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ORIGINAL ARTICLE

Dual use of electronic and tobacco cigarettes among adolescents: a cross-sectional study in Poland

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Abstract
Objectives Electronic cigarettes (e-cigarettes) are gaining in popularity among youth. While these products may be beneficial in adult smokers, the effect on young users of electronic and tobacco cigarettes (dual users) is unknown. The objective of this study was to assess the frequency of dual use among adolescents and to compare tobacco cigarette consumption among dual and exclusive tobacco cigarette users.
Methods A cross-sectional survey of a sample of 2213 Polish students aged 16–18 conducted between December 2013 and February 2014.
Results Overall, 21.8 % of students were dual users. Dual users were more likely to smoke tobacco cigarettes on a daily basis [adjusted odds ratio, AOR 3.54 (95 % CI 2.34–5.36) and less likely to smoke fewer cigarettes per day (AOR 0.27 (95 % CI 0.12–0.57)] than exclusive tobacco cigarette users.
Conclusions The frequency of dual use was higher than exclusive use of a single product among Polish adolescents. Young dual users do not smoke a lower number of tobacco cigarettes per day than exclusive tobacco cigarette users.

Keywords Electronic cigarette · Tobacco cigarette · Dual use · Adolescent

Introduction

Electronic cigarettes (e-cigarettes) are battery-powered electronic nicotine delivery systems, which are generally perceived to be safer than traditional tobacco cigarettes (Goniewicz et al. 2014b; Grana 2013). While these products may be beneficial among adult smokers, concerns have been raised about their uptake by nonsmokers and youth (Durmowicz 2014; Grana 2013; Protano et al. 2015). Since the introduction of e-cigarettes to the US and European markets in 2007–2008, these new tobacco products have become popular not only among adults, but also among

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youth (Camenga et al. 2014a; Goniewicz et al. 2014a; Goniewicz and Zielinska-Danch 2012; McCarthy 2013; Mitka 2014; Vardavas et al. 2014; Zhu et al. 2013). Due to the relatively recent introduction of e-cigarettes, laws and regulations regarding their use, sales and marketing are not yet fully deliberated or implemented. Most countries are only just beginning to regulate e-cigarettes, including restrictions on sales to minors (Benowitz and Goniewicz 2013; Kinnunen et al. 2014).

Since e-cigarette use is associated with tobacco cigarette smoking, there is concern that many youth may use both electronic and tobacco cigarettes concurrently (i.e., dual use) (Dutra and Glantz 2014; Lee et al. 2011). Recently, we reported an increased prevalence from 2010–2011 to 2013–2014 in dual use among adolescents in Poland (Goniewicz et al. 2014a). Very little is known about the patterns of use and determinants of e-cigarette use, or about dual use among youth. The first objective of this study was to assess the patterns of dual use among adolescents in Poland, and the second objective was to identify risk factors for dual use.

Some researchers suggest that nicotine products such as e-cigarettes could act as a gateway to tobacco cigarette use (Coleman et al. 2014; Grana 2013). The "gateway effect" posits that e-cigarette use in nonsmokers may increase their probability of becoming tobacco cigarette smokers. For example, smoking waterpipe (hookah, shisha) has been suggested as a gateway to tobacco cigarette smoking among youth (Mzayek et al. 2012; Hampson et al. 2013). It is unknown whether e-cigarettes act as a gateway to tobacco cigarette smoking. Our third objective was to describe the initiation of e-cigarette use and/or progression toward dual use.

Methods

Sampling for this survey was undertaken using a 3-stage stratified clustered design described previously (Goniewicz and Zielinska-Danch 2012). In the first stage, secondary and technical schools were treated as the primary sample unit; in the second stage, schools were randomly selected within large, medium and small cities. Finally, students were randomly selected from within each school. The survey was administered to 2213 students in 21 secondary and technical schools in two regions; one in northern and one in southern Poland, between December 2013 and February 2014. Nine towns and cities were sampled, with four located in the north and five located in the south. The northern sites comprised medium to small towns, while the sites sampled in the south comprised primarily medium to large cities. Eight-eight percent of schools sampled agreed to participate. Prior to the administration of the questionnaire, students were given a brief description of the study and they provided informed consent to participate. The study protocol was reviewed and approved by the Ethical Review Boards at the Medical University of Silesia and the Medical University of Gdansk, Poland.

Survey instrument

An anonymous, self-administered paper questionnaire was used in this study. The questionnaire included 58 questions, including 56 closed questions and two open-ended questions. The first group of questions collected data on demographics including age, sex, place of residence, number of family members, and type of school attended.

