Prevalence of E-Cigarette Use and Its Associated Factors Among Youths Aged 12 to 16 Years in 68 Countries and Territories: Global Youth Tobacco Survey, 2012–2019

Jiahong Sun, MD, Bo Xi, MD, Chuanwei Ma, MS, Min Zhao, MD, and Pascal Bovet, MD

See also Seaman, p. 541.

Objectives. To describe the recent global prevalence of e-cigarette use and to investigate its associated factors among youths aged 12 to 16 years in 68 countries and territories (hereafter "countries").

Methods. We analyzed 485 746 youths aged 12 to 16 years from the population-based cross-sectional Global Youth Tobacco Survey conducted in 67 countries between 2012 and 2019 and the 2019 National Youth Tobacco Survey in the United States. We defined past-30-day e-cigarette use as using e-cigarettes on 1 or more days during the past 30 days.

Results. The global prevalence of past-30-day e-cigarette use among youths was 9.2%, ranging from 1.9% in Kazakhstan to 33.2% in Guam. Maternal smoking (adjusted odds ratio [AOR] = 1.40; 95% confidence interval [CI] = 1.29, 1.52), paternal smoking (AOR = 1.13; 95% CI = 1.07, 1.19), secondhand smoke exposure (AOR = 1.74; 95% CI = 1.64, 1.84), youth cigarette smoking (AOR = 7.18; 95% CI = 6.84, 7.54), and youth other tobacco use (AOR = 3.88; 95% CI = 3.62, 4.15) were positively associated with e-cigarette use.

Conclusions. E-cigarette use was moderately frequent among youths aged 12 to 16 years globally. Several important factors were associated with youth e-cigarette use.

Public Health Implications. Our findings highlight the need for countries worldwide to develop policies to address e-cigarette use among youths. (*Am J Public Health*. 2022;112(4):650–661. https://doi.org/10.2105/AJPH.2021.306686)

AJPH April 2022, Vol 112, No. 4

The use of tobacco products, particularly combustible cigarettes, is the current second-leading cause for global deaths, accounting for nearly 9 million deaths (~15% of all deaths) in 2019.[1] Electronic cigarettes (e-cigarettes) do not use or burn tobacco leaves but heat e-liquid to vaporize aerosol containing flavorings dissolved in glycerin and propylene glycol.[2] A National Academics of Science, Engineering, and Medicine report suggested that e-cigarettes may be less harmful to health than combustible cigarettes because of not emitting combustible tobacco smoke, and they might be used as a substitute for combustible cigarettes for adult smokers.[3] A most recent Cochrane review with moderate-certainty evidence reported that e-cigarettes containing nicotine (i.e., electronic nicotine delivery systems [ENDS]) suggested potential benefits as a smoking cessation aid compared with usual care or no treatment, whereas further evidence is needed to investigate the potential adverse effects of e-cigarettes on human health.[4]

Accumulative evidence has shown that e-cigarette use has acute adverse effects on endothelial dysfunction and cerebral and vascular oxidative

stress.[5,6] However, the long-term safety of e-cigarettes has not been yet comprehensively quantified, and limited evidence has shown that e-cigarette use may have detrimental effects on pulmonary and cardiovascular systems.[7] ENDS may have additional adverse effects on memory, attention, and learning skills.[8] Other ingredients in e-cigarettes, such as flavoring additives and propylene glycol, may also have adverse effects on health.[9] The use of e-cigarettes might lead to consumption of combustible cigarettes among individuals who did not smoke combustible cigarettes previously, particularly among adolescents and young adults,[10–12] whereas the evidence is limited because of self-reported e-cigarette use instead of biochemical verification. In addition, e-cigarettes can also favor the consumption of other addictive substances such as alcohol and marijuana.[8,13] Therefore, considering the potential and uncertain adverse effects of e-cigarettes on health, monitoring the prevalence of e-cigarette use among youths is helpful to suggest opportunities for interventions and actions for policymakers at the national and local level.

It is reported that e-cigarette use (defined as use 1 day or more during the past 30 days) has increased from 0.6% in 2011 to 4.9% in 2018 among US middle-school students and from 1.5% to 20.8% among high-school students,[14] with a concomitant decrease in the prevalence of combustible cigarette smoking (middle-school students: 4.3% to 1.8%; high-school students: 15.8% to 8.1%). The use of e-cigarettes has also largely increased among older youths aged 16 to 19 years from 2017 to 2019 in Canada (8.4% to 17.8%) and England (8.7% to 12.6%).[15,16] However, limited data exist about e-cigarette use among youths in many other countries worldwide, particularly in low- and middle-income countries.

In this study, we estimated the recent prevalence of e-cigarette use among youths aged 12 to 16 years in 68 countries and territories (hereafter referred to as "countries") that had conducted a Global Youth Tobacco Survey (GYTS) and in the United States, which had a similar survey (National Youth Tobacco Survey [NYTS]). We also examined the association between selected influencing factors (including parental smoking, survey year, World Bank income level, youth cigarette smoking, youth other tobacco use, and secondhand smoke exposure) and e-cigarette use in youths.

METHODS

The most recent data on e-cigarette use among youths aged 12 to 16 years were extracted from the school-based GYTS conducted in 67 countries. The GYTS protocol was developed by the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC). Sampling followed a same 2-stage sampling strategy in all countries based on randomly selecting schools in each country considering the national or subnational populations in the first phase, and randomly selecting classes from the selected schools in the second phase. All included participants from each country voluntarily filled out a standard and anonymous questionnaire. Data from the GYTS are publicly available from the CDC Web site (https://www.cdc.gov/tobacco/global/gtss/gtssdata/index.html). For this study, we used all available GYTS data in the 67 countries that had conducted the GYTS between 2012 and 2019 (because data on e-cigarette use were available since 2012). All surveys were approved by the participating countries.

Because the GYTS was not conducted in the United States, we used similar data from the US NYTS done in 2019. The NYTS is a national survey of tobacco use and related factors among youths, with similar methods as the GYTS. In particular, the question and possible answers on e-cigarette use were identical in the GYTS and NYTS. Details on NYTS methodology are available electronically at https://www.cdc.gov/tobacco/data_statistics/index.htm. All participating youths and their parents gave informed consent for participation in the GYTS in all included countries and in the NYTS. A total of 485 746 youths aged 12 to 16 years with complete data on all variables of interest from the GYTS and the NYTS were included in the current study.

