

An Analysis of Associations Between Electronic Nicotine Delivery System Users

Nauris Tamulevicius, Mary P Martinasek, Sarah J Moss, Ines Pfeffer, Linda M Gibson-Young, and Musa Yahaya

BACKGROUND: Electronic nicotine-delivery systems have been increasing in prevalence among young adults. Although these devices are marketed to aid in quit smoking, young adults who do not smoke traditional cigarettes are using these devices. This study explored associations between individuals' quit type (ie, no plans to quit, plans to quit, or quit > 6 months ago) and perceived health status, perception of harm compared to cigarettes, perception of secondhand vapor harm, and reasons for first use. **METHODS:** We utilized a cross-sectional study design using a 33-item electronic survey questionnaire. The total sample size was 2,792. Out of these the ENDS users were 1,217. The survey was distributed to university students in 5 areas in 3 countries: the United States (ie, Florida, Alabama, and Illinois), Germany (ie, Hamburg) and South Africa (ie, Potchefstroom). **RESULTS:** Quantitative data analysis indicated that, regardless of quit status, there was a general lack of knowledge regarding secondhand vapor effects. Additionally, young adults are utilizing these products primarily due to peer influence and stress relief. Harm perception may factor into quit attempts using electronic nicotine-delivery systems. **CONCLUSIONS:** Education provided by respiratory therapists (and to respiratory therapy students) would be valuable as they inform patients and communities of the scholarly literature on vaping devices. *Key words:* electronic nicotine delivery systems (ENDS); e-cig; vaping; harm perception; health status; reason for first ends use; student population. [Respir Care 2020;65(3):355–361. © 2020 Daedalus Enterprises]

Introduction

Traditional cigarette smoking has declined among young adults in the United States through educational campaigns and statewide efforts. This celebrated decline has been met with an unfortunate increase in vaping among both young adults wanting to quit smoking and those who are cigarette-naïve (ie, never smoked a traditional cigarette). Con-

cerns are mounting that these nicotine-laden products will lead to a reversal in this decline.

Vaping is the use of electronic nicotine-delivery systems (ENDS), which encompass a wide variety of delivery devices that produce vapors (aerosols) typically containing nicotine, propellants, and additive flavorings. The ENDS are patented and advertised as a mechanism to help traditional cigarette smokers quit smoking. Young adults are drawn to these devices for other reasons. Since 2014, ENDS are the most widespread nicotine product used among the 18–25 y-old age group, and their use continues to increase.¹ The prevalence is not new: there has been an increasing trend of ever-use of ENDS from 6.9% in 2011

Drs Tamulevicius and Martinasek are affiliated with the Department of Health Science and Human Performance, The University of Tampa, Tampa, Florida. Dr Moss is affiliated with the Physical Activity, Sport and Recreation Research Focus Area, Faculty of Health Sciences, North-West University, Potchefstroom, South Africa. Dr Pfeffer is affiliated with the Department of Pedagogy, Medical School Hamburg, University of Applied Sciences and Medical University, Hamburg, Germany. Dr Gibson-Young is affiliated with the Auburn University School of Nursing, Auburn, Alabama. Mr Yahaya is affiliated with the Department of Public Health and Recreation Professions, Southern Illinois University, Carbondale, Illinois.

Correspondence: Nauris Tamulevicius PhD, Department of Health Sciences and Human Performance, College of Natural and Health Sciences, The University of Tampa, 401 W. Kennedy Blvd, Tampa, FL 33606-1490. E-mail: NTamulevicius@ut.edu.

The authors have disclosed no conflicts of interest.