The second group of questions collected data on patterns of tobacco cigarette use including when smoking was initiated, number of cigarettes smoked per day, frequency of smoking, and nicotine addiction (assessed using time to first cigarette after awakening in the morning according to the Fagerstrom Test for Nicotine Dependence) (Heatherton et al. 1991). More specifically, students were asked three questions regarding smoking habits: (1) if they had ever smoked or currently smoked tobacco cigarettes; (2) if they had ever puffed or currently puff on e-cigarettes; and (3) if they had ever or currently used both products at the same time (dual use). Ever use was defined as taking even a single puff of the product. Current use was defined as use of the product in the past 30 days. Current dual use was defined as use of both products in the past 30 days (even a single puff).

The last group of questions collected data on patterns of e-cigarette use including the order of onset of e-cigarette use relative to combustible tobacco cigarette use, reasons for e-cigarette use, frequency of puffing, and characteristics of the product typically used. Data were also collected on attitudes, beliefs, and perceptions of both electronic and tobacco cigarettes.

Data analysis

We restricted the analysis to data collected from students aged 16–18 years. We targeted this age group because adolescents tend to experiment with cigarettes and initiate smoking within this age range (Gilman et al. 2009). In addition, many students in this age range were below the legal age of buying tobacco products in Poland (i.e., age 18). The final analytic sample included only students who provided valid data on demographics and patterns of tobacco and e-cigarette use.

Descriptive statistics and multivariate analysis were performed using Excel (Microsoft, USA) and Statistica 12 (Statsoft Inc., USA), respectively. Multivariate logistic regression analyses were used to identify correlates of dual

versus exclusive use of electronic and tobacco cigarettes controlling for age, sex, place of residence, family size and type of school (all treated as categorical variables). Alpha 0.05 was used as the level of statistical significance.

Results

A total of 2138 students consented to participate. One hundred and forty-two students (6.4 %) were excluded because their age was outside the targeted age range. An additional 211 students (9.5 %) were excluded because of missing data. The final analytic sample included 1785 students and the response proportion was 80.7 %. The mean (SD) age of students was 17.1 (0.8) years. Selected characteristics of the sample are described in Table 1.

Prevalence of e-cigarette use and tobacco smoking

Overall, 21.8 % of students ($n = 389$) were dual users of both electronic and tobacco cigarettes. Among current e-cigarette users ($n = 528$), 73.7 % were current tobacco

Table 1 Prevalence of e-cigarette use and tobacco cigarette smoking among adolescents aged 16–18 years in Poland ($n = 1785$) December 2013–February 2014)

	Total ($n = 1785$), %	Current users ($n = 810$)			AOR (95 % CI)[a]	
		Dual use ($n = 389$), %	Exclusive e-cigarettes ($n = 139$), %	Exclusive tobacco cigarettes ($n = 282$), %	Dual use vs. exclusive e-cigarettes, %	Dual use vs. exclusive tobacco cigarette, %
Age, years						
16	25.0	26.2	28.8	17.7	0.59 (0.35–1.01)	1.96 (1.26–3.04)*
17	36.1	36.5	45.3	29.4	0.56 (0.34–0.91)*	1.70 (1.16–2.29)*
18	38.8	37.3	25.9	52.8	Ref	Ref
Sex						
Female	52.0	39.8	41.0	63.5	0.96 (0.64–1.45)	0.51 (0.36–0.73)*
Male	48.0	60.2	59.0	36.5	Ref	Ref
Place of residence						
Medium or large city (>100 K)	51.0	53.2	53.2	53.9	0.93 (0.62–1.40)	0.97 (0.69–1.36)
Small city or rural (<100 K)	49.0	46.8	46.8	46.1	Ref	Ref
Family size						
3 or less	20.6	21.3	22.3	21.3	1.10 (0.64–1.88)	1.08 (0.68–1.73)
4	44.8	46.0	40.3	44.7	1.33 (0.84–2.10)	1.25 (0.85–1.83)
5 or more	34.7	32.7	37.4	34.0	Ref	Ref
Type of school						
Secondary school	58.4	41.4	49.2	8.0	0.78 (0.51–1.17)	0.32 (0.22–.0.46)*
Technical/vocational school	41.6	58.6	50.8	22.1	Ref	Ref
Ever tobacco cigarette smoking						
Yes	65.7	100	77.0	100	–	–
No	34.3	0	23.0	0	–	–
Current tobacco cigarette smoking						
Yes	37.6	100	0	100	–	–
No	62.4	0	100	0	–	–
Ever use e-cigarettes						
Yes	60.7	100	100	83.7	–	–
No	39.3	0	0	16.3	–	–
Current use of e-cigarettes						
Yes	29.6	100	100	0	–	–
No	70.4	0	0	100	–	–