Definition of E-Cigarette Use and Tobacco Use

Past-30-day e-cigarette use in youths was defined as using e-cigarettes on 1 or more days during the past 30 days. Participants were asked to respond to the question "During the past 30 days, on how many days did you use e-cigarettes?" with the corresponding possible answers comprising "0 day," "1 to 2 days," "3 to 5 days," "6 to 9 days," "10 to 19 days," "20 to 29 days," and "All 30 days." The other frequency categories of e-cigarette use were defined as using e-cigarettes on 3 or more, 6 or more, and 10 or more days during the past 30 days. The e-cigarette use on 21 or more days or on 51 or more days of entire life was defined according to the question "How many days have you used an e-cigarette in your entire life?"

with corresponding responses of "0 day," "1 day," "2 to 10 days," "11 to 20 days," "21 to 51 days," and "51 to 100 days."

Past-30-day cigarette smoking in youths was assessed with the question "During the past 30 days, on how many days did you smoke cigarettes?" and smoking was defined as using cigarettes on 1 or more days during the past 30 days. Other tobacco use was assessed with the question "During the past 30 days, have you ever used any form of tobacco products other than cigarettes (e.g., chewing tobacco, snuff, dip, cigars, cigarillos, little cigars, or pipe)?" with answers of "Yes" or "No." Secondhand smoke exposure was assessed with the following 2 questions: "During the past 7 days, on how many days have people smoked in your home, in your presence?" and "During the past 7 days, on how many days have people smoked in your presence, in places other than in your home?" and defined as exposure to secondhand smoke at home or in other places on at least 1 day during the past 7 days. Parents' smoking status was assessed with the question "Do your parents smoke tobacco?" The corresponding possible answers were "Neither," "Father only," "Mother only," and "Both."

We extracted the policies on e-cigarette use in each included country and territory from the Web sites of the Institute for Global Tobacco Control supported by Johns Hopkins Bloomberg School of Public Health (i.e., https://globaltobaccocontrol.org/en/policy-scan/e-cigarettes/countries?country=263; https://www.tobaccocontrollaws.org/legislation). We obtained country income level from the World Bank classification according to the conducted year of GYTS survey.

Statistical Analysis

We calculated prevalence estimates and 95% confidence intervals (CIs) in each country by using the primary sampling units, strata, and sampling weights provided in the participating countries in the dataset. We used the χ^2 test to test differences in prevalence estimates between groups (i.e., sex, age group, and WHO region). We used multivariable logistic regression analyses considering the primary sampling units, strata, and sampling weights to examine the associations of sex, age group, parental smoking, youth cigarette smoking, youth other tobacco use, World Bank income level, survey year, and secondhand smoke exposure with youth e-cigarette use. There was no multicollinearity between all included variables, including the outcome (Table A, available as a supplement to the online version of this article at http://www.ajph.org). Therefore, all variables were included in the logistic regression model for analysis.

We conducted data analyses with SPSS version 16.0 using the Complex Samples module (SPSS Inc, Chicago, IL). We calculated total and subgroup-specific prevalence estimates by using meta-analysis with a random-effects model conducted with Stata version 11.0 (StataCorp LP, College Station, TX), because of the high heterogeneity ($I^2 > 50\%$) between countries by using the following command: "metan r ser, random label (namevar=study)," where "r" represents the prevalence of each country and "ser" represents standard error. We considered a 2-sided *P* level of less than .05 or nonoverlapped 95% CIs to be statistically significant because 95% CIs could be simultaneously provided independent of the change in sample size.[17,18]

RESULTS

The study included 485 746 youths aged 12 to 16 years (males: 50.1%) from the 68 included countries and territories (Macao is the special administrative region of China; Guam is an overseas territory of the United States; Gaza and West Bank are territories of Palestine) with data on e-cigarettes between 2012 and 2019. If a country had conducted more than 1 survey in the interval, we considered the latest survey, which was the case for 5 countries (Georgia, Romania, San Marino, China [without raw data], and the United States). Of these 68 countries (from Finland in 2012 to the United States and China in 2019), 4 (5.9%) were located in the WHO African region, 22 (32.4%) in the American region, 10 (14.7%) in the Eastern Mediterranean region, 19 (27.9%) in the European region, 1 (1.5%) in the Southeast Asian region, and 12 (17.6%) in the Western Pacific region; 15 of 68 countries (22.1%) had implemented policies on ENDS and electronic nonnicotine delivery systems (ENNDS) before the survey year of e-cigarette use in the country (Table 1).

As shown in Table 2 and Figure A (available as a supplement to the online version of this article at http://www.ajph.org), 9.2% (95% CI = 8.2%, 10.2%) of youths aged 12 to 16 years in 68 countries reported having used e-cigarettes on 1 or more days during the past 30 days, 3.9% (95% CI = 3.4%, 4.4%) on 3 or more days, 2.2% (95% CI = 1.9%, 2.5%) on 6 or more days, and 1.4% (95% CI = 1.2%, 1.6%) on 10 or more days. The prevalence of past-30-day e-cigarette use on 1 or more days was higher among male youths (11.7%; 95% CI = 10.5%, 13.0%) and

TABLE 1— Characteristics of Global Youth Tobacco Surveys Among Youths Aged 12–16 Years in 68 Countries and Territories, Using the Most Recent Data in Each Country: 2012–2019