DOI: 10.4187/respcare.07172

to 7.8% in 2013 and almost doubling to 14.3% in 2014.¹ The most current prevalence of ever-use and current-use of ENDS among young adults 18–24 y old is 35.8% and 13.6%, respectively.¹ In some areas there has been a 10% increase in ENDS use in a single year.² College student data in California indicated a 49% ever-use and 10% current-use rate.³ Other studies have reported 29.0–30.7% ever-use and 7.1–14% current-use among college students.^{4,6} As compared to older adults, these prevalence rates are significantly higher; adult prevalence approximates 16.4% for ever-use and 5.7% for current-use.¹

The prevalence of ENDS users in some countries is limited. A recent national survey among the South African population of persons age ≥ 15 y reported that 2% of women and 3% of men use ENDS.⁷ In Germany, prevalence data of ENDS users among young adults, specifically, is limited. In one study, 3,000 subjects age 14–45 y were interviewed by telephone; 20% had previously used ENDS, of which 80% used liquids advertised as containing nicotine.⁸ In a 2016 study in Germany, of 1,051 adults surveyed between the ages of 20–39 y, 16.% had ever-used ENDS and 2.5% were current regular users.⁹ Globally, 11.4% ever-use was reported in the United Kingdom,¹⁰ 23.0% ever-use and 5.7% current-use in France,¹¹ 22.6% ever-use and 1.7% current-use in Spain,¹² and in Malaysia among university students, 74.8% reported current use.¹³

From a demographic perspective, the prevalence is consistently higher in men across all states in the United States.^{1,14} However, there are a few studies that have shown higher usage among female college students than males.^{3,15–18} Demographic predictors of ENDS use include male gender, current cigarette use, non-Hispanic white ethnicity, and college education level.⁴ In Germany, men, younger people, people with a migrant background, and people with a lower education level were more likely to have used e-cigarettes.⁸

Reported reasons for increased use of ENDS include the concept of enjoyment, the rights of an individual, a means of quitting cigarettes or a reduction in the number of cigarettes used, less toxic compared to cigarettes, no associated smell, cheaper than conventional cigarettes, exploration of newer products, and a mechanism to socialize with friends.^{4,6} Adult and youth ENDS users also perceive it as less addictive and as a means of evading smoking restrictions, while also being a low-cost “cool” product that mimics smoking but is more socially acceptable and safer for bystanders.¹⁹ Flavor options, intense marketing strategies, and the ability to purchase online are well known enabling factors attracting youth to electronic cigarette smoking. The increased marketing of ENDS has led to increased awareness, popularity, and use of e-cigarettes among college students.⁴

The rise in ENDS use poses public health concerns among young adults who are cigarette-naïve. Although

QUICK LOOK

Current knowledge

Electronic nicotine-delivery systems (ENDS) use is prolific among youth and young adults. These devices contain high levels of nicotine, carcinogens, and pollutants affecting both the person vaping and those who are exposed to the secondhand vapor. These devices are being considered in indoor air policies in various states.

What this paper contributes to our knowledge

Young adults take part in vaping due to peer influence. Young adults view secondhand vapor as not harmful even though devices emit heavy metals, carcinogens and nicotine. More information needs to be made available to educate all patients on what is known about these products. ENDS are harm reduction, but not harm-free.

most ENDS do not contain the magnitude of toxic constituents found in traditional cigarettes (eg, tars, carbon monoxide), many ENDS products contain potentially toxic and carcinogenic substances such as propylene glycol, formalin, acetylaldehyde, acrolein, lead, and diacetyl.^{20–25} It has been documented that the flavor additives in e-cigarettes contain aldehydes and, when consumed in higher concentration, could irritate the respiratory mucosal lining.^{4,22} ENDS devices have been reported to cause burns and explosive and chemical injuries due to device malfunction from battery alterations and charging.^{26,27} Furthermore, different routes of exposure to the ENDS fluids, such as skin contact or oral or parenteral ingestion have been linked to seizures, anoxic brain injuries, lactic acidosis, and death in children due to accidental nicotine poisoning.²⁸ For young adults, particular health concerns include nicotine dependence, which could ultimately lead to traditional tobacco use, and adverse respiratory symptoms or conditions such as cough, bronchitis, and asthma.^{29–32}

This study explored associations in quit type (ie, no plans to quit, plans to quit, and quit > 6 months ago) with perceived health status, perception of harm as compared to cigarettes, perception of secondhand vapor harm, and reasons for first use. To our knowledge, this is the first study to look at associations among no plans to quit vaping, plans to quit vaping, and those who quit > 6 months ago in a multi-country study.