* Statistically significant

[a] The adjusted odds ratio (AOR) for the demographic variables represent the odds ratio for each demographic variable adjusted for the other variables

cigarette smokers (i.e., dual users), 20.3 % were ex-smokers, and 6.1 % reported that they have never smoked tobacco cigarettes (Table 1). Among current smokers ($n = 671$), 57.9 % were current e-cigarettes users (i.e., dual users), 92.5 % had previous experience with e-cigarettes but were not currently using e-cigarettes, and 7.5 % reported that they had never tried e-cigarettes (Table 1). Only 7.8 % ($n = 139$) of all students ($n = 1785$) were exclusive e-cigarette users, while 15.8 % ($n = 282$) were exclusive tobacco cigarette users.

Risk factors for dual use

Compared to students age 18 years, those age 16 [AOR 1.96 (95 % CI 1.26–3.04) and 17 (AOR 1.70 (95 % CI 1.16–2.29)] were significantly more likely to be dual users than exclusive tobacco cigarette smokers (Table 1). In contrast, relative to exclusive e-cigarettes users, younger students were significantly less likely to be dual users than exclusive e-cigarette users [AOR 0.56 (0.34–0.91) for age 17 vs. 18] (Table 1). Females were significantly less likely to be dual users than exclusive tobacco users [AOR 0.51 (95 % CI 0.36–0.73)]; and those who attended secondary school were less likely to be exclusive tobacco users [AOR 0.32 (0.22–0.46)] (Table 1).

Initiation of dual use

Seventy-three percent of dual users ($n = 389$) reported that they had used tobacco cigarettes before e-cigarettes. However, 15.7 % of dual users reported that the first product they had ever tried was an e-cigarette. Most dual users tried e-cigarettes out of curiosity [i.e., trying something new (28.8 %) or testing how e-cigarettes were different from tobacco cigarettes (28.0 %)]. Only 18.8 % of dual users reported that they had used e-cigarettes to quit smoking, and 12.1 % used e-cigarettes as a safer alternative to tobacco cigarettes. Similarly, among exclusive e-cigarette users, 34.5 % reported they wanted to try something new and 24.5 % wanted to see if e-cigarettes were different from tobacco cigarettes. Only 10.8 % of exclusive e-cigarette users reported that they used e-cigarettes to quit smoking, and 11.5 % used e-cigarettes as a safer alternative to tobacco cigarettes.

Patterns of electronic and tobacco cigarette use among dual users

Dual users were more likely than exclusive e-cigarette smokers to smoke tobacco cigarettes on a daily basis (Fig. 1). The AOR for smoking daily vs. less than one