Country or Territory	Representativeness	Survey Year	Sample Size	Male Youths, %	Availability of Policy for E-Cigarettes[a]
Africa					
Ghana	National	2017	5 253	50.7	No
Mauritania	National	2018	3 273	50.0	No
Mauritius	National	2016	3 944	48.7	No
Seychelles	National	2015	2 384	49.9	No
Americas					
Antigua and Barbuda	National	2017	1 961	51.0	No
Argentina	National	2018	1 329	49.2	Yes
Belize	National	2014	1 714	48.4	No
Bolivia	National	2018	4 365	50.0	No
Chile	Subnational	2016	10 898	49.3	No
Cuba	National	2018	4 043	50.9	No
Dominican Republic	National	2016	1 222	47.7	No
Ecuador	National	2016	5 051	49.8	No
El Salvador	National	2015	2 984	50.0	No
Grenada	National	2016	2 014	49.8	No
Guatemala	National	2015	3 943	51.9	No
Guyana	National	2015	1 538	49.7	No
Jamaica	National	2017	1 383	44.5	No
Nicaragua	National	2014	3 938	49.0	No
Panama	National	2017	2 544	50.1	Yes
Paraguay	National	2014	6 453	49.6	No
Peru	National	2014	3 497	50.4	No
Saint Lucia	National	2017	1 456	51.0	No
Saint Vincent and the Grenadines	National	2018	1 294	49.5	No
Suriname	National	2016	1 772	47.8	Yes
Trinidad and Tobago	National	2017	3 420	48.4	No
United States[b]	National	2019	13 642	52.2	Yes
Eastern Mediterranean					
Iraq	National	2014	1 600	53.6	No
Morocco	National	2016	3 704	43.6	No
Oman	National	2016	2 015	49.0	Yes
Qatar	National	2018	1 844	46.3	Yes
Tunisia	National	2017	2 390	50.2	No
UNRWA Gaza (Palestine)[c]	Regional	2013	1 664	50.4	No
UNRWA Jordan	Regional	2014	1 305	51.2	No
UNRWA Lebanon	Regional	2013	1 400	45.6	No
UNRWA West Bank (Palestine)[c]	Regional	2014	1 332	41.0	No
Yemen	National	2014	1 857	60.5	No

Continued

TABLE 1— Continued

Country or Territory	Representativeness	Survey Year	Sample Size	Male Youths, %	Availability of Policy for E-Cigarettes[a]
Europe					
Albania	National	2015	4 483	52.7	No
Bulgaria	National	2015	3 970	51.9	No
Croatia (Hrvatska)	National	2016	3 201	49.9	No
Czech Republic	National	2016	3 914	51.4	No
Finland	National	2012	4 769	50.5	No
Georgia	National	2017	1 266	50.6	No
Greece	National	2013	4 515	51.7	No
Kazakhstan	National	2014	2 043	49.7	No
Kosovo	National	2016	4 925	51.5	No
Latvia	National	2014	4 256	49.8	Yes
Malta	National	2017	1 225	55.3	No
Poland	National	2016	4 996	51.2	Yes
Republic of North Macedonia	National	2016	5 081	52.5	No
Romania	National	2017	5 294	51.2	Yes
Russian Federation	Subnational	2015	6 490	50.6	No
San Marino	National	2018	594	55.5	No
Serbia	National	2017	3 780	49.5	Yes
Slovakia	National	2016	3 955	49.9	No
Ukraine	National	2017	3 978	50.8	Yes
Southeast Asia					
Thailand	National	2015	1 863	51.1	Yes
Western Pacific					
Cambodia	National	2016	2 784	48.2	Yes
Cook Islands	National	2016	479	48.2	No
China	National	2019	273 206	51.8	No
Fiji	National	2016	2 274	48.5	Yes
Guam[d]	National	2017	1 736	52.2	No
Kiribati	National	2018	1 882	47.6	No
Laos	National	2016	5 625	50.2	No
Macao (China)[e]	Regional	2015	1 635	50.3	Yes
Marshall Islands	National	2016	2 233	44.2	No
Papua New Guinea	National	2016	1 854	50.6	No
Samoa	National	2017	1 467	48.7	No
Vanuatu	National	2017	1 547	47.1	No
Total			485 746	50.1	

Note. UNRWA = United Nations Relief and Works Agency for Palestine Refugees in the Near East.

[a]Data are from https://www.tobaccocontrollaws.org/legislation.
[b]The survey in the United States, which was not a Global Youth Tobacco Survey, is described in the text.
[c]Gaza and West Bank are territories of Palestine.
[d]Guam is an overseas territory of the United States.
[e]Macao is the special administrative region of China.

TABLE 2— Prevalence of Past-30-Day E-Cigarette Use Among Youths Aged 12–16 Years by Use Frequency, Sex, Age Group, and WHO Region in 68 Countries and Territories: 2012–2019