Methods

We utilized a cross-sectional study design for primary data collection. A 33-item electronic survey questionnaire

was prepared following a review of the literature by a group of experts focused on ENDS usage. Each author's institutional review board approved the study design. Data were collected from voluntary participants through an online link to a Google Forms survey either accessed via iPad or emailed to the student bodies at 5 universities. By reading the introduction to the survey, participants clicked on the survey link if they agreed to participate in the research study. Descriptive statistics were conducted on the entire sample. Associations were assessed between type of quitter and harm perception of secondhand vapor, perceived health status, and reasons for first use among respondents who used ENDS.

Participant Demographics

Subjects for this study were recruited from 3 U.S. universities, 1 university in Germany, and 1 university area in South Africa; 9% of the subjects were from Germany, 3.5% were from South Africa, and the remaining were from the 3 U.S. universities. The total sample size for this study was 2,792 subjects after data cleaning. Individuals were excluded if they did not denote one of the universities listed or if they answered no to the final question on the survey regarding honesty in responses. A total of 10 individuals were removed from the sample. Subject demographics indicated that 84% identified as white, 4.4% identified as black/African, 3.2% identified as Hispanic/Latino, 2.7% identified as multi-ethnic, 2.4% identified as Asian/Pacific Islanders, and the remaining identified as other ethnicities. The majority of subjects were female (62%), with males comprising 36% of the total sample. The mean age of the participants was 21 years of age as noted in Table 1.

Data Analysis

We analyzed the data collected from universities across 3 countries: the United States (Florida, Alabama, and Illinois), Germany (Hamburg), and South Africa (Potchefstroom) with SPSS 24 (IBM, Armonk, New York). The overall sample size was assessed for demographics. From this overall sample, the data were sorted for assessing just those individuals who had ever used ENDS. This information was assessed by asking the respondents "Have you ever smoked an electronic device such as an electronic cigarette, e-cigar, or e-hookah, even one or two puffs?" The data were analyzed for the variables of interest after removing those individuals who reported having never vaped. The sample size decreased to 1,217 subjects after cleaning of these 2 variables (Table 2). The survey asked respondents to describe their behavior in terms of current use and plans to quit. The data were grouped into those individuals who currently vape and do not plan to quit, those who currently vape but do plan to quit, and those

Table 1. Demographics of Total Sample

University location	
Germany	256 (9.2)
South Africa	98 (3.5)
United States of America	2,438 (87.4)
Gender	
Male	995 (36.4)
Female	1,703 (62.4)
Transgender/gender nonconforming	32 (1.2)
Age, y	
18	323 (13.5)
19	531 (22.1)
20	420 (17.5)
21	447 (18.6)
22	254 (10.6)
23	107 (4.5)
24 and older	267 (2.6)
Race/ethnicity	
White	2,333 (85.9)
Black/African	119 (4.4)
Hispanic/Latino	87 (3.2)
Asian/Pacific Islander	64 (2.4)
Native American	12 (0.4)
African/Caribbean	6 (0.2)
Middle Eastern/North African	15 (0.6)
Multi-ethnic	74 (2.7)
Other	6 (0.2)

Data are presented as *n* (%).

who vaped in the past and quit > 6 months ago. Based on these 3 groups, we assessed primary initiation, harm perception, and perception of their own health status. Primary initiation was assessed categorically by most reported reasons. Harm perception was based on a comparison to traditional cigarettes as well as perception of secondhand vapor.