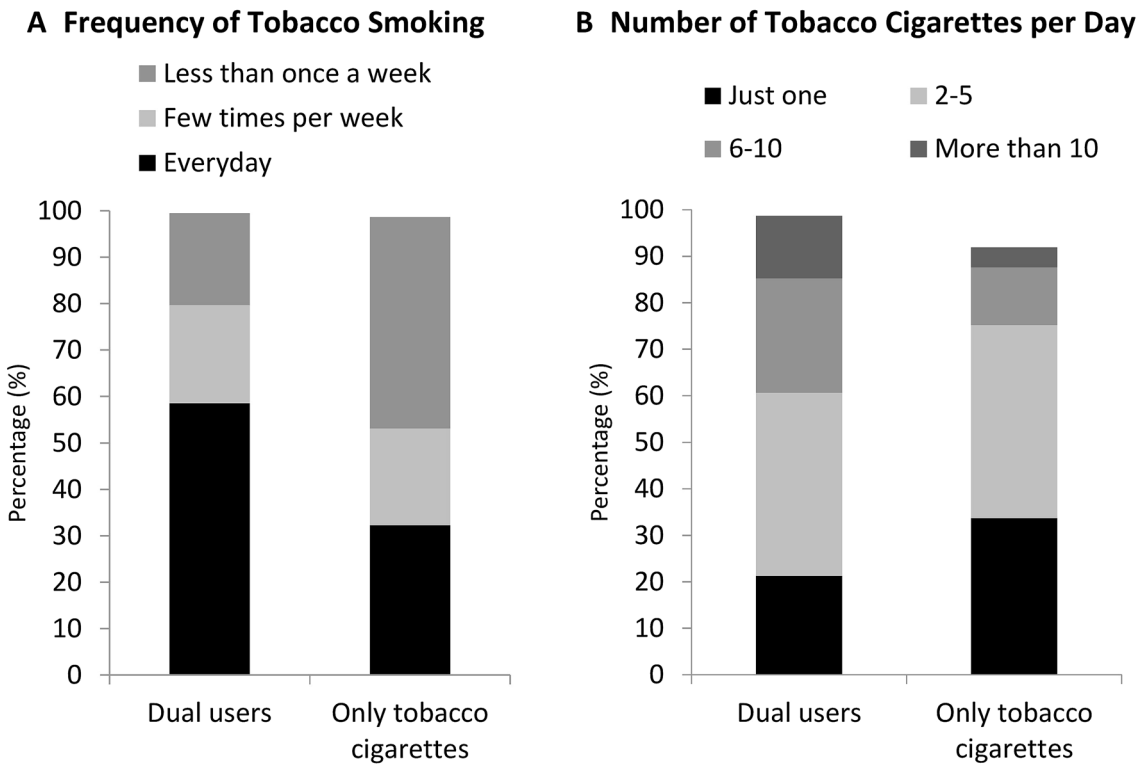

Fig. 1 Differences between dual users and exclusive tobacco smokers in frequency of smoking (**a**; *left*) and numbers of tobacco cigarettes smoked per day (**b**; *right*) in a sample of adolescents aged 16–18 in Poland ($n = 1785$; December 2013–February 2014)

cigarette per week was 3.54 (95 % CI 2.34–5.36) (Table 2). Dual users were also more likely to smoke tobacco cigarettes a few times a week vs. less often [AOR 2.24 (95 % CI 1.39–3.59)] (Table 2). Dual users were less likely to smoke fewer cigarettes per day than exclusive smokers [Fig. 1; AOR comparing smoking one vs. more than 10 cigarettes: 0.27 (95 % CI 0.12–0.57); Table 2]. Finally, a higher proportion of dual users smoked tobacco cigarettes within the first 30 min after awakening in the morning compared with using e-cigarettes in the same time (24.7 % smoked the first cigarette within 30 min after awaking vs. 15.4 % puffed on e-cigarette within 30 min after awaking; Table 2).

Dual users were more likely to use e-cigarettes on a daily basis than exclusive e-cigarette users [AOR comparing daily use vs. less than once per week: 3.01 (95 % CI 1.67–5.41); Table 2]. However, dual users used e-cigarettes less frequently during the day than exclusive e-cigarette users [AOR comparing use of e-cigarettes 1–5 times vs. more than 10 times per day: 0.42 (95 % CI 0.22–0.77); Table 2].

Product preferences among dual users

Refillable e-cigarette models (i.e., tank systems) were more popular among dual users than products with replaceable cartridges (86.4 vs. 5.1 %; Table 2). Among exclusive e-cigarette users, refillable e-cigarette models were more popular (73.4 vs. 19.4 %; Table 2). Both dual users and exclusive e-cigarette users preferred products with higher nicotine content (Table 2). Compared to exclusive e-cigarette users, dual users were more likely to use nicotine-containing products than nicotine-free products. Only 2.6 % of dual users used nicotine-free cartridges and 3.3 % reported using a solution without nicotine, while 5.8 % of exclusive e-cigarette users used nicotine-free cartridges and 10.8 % used nicotine-free solutions (Table 2).

Both dual and exclusive e-cigarette users preferred fruit-flavored products (58.4 and 54.7 %, respectively), followed by chocolate (2.6 and 1.4 %), and vanilla flavors (2.1 and 2.9 %). Only 3.9 % of dual users and 1.4 % of exclusive e-cigarette users used tobacco-flavored products. There were no differences in flavor preferences between dual users and exclusive e-cigarette users (Table 2).

Discussion

Our study adds to previous studies that report increasing use of novel nicotine products among minors (Camenga et al. 2014a; Goniewicz et al. 2014a) by showing that the prevalence of dual use is higher than the prevalence of exclusive use of a single product, whether it be electronic or tobacco cigarettes.