Group	No. of Countries or Territories	≥ 1 Day, % (95% CI)			≥ 3 Days, % (95% CI)			≥ 6 Days, % (95% CI)			≥ 10 Days, % (95% CI)		
		Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	68	9.2 (8.2, 10.2)	11.7 (10.5, 13.0)	6.6 (5.9, 7.2)[a]	3.9 (3.4, 4.4)	5.1 (4.4, 5.7)	2.4 (2.1, 2.8)[a]	2.2 (1.9, 2.5)	3.0 (2.6, 3.4)	1.3 (1.1, 1.5)[a]	1.4 (1.2, 1.6)	2.0 (1.7, 2.3)	0.8 (0.7, 0.9)[a]
Age group, y													
12–14	68	8.0 (7.1, 8.9)	10.2 (9.0, 11.4)	5.8 (5.1, 6.5)[a]	3.0 (2.6, 3.4)	4.1 (3.6, 4.7)	1.8 (1.5, 2.0)[a]	1.7 (1.4, 1.9)	2.4 (2.0, 2.7)	1.0 (0.8, 1.1)[a]	1.1 (0.9, 1.2)	1.4 (1.2, 1.7)	0.7 (0.5, 0.8)[a]
15–16	68	11.2 (9.8, 12.6)[b]	13.8 (12.0, 15.5)[b]	8.0 (6.9, 9.1)[a,b]	4.9 (4.2, 5.6)[b]	6.2 (5.3, 7.1)[b]	3.0 (2.5, 3.5)[a,b]	2.8 (2.3, 3.2)[b]	3.5 (3.0, 4.1)[b]	1.5 (1.2, 1.8)[a,b]	1.8 (1.5, 2.1)[b]	2.5 (2.0, 2.9)[b]	1.0 (0.8, 1.2)[a,b]
WHO region													
Africa	4	9.9 (6.0, 13.9)	12.7 (6.8, 18.6)	6.4 (3.6, 9.2)[a]	4.4 (2.3, 6.6)	6.0 (3.2, 8.7)	2.7 (0.7, 4.6)[a]	2.8 (1.2, 4.3)	3.5 (1.7, 5.3)	1.7 (0.4, 3.1)[a]	1.8 (0.7, 2.8)	2.1 (1.0, 3.3)	1.3 (0.2, 2.4)
Americas	22	7.8 (6.2, 9.5)	9.3 (7.4, 11.1)	6.4 (4.8, 8.0)[a]	3.3 (2.5, 4.2)	4.1 (3.1, 5.1)	2.5 (1.8, 3.2)[a]	1.9 (1.4, 2.5)	2.4 (1.8, 3.0)	1.3 (0.9, 1.7)[a]	1.3 (1.0, 1.6)	1.7 (1.2, 2.1)	0.8 (0.6, 1.1)[a]
Eastern Mediterranean	10	10.6 (7.9, 13.4)[c]	16.2 (11.7, 20.7)[c]	5.9 (4.2, 7.6)[a]	3.7 (2.6, 4.8)	6.0 (4.2, 7.8)[c]	1.6 (1.1, 2.2)[a,c]	2.0 (1.4, 2.5)	3.2 (2.2, 4.2)	0.9 (0.6, 1.2)[a]	1.1 (0.8, 1.4)	1.7 (1.2, 2.1)	0.5 (0.4, 0.7)[a,c]
Europe	19	9.3 (7.3, 11.3)	11.6 (9.3, 13.9)	6.6 (5.2, 8.1)[a]	4.3 (3.4, 5.3)	5.7 (4.4, 6.9)[c]	2.6 (1.9, 3.2)[a]	2.6 (2.0, 3.2)[c]	3.6 (2.8, 4.4)[c]	1.3 (0.9, 1.7)[a]	1.7 (1.3, 2.1)	2.6 (1.9, 3.3)[c]	0.8 (0.6, 1.1)[a]
Southeast Asia	1	3.3 (2.4, 4.6)	4.7 (3.5, 6.3)	1.9 (1.0, 3.6)[a]	1.1 (0.8, 1.6)	2.0 (1.3, 2.9)	0.2 (0.1, 0.9)[a]	0.9 (0.5, 1.4)	1.4 (0.9, 2.4)	0.2 (0.1, 0.9)[a]	0.4 (0.1, 1.0)	0.7 (0.3, 1.9)	0.0[a]
Western Pacific	12	10.8 (8.1, 13.6)[c]	13.5 (10.1, 16.9)[c]	8.1 (5.9, 10.2)[a]	4.6 (3.0, 6.2)	5.6 (3.6, 7.5)	3.2 (2.1, 4.2)[a]	2.4 (1.7, 3.2)	3.0 (1.9, 4.1)	1.5 (0.9, 2.1)[a]	1.6 (1.0, 2.2)	2.2 (1.3, 3.1)	1.0 (0.6, 1.4)[a]

Note. CI = confidence interval; WHO = World Health Organization.

[a]There was a statistically significant difference between sexes.
[b]There was a statistically significant difference between age groups.
[c]There was a statistically significant difference across WHO regions (Americas as Ref).

older youths aged 15 to 16 years (11.2%; 95% CI = 9.8%, 12.6%) than among female youths (6.6%; 95% CI = 5.9%, 7.2%) and younger youths aged 12 to 14 years (8.0%; 95% CI = 7.1%, 8.9%) with a *P* level of less than .001 and nonoverlapped 95% CIs. The prevalence was higher in regions of the Western Pacific and Eastern Mediterranean than in the Americas.

As shown in Table 3, the prevalence was higher in youths who smoked cigarettes (vs those who did not), in those who smoked other tobacco products (vs those who did not), and in low-income and high-income countries (vs middle-income countries). The prevalence of past-30-day e-cigarette use on 1 or more days during the past 30 days among youths varied across countries, ranging from 1.9% in Kazakhstan to 33.2% in Guam (Figure B and Table B, available as supplements to the online version of this article at http://www.ajph.org). Similar patterns were found in other frequency categories of e-cigarette use (≥ 3 days, ≥ 6 days, and ≥ 10 days during the past 30 days, Tables 2 and 3). In addition, in nearly all included countries, cigarette smokers were more likely to use e-cigarettes than noncigarette smokers (Table C, available as a supplement to the online version of this article at http://www.ajph.org). Among youths who were e-cigarette users (on ≥ 1 day during the past 30 days), 19.2% and 12.1% had used e-cigarettes on 21 or more days and 51 or more days, respectively, during their entire life (Table D, available as a supplement to the online version of this article at http://www.ajph.org). In addition, youths with more days of past-30-day e-cigarette use were more likely to be sustained users of e-cigarettes over a longer period (e.g., on ≥ 21 or ≥ 51 lifetime days; Table E, available as a supplement to the online version of this article at http://www.ajph.org).

As shown in Table 4, male youths (vs female youths; adjusted odds ratio [AOR] = 1.73; 95% CI = 1.65, 1.80), older youths aged 15 to 16 years (vs younger ones aged 12 to 14 years; AOR = 1.07; 95% CI = 1.03, 1.12), mother alone smoked (vs neither; AOR = 1.40; 95% CI = 1.29, 1.52), father alone smoked (vs neither; AOR = 1.13; 95% CI = 1.07, 1.19), both parents smoked (vs neither; AOR = 1.76; 95% CI = 1.66, 1.87), youth past-30-day cigarette use (vs no; AOR = 7.18; 95% CI = 6.84, 7.54), youth other tobacco use (vs no; AOR = 3.88; 95% CI = 3.62, 4.15), low income level (vs middle income level; AOR = 2.09; 95% CI = 1.88, 2.33), high income level (vs middle income level; AOR = 1.75; 95% CI = 1.39, 2.12), survey year 2016–2019 (vs 2012–2015; AOR = 1.44; 95% CI = 1.37, 1.52), and youth secondhand smoke exposure (vs no; AOR = 1.74; 95% CI = 1.64, 1.84) were positively associated with youth e-cigarette use. Subgroup analyses by sex and a country's World Bank income level showed similar results (Tables F and G, available as supplements to the online version of this article at http://www.ajph.org).

DISCUSSION

Our study showed that the prevalence of past-30-day e-cigarette use on 1 or more days was 9.2% among youths aged 12 to 16 years from 68 countries surveyed between 2012 and 2019, similar to (somewhat higher than) a recent meta-analysis of data from 69 countries between 2016 and 2020 showing that the pooled prevalence of current e-cigarette use among youths younger than 20 years was 7.8%.[19] However, there are 2 limitations for that meta-analysis. First, not all included countries in that meta-analysis used standard methods for data collection. Second, that meta-analysis did not include low-income countries. We additionally found that the prevalence of e-cigarette use in low-income countries was significantly higher than that in middle-income countries, which might be attributable to insufficient economic power to implement regulations and low awareness of harms of e-cigarettes. Furthermore, to the best of our knowledge, we first found that the prevalence was much higher in male youths and older youths, and that youth cigarette use, low and high levels of country income, youth other tobacco product use, the survey years of 2016 to 2019, parental smoking, and secondhand smoking exposure were positively associated with the use of e-cigarettes among youths.

