, using multiple measures of SES—those of the child, the parents and the family, can be informative.<sup>38</sup>

Our study has several limitations. First, data were self-reported by students, which might result in misreporting of e-cigarette use. Our operational definition of current e-cigarette users as those who reported having used e-cigarettes on one or more days in the past 30 days ensured sufficient number of observations for comparative and adjusted analyses and potentially reduced information bias. Although by doing so, we could not differentiate between daily vs. occasional monthly use, based on our exploratory analyses, '1 or 2 days' was the most frequently selected response option compared with options of 3–5, 6–9, 10–19, 20–29 and all 30 days. Second, given the lack of data on different types of tobacco products and its consistent collection in several study sites, as well as small sample sizes (e.g. when looking at dual- and poly-users as variables with mutually exclusive categories), we could only examine prevalence for e-cigarette users, which may include users of other tobacco products, across all study sites. However, we report crude prevalence of dual- and poly-use in [Supplementary tables 1 and 2](#). Third, the data came from youths enrolled in schools, which might have limited generalizability to all youths in these study sites. However, across all the countries, in the study there were on average 2 per cent (range 0.3–11.7%) of children of school-going age not enrolled in primary or secondary school.<sup>39</sup> Fourth, since our study was based on cross-sectional data, causality between e-cigarette use, sex and pocket money cannot be established. However, reliance on cross-sectional survey data is justified by descriptive type of research intended to provide estimates on use rates across a large number of countries and identify areas for future research and surveillance.

In conclusion, this study encompassing 17 study sites demonstrates e-cigarette use poses a growing concern in the WHO European Region regardless of countries' income level, e.g. Kyrgyzstan, the Republic of Moldova, and Ukraine (low middle income), Albania, Bulgarian, Georgia, The Federation of Bosnia and Herzegovina, North Macedonia, Romania, and Serbia (upper middle income), as well as Croatia, Italy, Latvia, Poland, San Marino, Slovakia and The Czech Republic (high income).<sup>40</sup> Population-level survey data on ENDS and ENNDS use among youth consistently collected by countries across the globe are needed to enable explanatory studies and inform development and delivery of evidence-based public health interventions to address the concerning growth in youth access to e-cigarettes.

## Supplementary data

[Supplementary data](#) are available at *EURPUB* online.

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## Disclaimer

The findings and conclusions of this paper are those of the author(s) and do not necessarily represent the official position of the Regional Office for Europe, the World Health Organization.

*Conflicts of interest:* None declared.

## Key points

- E-cigarette use poses a growing concern in the WHO European Region.
- Students as young as 11 years old tried e-cigarettes at least once in 17 European study sites.
- Significantly more male than female students aged 11–17 years use e-cigarettes.
- E-cigarette use is higher among students with more pocket money.
- Surveillance of e-cigarette use in youth is needed among all WHO member states.

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