Concerns have been raised that using multiple tobacco products concurrently may result in greater nicotine dependence. Hamari et al. (2012) reported that dual users of snus and tobacco cigarettes in Sweden had higher levels of nicotine dependence and used the products more frequently than tobacco only smokers. We found that, compared to single product users, dual users puffed and smoked more, consumed electronic and tobacco cigarettes more frequently, were more likely to smoke a tobacco cigarette when they first woke up, and that they used products with higher nicotine levels compared to exclusive e-cigarette users. Taken together, these findings suggest that dual users are more addicted to nicotine.

Several studies suggest that e-cigarette users are exposed to lower yields of toxicants and carcinogens (Goniewicz et al. 2014b; Hecht et al. 2014) and thus substituting tobacco cigarettes with e-cigarettes may reduce the risk of developing tobacco-related diseases (Hajek et al. 2014; McNeill et al. 2014). However, young dual users who participated in our study reported smoking cigarettes more frequently and smoked more cigarettes per day than students who only smoked tobacco. In addition, using e-cigarettes in addition to tobacco cigarettes may reduce the likelihood of quitting (Grana et al. 2014). Studies are urgently needed to assess potential health benefits and risks of dual use of electronic and tobacco cigarettes, especially among younger smokers.

Our study found that the most dual users initiated smoking with tobacco cigarettes and later added e-cigarettes. However, the proportion of dual users who initiated smoking with e-cigarettes was not negligible. One in four students who used e-cigarettes only never smoked tobacco cigarettes. However, our data were cross sectional, and there is an urgent need for longitudinal studies of youth to carefully examine transitions between nicotine-containing products.

Some cross-sectional and longitudinal studies among adult smokers, as well as two randomized controlled trials, have suggested that e-cigarettes might facilitate smoking cessation among adult smokers (Biener and Hargraves 2014; Brown et al. 2014; Farsalinos et al. 2014). In surveys among adult e-cigarette users, the majority reported using e-cigarettes as a way to quit or reduce the number of tobacco cigarettes used (Goniewicz et al. 2013; Pepper and Brewer 2013). In our study, more than three quarters of exclusive e-cigarettes users were ex-smokers. While these findings are suggestive that e-cigarettes might be effective as a cessation aid, most students reported that they used e-cigarettes out of curiosity and not to quit smoking. Our findings are consistent with previous reports showing that

Table 2 Differences in use of electronic and tobacco cigarettes among current dual and exclusive users aged 16–18 in Poland ($n = 810$; December 2013–February 2014)

	Dual users ($n = 389$), %	Exclusive e-cigarette users ($n = 139$)	Dual vs. exclusive use, AOR (95 % CI)
Frequency of e-cigarette use			
Everyday	26.2	12.2	3.01 (1.67–5.41)*
Few times per week	21.3	11.5	2.66 (1.46–4.85)*
Less than once a week	51.9	71.9	Ref
Missing	0.5	4.3	–
Number of puffing episodes per day			
1–5	58.6	66.9	0.42 (0.22–0.77)*
6–10	9.5	3.6	1.26 (0.42–3.78)
More than 10	22.6	10.8	Ref
Missing	9.3	18.7	–
Time to first puff on e-cigarette on awakening			
Less than 30 min	15.4	7.2	1.44 (0.68–3.05)
More than 30 min	60.7	41.0	Ref
Missing	23.9	51.8	–
Flavor used			
Fruit	58.4	54.7	0.42 (0.09–1.93)
Chocolate	2.6	1.4	0.82 (0.09–7.01)
Vanilla	2.1	2.9	0.31 (0.05–2.17)
Other	17.0	15.8	0.43 (0.08–2.07)
Tobacco	3.9	1.4	Ref
Missing	16.2	23.7	–
Most common type of product used			
With disposable cartridges	5.1	7.2	0.61 (0.27–1.37)
Refillable	86.4	73.4	Ref
Missing	8.5	19.4	–
Nicotine level in e-cigarette cartridge			
Very strong (>24 mg)	4.4	4.3	1.86 (0.47–7.26)
Strong (17–24 mg)	11.8	6.5	3.15 (0.92–10.7)
Medium (12–16 mg)	10.3	5.8	2.87 (0.79–10.4)
Light (1–11 mg)	4.6	4.3	1.65 (0.40–6.82)
Zero (no nicotine)	2.6	5.8	Ref
Not used cartridges or missing data	66.3	73.4	–
Nicotine level in e-cigarette liquid			
24–36 mg	8.5	2.9	9.54 (2.59–35.1)*
18–23 mg	21.1	7.9	8.83 (3.26–24.0)*
11–17 mg	28.0	16.6	5.76 (2.35–14.1)*
1–10 mg	13.9	16.5	2.59 (1.05–6.40)*
0 mg	3.3	10.8	Ref
Not used liquids or missing data	12.1	45.3	–
	Dual use ($n = 389$)	Exclusive tobacco cigarette users ($n = 282$)	Dual vs. exclusive use, AOR (95 % CI)[a]
Frequency of tobacco smoking			
Everyday	58.6	32.3	3.54 (2.34–5.36)*
Few times per week	21.1	20.9	2.24 (1.39–3.59)*