In this study, the prevalence of past-30-day e-cigarette use on 1 or more days ranged from 1.9% in Kazakhstan to 33.2% in Guam, and nearly half of the included countries (31 of 68) had prevalence greater than 10.0%. Although the prevalence varied largely across countries in our study, previous studies in specific countries also showed a high national prevalence of past-30-day e-cigarette use on 1 or more days among youths (e.g., 19.2% in 2019 among the US middle- and high-school students,[20] 6.2% in 2017 among Serbian youths aged 13–15 years,[21] 32.9% in 2017–2018 among Guam middle- and high-school students[22]). These findings suggest that the high prevalence of e-cigarette use among youths in many countries is worrying, and continuous efforts are needed to prevent and reduce the use of e-cigarettes among youths.

TABLE 3— Prevalence of Past-30-Day E-Cigarette Use Among Youths Aged 12–16 Years by Use Frequency, Sex, World Bank Income Level, Cigarette Smoking, and Other Tobacco Use in 68 Countries and Territories: 2012–2019

Group	No. of Countries or Territories	≥ 1 Day, % (95% CI)			≥ 3 Days, % (95% CI)			≥ 6 Days, % (95% CI)			≥ 10 Days, % (95% CI)		
		Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
World Bank income level													
Low	4	14.3[b] (11.1, 17.4)	23.6[b] (17.7, 29.5)	7.1[a] (5.3, 8.9)	5.3[b] (3.8, 6.8)	9.1[b] (6.5, 11.7)	2.0[a] (1.2, 2.7)	2.6[b] (1.8, 3.3)	4.3[b] (2.7, 6.0)	1.1[a] (0.6, 1.6)	1.4 (1.0, 1.8)	2.2 (1.4, 2.9)	0.7[a] (0.4, 0.9)
Middle	17	8.1 (6.5, 9.7)	10.3 (8.0, 12.6)	5.4[a] (4.3, 6.5)	3.0 (2.3, 3.7)	4.0 (3.1, 4.9)	1.7[a] (1.2, 2.2)	1.6 (1.2, 2.0)	2.3 (1.6, 2.9)	0.8[a] (0.6, 1.1)	1.1 (0.8, 1.4)	1.5 (1.1, 1.9)	0.5[a] (0.3, 0.6)
Upper-middle	29	8.1 (6.8, 9.3)	10.3 (8.7, 12.0)	5.6[a] (4.8, 6.5)	3.1 (2.6, 3.6)	4.1 (3.4, 4.9)	1.9[a] (1.5, 2.3)	1.7 (1.4, 2.0)	2.4 (2.0, 2.8)	0.9[a] (0.7, 1.1)	1.0 (0.9, 1.2)	1.6 (1.3, 1.9)	0.7[a,b] (0.5, 0.8)
High	18	11.0[b] (8.1, 13.9)	12.9 (9.7, 16.2)	8.9[a,b] (6.4, 11.4)	5.5[b] (4.0, 7.1)	6.7[b] (5.0, 8.5)	4.0[a,b] (2.9, 5.2)	3.5[b] (2.6, 4.3)	4.3[b] (3.2, 5.4)	2.3[a,b] (1.6, 3.1)	2.4[b] (1.8, 3.0)	3.2[b] (2.3, 4.1)	1.5[a,b] (1.0, 1.9)
Cigarette smoking													
No	68	5.7 (5.0, 6.4)	7.2 (6.3, 8.1)	4.1[a] (3.6, 4.7)	1.8 (1.6, 2.1)	2.4 (2.1, 2.7)	1.1[a] (1.0, 1.3)	1.0 (0.9, 1.2)	1.3 (1.1, 1.5)	0.7[a] (0.5, 0.8)	0.7 (0.5, 0.8)	0.8 (0.7, 1.0)	0.4[a] (0.3, 0.5)
Yes	68	33.5[c] (29.2, 37.8)	35.5[c] (31.2, 39.8)	29.9[a,c] (25.8, 34.1)	17.5[c] (14.9, 20.2)	19.2[c] (16.2, 22.1)	15.1[a,c] (12.7, 17.5)	10.6[c] (8.9, 12.2)	12.3[c] (10.3, 14.2)	7.7[a,c] (6.3, 9.1)	7.2[c] (6.0, 8.4)	8.6[c] (7.1, 10.1)	4.7[a,c] (3.7, 5.6)
Other tobacco products use													
No	68	7.5 (6.7, 8.2)	8.6 (7.8, 9.5)	5.2[a] (4.6, 5.8)	2.1 (1.8, 2.4)	2.7 (2.4, 3.0)	1.5[a] (1.2, 1.9)	1.3 (1.1, 1.5)	1.6 (1.4, 1.8)	1.1[a] (0.9, 1.3)	0.8 (0.5, 1.0)	0.9 (0.7, 1.1)	0.6[a] (0.5, 0.7)
Yes	68	23.2[d] (21.0, 25.3)	26.5[d] (23.2, 29.7)	20.3[a,d] (18.7, 21.8)	13.6[d] (11.5, 15.6)	15.8[d] (13.6, 17.9)	12.6[a,d] (11.2, 13.0)	9.8 (9.5, 10.1)	11.3[d] (10.2, 12.3)	6.8[a,d] (6.1, 7.5)	6.6[d] (5.8, 7.4)	7.2[d] (6.6, 7.8)	4.5[a,d] (3.4, 5.5)

Note. CI = confidence interval.

[a]There was a statistical significance between sexes.
[b]There was a statistically significant difference compared with middle-income countries.
[c]There was a statistically significant difference between cigarette smoking statuses.
[d]There was a statistically significant difference between other tobacco products use statuses.

TABLE 4— Associated Factors With Past-30-Day E-Cigarette Use (on ≥ 1 Day) Among Youths Aged 12–16 Years in 68 Countries and Territories: 2012–2019

Variable	Prevalence, %	B	AOR (95% CI)[a]
Sex			
Female	6.6		1 (Ref)
Male	11.7	0.546	1.73 (1.65, 1.80)
Age group, y			
12–14	8.0		1 (Ref)
15–16	11.2	0.070	1.07 (1.03, 1.12)
Parental smoking status			
Neither	7.2		1 (Ref)
Father only	10.3	0.122	1.13 (1.07, 1.19)
Mother only	15.7	0.334	1.40 (1.29, 1.52)
Both	20.4	0.567	1.76 (1.66, 1.87)
Cigarette smoking			
No	5.7		1 (Ref)
Yes	33.5	1.971	7.18 (6.84, 7.54)
Other tobacco product use			
No	7.5		1 (Ref)
Yes	23.2	1.355	3.88 (3.62, 4.15)
World Bank income level			
Low	14.3	0.737	2.09 (1.88, 2.33)
Middle	8.1		1 (Ref)
Upper-middle	8.1	−0.088	0.92 (0.78, 1.06)
High	11.0	0.562	1.75 (1.39, 2.12)
Survey year			
2012–2015	6.9		1 (Ref)
2016–2019	10.3	0.365	1.44 (1.37, 1.52)
Secondhand smoke exposure			
No	4.9		1 (Ref)
Yes	11.8	0.551	1.74 (1.64, 1.84)

Note. AOR = adjusted odds ratio; CI = confidence interval. All variables listed in the table were introduced into logistic regression models.

[a]Odds ratios after adjustment for all potential covariates listed in the table.

The prevalence was lower when based on using e-cigarettes on 3 or more days versus 1 or more days (e.g., in Guam: 19.0% vs 33.2%). This is consistent with the finding that the prevalence of regular cigarette smoking in youths decreased by 2 times when based on smoking on 1 or more days versus 3 or more days in the past 30 days.[23] This suggests that the high prevalence of e-cigarette use on 1 or more days might include a substantial proportion of experimenters. Smoking uptake typically transits through 5 stages: preparation, initial trying, experimentation, regular smoking, and nicotine addiction.[24] We also found that nearly one fifth of youths who were past-30-day e-cigarette users (on ≥ 1 day) regularly used e-cigarettes on 21 or more days in their entire life. Our findings suggest that nearly four fifths of youths who were past-30-day e-cigarette users (on ≥ 1 day) might be in preparation for the experimentation stage. We are not aware of studies assessing the proportion of experimenters who transit to regular users, but we can speculate that this proportion would not largely differ from that of combustible cigarettes given the nicotine content in the main types of e-cigarettes. We additionally found that youths with more days of past-30-day e-cigarette use were more likely to be sustained users of e-cigarettes over a

longer period (e.g., ≥ 21 or ≥ 51 lifetime days). Therefore, strategies aimed at preventing experimenters from becoming sustained smokers are greatly needed.

We found that the use of e-cigarettes was strongly associated with cigarette use. However, the temporal relation between using e-cigarettes and using combustible cigarettes is controversial, which needs to be investigated in further studies using longitudinal study design with an adequate follow-up. Although previous meta-analyses and reviews based on longitudinal cohort data suggested that e-cigarette use could be a gateway to cigarette use among youths,[11] the aggregate impact might be minimal because of the small increase in smoking initiation among young people.[25] In addition, the information on e-cigarette use was self-reported, and there were several limitations in study designs of previous studies. Although e-cigarettes have been regarded as a smoking cessation aid among adults, they contain pleasurable flavors that may stimulate a vaper's sensory experience.[26] Based on data from the 2016 NYTS in the United States, the common reasons for e-cigarette use among students were the use by family members or friends, pleasurable flavors, and belief of it being less harmful than cigarettes.[27] These findings highlight the need for balancing e-cigarettes' benefits for smoking cessation and their risks to youths, especially to nonsmokers, which may include prohibiting some flavors in e-cigarettes that make them more attractive, limiting added chemicals, ensuring that e-cigarette cartridges and tanks are sealed and disposable, and promoting educational campaigns, such as including messages with specific health effects of e-cigarette use.

Although we did not assess trends in the use of e-cigarettes based on GYTS because of limited available data in the data set, we found prevalence of e-cigarette use increased with survey years. Several previous studies have shown an increasing trend in e-cigarette use among youths.[14,28] These findings highlight that policymakers should also pay close attention to effective control measures of e-cigarette use among youths. Trends in e-cigarette use prevalence in other countries and worldwide among youths should be explored in the future. We found that male youths and older youths were more likely to use e-cigarettes compared with female youths and younger youths, which may be related to sex-specific risk-taking behaviors and peer pressure[29,30] as youths grow older.[31] It has been shown that smoking combustible cigarettes is influenced by family members.[32] We found a similar association of youth e-cigarette use with parental cigarette smoking. In addition, maternal smoking appears to be more influential on e-cigarette use among youths than paternal smoking. This may relate to generally longer time spent at home by youths with their mother versus father and possibly stronger maternal than paternal influence on children's behaviors.[33] Our finding of a relation between e-cigarette use by youths and secondhand cigarette smoking exposure likely partly reflects an effect of parental smoking.[34] In addition, secondhand smoking exposure also reflects habits by peers and by the general public outside of schools.[35] These findings underscore the importance of smoke-free environments in places attended by children and youths, and it might be necessary for policymakers to consider strategies addressing disparities in sex and age.

Strengths and Limitations

A strong point of this study was that data relied on a same standard questionnaire and sampling strategy in all countries, making prevalence estimates directly comparable across countries. In addition, we examined the frequency of e-cigarette use (e.g., ≥ 1 day, ≥ 3 days, ≥ 6 days, or ≥ 10 days during the past 30 days), which may help distinguish experimentation versus regular use.

However, the study also has several limitations. First, data on e-cigarette use were self-reported, which may lead to recall bias with over- or underestimation. Second, data were based on answers to a single question on e-cigarettes in the GYTS surveys, so we are unable to distinguish the use of different systems of e-cigarettes (i.e., ENDS and ENNDS[2]). Third, because data were based on cross-sectional designs, and surveys included in this study were done on only 1 point of time, we cannot infer whether the use of e-cigarettes precedes, follows, or adds to cigarette smoking among youths. Fourth, survey years were different across countries (2012–2019), which may impede the direct comparisons. However, the years when the surveys were conducted were mainly distributed between 2014 and 2018 (91%; 62 of 68 countries). In addition, the pooled prevalence of past-30-day e-cigarette use on 1 or more days based on the 62 countries between 2014 and 2018 was 9.3% (95% CI = 8.2%, 10.4%), which is largely similar to the pooled prevalence based on the 68 countries between 2012 and 2019 (9.2%; 95% CI = 8.2%, 10.2%).