Table 2 continued

	Dual use ($n = 389$)	Exclusive tobacco cigarette users ($n = 282$)	Dual vs. exclusive use, AOR (95 % CI)[a]
Less than once a week	19.8	45.4	Ref
Missing	0.5	1.4	–
Number of cigarettes per day			
Just 1	21.3	33.7	0.27 (0.12–0.57)*
2–5	39.3	41.5	0.45 (0.22–0.91)*
6–10	24.7	12.4	0.80 (0.37–1.73)
More than 10	13.4	4.3	Ref
Missing	1.3	7.4	–
Time to First Cigarette after Waking Up			
Less than 30 min	24.7	10.6	1.91 (1.18–3.09)*
More than 30 min	64.5	64.2	Ref
Missing	10.8	25.2	–
Usual type of cigarette based on nicotine content			
High nicotine (strong)	33.4	25.2	1.03 (0.68–1.58)
Low nicotine (light, super light, slim)	40.6	44.7	Ref
Other or missing	26.0	30.1	–
Usual type of tobacco flavor			
Menthol	35.5	46.8	0.93 (0.65–1.33)
Non-menthol	63.7	51.4	Ref
Missing	0.8	1.8	–

* Statistically significant

[a] ORs were adjusted for age, sex, family size, place of residence, and type of school (missing data were excluded from analysis)

young smokers use e-cigarettes in addition to tobacco cigarettes rather than as a smoking cessation tool (Carroll Chapman and Wu 2014; Kinnunen et al. 2014; Sutfin et al. 2013). It also suggests that motivations to try and use e-cigarettes differ between young people and adults.

Concerns have been raised about the appeal of flavors in e-cigarettes to children and adolescents (Durmowicz 2014; Pepper et al. 2013). Our study showed that flavored e-cigarettes are very popular among young users. Most dual users consumed products with non-tobacco flavorings, with fruit flavors being particularly popular. Studies are urgently needed to assess whether flavored e-cigarettes may appeal to nonsmoking children and increase the likelihood of e-cigarette uptake.

This study has several limitations and its findings need to be interpreted with caution. We did not use a nationally representative sample so that e-cigarette prevalence among students age 16–18 years in Poland may differ from that observed in our sample. However, cigarette smoking rates reported in our study were similar to estimates from a nationally representative sample in 2013 (38 vs. 42 %, respectively) (Public Opinion Research Center 2014). Although this study was conducted in Poland, our results are consistent with data from other countries showing high levels of dual use in youth (Dutra and Glantz 2014). Our study had a cross-sectional design that did not permit validation of reports of the temporal relationship between cigarette smoking and e-cigarette use. Nor did it permit assessment of the time between initiation of a single product and progression to dual use. Although these data were collected relatively recently, the observed relationship between using e-cigarettes and smoking among students may change, as popularity and use of e-cigarettes in this group is rapidly increasing. Finally, this study did not take concurrent use of e-cigarettes with tobacco products other than cigarettes (i.e., cigars, smokeless tobacco, hookah) or with other drugs such as alcohol and marijuana into account (Camenga et al. 2014b; Soneji et al. 2014).

Our study suggests urgent need for comprehensive tobacco control policy with regard to e-cigarettes. Regulations are needed to protect children and adolescents against uptake of both tobacco and electronic cigarettes. The new regulations should limit access to e-cigarettes by minors without restricting the access to the less-harmful products by current smokers.

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Compliance with ethical standards

Conflict of interest Dr. Goniewicz reports grants from Pfizer Inc., a manufacturer of smoking cessation drugs, outside the submitted work; Dr. Balwicki reports grants from Tobacco-Free Kids, outside the submitted work; Dr. Sobczak reports personal fees from the eSmoking Institute, Poznan, Poland and non-financial support from Chic Group LTD, a manufacturer of electronic cigarettes in Poland, outside the submitted work. The other authors have nothing to disclose.

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