Fifth, many countries outside the included 68 countries were not included in our study because GYTS data did not include data on e-cigarette use in those countries. Sixth, GYTS did not provide information on different types and flavors of e-cigarettes, which should be added in later GYTS questionnaires. Seventh, because the policies across different countries vary, we cannot directly answer whether the policy in the specific country had an effect on e-cigarette use among youths worldwide. To answer this question, it is better to be based on repeated cross-sectional data at least before and after the implementation of policy in the specific country.

Conclusions

In conclusion, we found that e-cigarette use among youths remains a significant public health issue worldwide. Further studies will need to assess to what extent youths use e-cigarettes and combustible cigarettes simultaneously or whether the use of one product leads to the use of the other. Furthermore, our study emphasizes the need for adequate strategies and measures to control tobacco products generally and e-cigarettes more specifically among youths globally. AJPH

ABOUT THE AUTHORS

Jiahong Sun, Bo Xi, and Chuanwei Ma are with the Department of Epidemiology, School of Public Health, Qilu Hospital, Cheeloo College of Medicine, Shandong University, Jinan, Shandong, China. Min Zhao is with the Department of Nutrition and Food Hygiene, School of Public Health, Cheeloo College of Medicine. Pascal Bovet is with the Center for Primary Care and Public Health (Unisanté), University of Lausanne, Lausanne, Switzerland.

CORRESPONDENCE

Correspondence should be sent to Bo Xi, Department of Epidemiology, School of Public Health, Qilu Hospital, Cheeloo College of Medicine, Shandong University, 44 Wen Hua Xi Road, Jinan, 250012, China (e-mail: xibo2007@126.com). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

PUBLICATION INFORMATION

Full Citation: Sun J, Xi B, Ma C, Zhao M, Bovet P. Prevalence of e-cigarette use and its associated factors among youths aged 12 to 16 years in 68 countries and territories: Global Youth Tobacco Survey, 2012–2019. *Am J Public Health*. 2022; 112(4):650–661.

Acceptance Date: December 16, 2021.

DOI: https://doi.org/10.2105/AJPH.2021.306686

CONTRIBUTORS

B. Xi and P. Bovet designed the study and led the writing of the article. B. Xi was the principal investigator. J. Sun drafted the first version of the article. C. Ma did the data analysis. M. Zhao collated the data. All authors critically revised the article and approved the final version of the article.

ACKNOWLEDGMENTS

This study was supported by the Youth Team of Humanistic and Social Science of Shandong University (20820IFYT1902).

We thank the US Centers for Disease Control and Prevention for sharing the Global Youth Tobacco Survey (GYTS) data.

Note. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.

CONFLICTS OF INTEREST

We declare no competing interests.

HUMAN PARTICIPANT PROTECTION

Data from the GYTS and the NYTS are deidentified and do not include any data that allow participant identification. The country data sets are publicly available and have complied with a corresponding national ethical board review.

REFERENCES

1. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet.* 2020;396(10258):1223–1249. https://doi.org/10.1016/S0140-6736(20)30752-2
2. World Health Organization. Electronic nicotine delivery systems and electronic non-nicotine delivery systems (ENDS/ENNDS). January 22, 2017. Available at: https://www.who.int/news/item/22-01-2017-electronic-nicotine-delivery-systems-and-electronic-non-nicotine-delivery-systems-(ends-ennds). Accessed June 30, 2021.
3. Rigotti NA. Balancing the benefits and harms of e-cigarettes: a National Academies of Science, Engineering, and Medicine report. *Ann Intern Med.* 2018;168(9):666–667. https://doi.org/10.7326/M18-0251
4. Hartmann-Boyce J, McRobbie H, Lindson N, et al. Electronic cigarettes for smoking cessation. *Cochrane Database Syst Rev.* 2020;10:CD010216.
5. Münzel T, Hahad O, Kuntic M, Keaney JF, Deanfield JE, Daiber A. Effects of tobacco cigarettes, e-cigarettes, and waterpipe smoking on endothelial function and clinical outcomes. *Eur Heart J.* 2020;41(41):4057–4070. https://doi.org/10.1093/eurheartj/ehaa460
6. Wills TA, Soneji SS, Choi K, Jaspers I, Tam EK. E-cigarette use and respiratory disorders: an integrative review of converging evidence from epidemiological and laboratory studies. *Eur Respir J.* 2021;57(1):1901815. https://doi.org/10.1183/13993003.01815-2019
7. Blagev DP, Harris D, Dunn AC, Guidry DW, Grissom CK, Lanspa MJ. Clinical presentation, treatment, and short-term outcomes of lung injury associated with e-cigarettes or vaping: a prospective observational cohort study. *Lancet.* 2019;394(10214):2073–2083. https://doi.org/10.1016/S0140-6736(19)32679-0
8. Office of the Surgeon General. *E-cigarette Use Among Youth and Young Adults: A Report of the Surgeon General.* 2016. Available at: https://e-cigarettes.surgeongeneral.gov/documents/2016_SGR_Full_Report_non-508.pdf. Accessed June 29, 2021.
9. Barrington-Trimis JL, Samet JM, McConnell R. Flavorings in electronic cigarettes: an unrecognized respiratory health hazard? *JAMA.* 2014;312(23): 2493–2494. https://doi.org/10.1001/jama.2014.14830
10. Khouja JN, Suddell SF, Peters SE, Taylor AE, Munafo MR. Is e-cigarette use in non-smoking young adults associated with later smoking? A systematic review and meta-analysis. *Tob Control.* 2020;10(30):8–15.
11. O'Brien D, Long J, Quigley J, Lee C, McCarthy A, Kavanagh P. Association between electronic cigarette use and tobacco cigarette smoking initiation in adolescents: a systematic review and meta-analysis. *BMC Public Health.* 2021;21(1):954. https://doi.org/10.1186/s12889-021-10935-1
12. Glasser A, Abudayyeh H, Cantrell J, Niaura R. Patterns of e-cigarette use among youth and young adults: review of the impact of e-cigarettes on cigarette smoking. *Nicotine Tob Res.* 2019;21(10): 1320–1330. https://doi.org/10.1093/ntr/nty103
13. Chadi N, Schroeder R, Jensen JW, Levy S. Association between electronic cigarette use and marijuana use among adolescents and young adults: a systematic review and meta-analysis. *JAMA Pediatr.* 2019;173(10):e192574. https://doi.org/10.1001/jamapediatrics.2019.2574
14. Gentzke AS, Creamer M, Cullen KA, et al. Vital signs: Tobacco product use among middle and high school students—United States, 2011–2018. *MMWR Morb Mortal Wkly Rep.* 2019;68(6): 157–164. https://doi.org/10.15585/mmwr.mm6806e1
15. Hammond D, Rynard VL, Reid JL. Changes in prevalence of vaping among youths in the United States, Canada, and England from 2017 to 2019. *JAMA Pediatr.* 2020;174(8):797–800. https://doi.org/10.1001/jamapediatrics.2020.0901
16. 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 [erratum in *BMJ.* 2020;370:m2579]. *BMJ.* 2019;365:l2219. https://doi.org/10.1136/bmj.l2219

17. Cumming G. Replication and p intervals: p values predict the future only vaguely, but confidence intervals do much better. *Perspect Psychol Sci.* 2008;3(4):286–300. https://doi.org/10.1111/j.1745-6924.2008.00079.x
18. Hazra A, Gogtay N. Biostatistics series module 2: overview of hypothesis testing. *Indian J Dermatol.* 2016;61(2):137–145. https://doi.org/10.4103/0019-5154.177775
19. Yoong SL, Hall A, Leonard A, et al. Prevalence of electronic nicotine delivery systems and electronic non-nicotine delivery systems in children and adolescents: a systematic review and meta-analysis. *Lancet Public Health.* 2021;6(9):e661–e673. https://doi.org/10.1016/S2468-2667(21)00106-7
20. Cullen KA, Gentzke AS, Sawdey MD, et al. E-cigarette use among youth in the United States, 2019. *JAMA.* 2019;322(21):2095–2103. https://doi.org/10.1001/jama.2019.18387
21. Kilibarda B, Vukovic D, Krstev S. Prevalence and correlates of concurrent use of cigarettes, electronic cigarettes, and waterpipes among Serbian youth. *Tob Induc Dis.* 2019;17:66. https://doi.org/10.18332/tid/111357
22. Pokhrel P, Dalisay F, Pagano I, Buente W, Guerrero E, Herzog TA. Adolescent tobacco and betel nut use in the US-affiliated Pacific Islands: evidence from Guam. *Am J Health Promot.* 2019;33(7):1058–1062. https://doi.org/10.1177/0890117119847868
23. Ma C, Xi B, Li Z, et al. Prevalence and trends in tobacco use among adolescents aged 13–15 years in 143 countries, 1999–2018: findings from the Global Youth Tobacco Surveys. *Lancet Child Adolesc Health.* 2021;5(4):245–255. https://doi.org/10.1016/S2352-4642(20)30390-4
24. Choi WS, Pierce JP, Gilpin EA, Farkas AJ, Berry CC. Which adolescent experimenters progress to established smoking in the United States. *Am J Prev Med.* 1997;13(5):385–391. https://doi.org/10.1016/S0749-3797(18)30159-4
25. Balfour DJK, Benowitz NL, Colby SM, et al. Balancing consideration of the risks and benefits of e-cigarettes. *Am J Public Health.* 2021;111(9):1661–1672. https://doi.org/10.2105/AJPH.2021.306416
26. 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(8):788–797. https://doi.org/10.1001/jamapediatrics.2017.1488
27. Tsai J, Walton K, Coleman BN, et al. Reasons for electronic cigarette use among middle and high school students—National Youth Tobacco Survey, United States, 2016. *MMWR Morb Mortal Wkly Rep.* 2018;67(6):196–200. https://doi.org/10.15585/mmwr.mm6706a5
28. Chinese Center for Disease Control and Prevention. Report on tobacco use among middle school students in China, 2019. May 31, 2020. Available at: http://www.chinacdc.cn/jkzt/sthd_3844/slhd_4156/202005/t20200531_216942.html. Accessed March 23, 2021.
29. Okoli C, Greaves L, Fagyas V. Sex differences in smoking initiation among children and adolescents. *Public Health.* 2013;127(1):3–10. https://doi.org/10.1016/j.puhe.2012.09.015
30. Reidpath DD, Davey TM, Kadirvelu A, Soyiri IN, Allotey P. Does one cigarette make an adolescent smoker, and is it influenced by age and age of smoking initiation? Evidence of association from the US Youth Risk Behavior Surveillance System (2011). *Prev Med.* 2014;59:37–41. https://doi.org/10.1016/j.ypmed.2013.11.011
31. Goncy EA, Mrug S. Where and when adolescents use tobacco, alcohol, and marijuana: comparisons by age, gender, and race. *J Stud Alcohol Drugs.* 2013;74(2):288–300. https://doi.org/10.15288/jsad.2013.74.288
32. Joung MJ, Han MA, Park J, Ryu SY. Association between family and friend smoking status and adolescent smoking behavior and e-cigarette use in Korea. *Int J Environ Res Public Health.* 2016;13(12):1183. https://doi.org/10.3390/ijerph13121183
33. Huizink AC, Greaves-Lord K, Oldehinkel AJ, Ormel J, Verhulst FC. Hypothalamic-pituitary-adrenal axis and smoking and drinking onset among adolescents: the longitudinal cohort TRacking Adolescents' Individual Lives Survey (TRAILS). *Addiction.* 2009;104(11):1927–1936. https://doi.org/10.1111/j.1360-0443.2009.02685.x
34. Zhang X, Pu J. E-cigarette use among US adolescents: secondhand smoke at home matters. *Int J Public Health.* 2016;61(2):209–213. https://doi.org/10.1007/s00038-015-0784-6
35. Dai H. Exposure to secondhand aerosol from electronic cigarettes among US youth from 2015 to 2018. *JAMA Pediatr.* 2020;174(3):298–300. https://doi.org/10.1001/jamapediatrics.2019.5665