Results

This survey consisted of 2,792 respondents from 2 international universities and 3 universities in the United States. The study assessed associations between type of quitter and harm perception of secondhand vapor, perceived health status, and reasons for first use among respondents who used ENDS. When assessing these categorical variables, we conducted chi-square tests. First, we examined the association between type of quitter and primary reason for initiation as noted in Table 3. The results indicated statistically significant results (ie, $P < .001$). The outcomes identified 2 primary initiation factors: friends who were vaping and stress relief; these primary factors were cited by the majority of participants who reported being former vapers. For those respondents who had no

Table 2. Demographics of ENDS Ever-Users Only

University location	
Germany	75 (6.2)
South Africa	38 (3.1)
United States of America	1,104 (80.8)
Gender	
Male	542 (45.2)
Female	641 (53.5)
Transgender/gender nonconforming	16 (1.4)
Age, y	
18	146 (13.4)
19	261 (24.0)
20	212 (19.5)
21	197 (18.1)
22	106 (9.7)
23	46 (4.2)
24 and older	115 (10.6)
Race/ethnicity	
White	1,040 (87.2)
Black/African	42 (3.5)
Hispanic/Latino	39 (3.3)
Asian/Pacific Islander	27 (2.3)
Native American	2 (0.2)
African/Caribbean	2 (0.2)
Middle Eastern/North African	7 (0.6)
Multi-ethnic	31 (2.6)
Other	2 (0.2)

Data are presented as *n* (%).

plans to quit vaping, their primary influence was that they are trying to quit vaping and that vaping helps relieve stress.

When analyzing the type of user for association with perception of harm, we analyzed 2 different questions. First was the perception of harm as compared to cigarettes. The results indicated statistically significant results (ie, $P < .001$). Those who had no plans to quit viewed electronic devices as less harmful than traditional cigarettes, and those who quit > 6 months ago perceived them as being equally as harmful.

The analysis was also statistically significant ($P < .001$) among the 3 groups when we assessed the perception of secondhand vapor. Those who did not plan to quit found it to be safe for others to be around, and those who quit > 6 months ago reported being unsure.

Finally, we assessed the health perception of the 3 groups. These results were not statistically significant ($P = .09$). Overall, subjects viewed their own health status as average or excellent on a scale of poor, fair, average, or excellent. There were no statistically significant associations between type of quitter and how a student perceived their own health status.

Discussion

Over the past 10 years, ENDS have gained popularity with young adults and college students for reasons other than using these devices as a mechanism to quit smoking traditional cigarettes. While rates of traditional cigarette usage have decreased, various alternative forms of ENDS devices have increased primarily due to the novelty of the devices and the benefits that students feel they receive from using such devices.

Multiple studies have looked at the factors related to initiation of ENDS use in young adults. Leading reasons in such studies include curiosity, flavorings and pleasant taste, low perceived harm compared to cigarettes, enjoyment, calming effect, watching the exhaled vapor, possibility of indoor smoking, peer pressure and friends' influence, personal desire, easily concealed, social influence, emotional factors such as boredom and loneliness, to avoid smoking restrictions, and to reduce tobacco smoking.^{1,3,11,13,19,33} In a German study of young adults age 20–39 y, 62.6% cited curiosity as their main reason for use while 29.4% reported using ENDS to quit tobacco.⁹ In our study, one of the primary reasons for initiation of ENDS was for stress relief and influence by friends. Respondents who had no plans to quit vaping indicated that trying to quit smoking was their main reason for initiation. ENDS companies often promote ENDS as a healthy product to quit cigarette smoking, yet there is evidence to suggest otherwise.³⁴ On an individual level, there is also very limited evidence to suggest that ENDS are effective at reducing cigarette use among adult smokers intending to quit.^{35–37} Our recent study³⁸ also reported that ENDS are not commonly used as a tool to quit among college students but rather as a secondary source of nicotine among current cigarette smokers and that ENDS use, as a tool to quit smoking, is not the primary reason of use among young adults.

Furthermore, our study indicates that education and data are needed to prevent initiation in this particular age group because ENDS products are marketed strategically to appeal to adolescents and young adults, including luring themes and customer satisfaction through a wide variety of media coverage such as television, radio, internet, and point of sale.¹ In particular, using appealing flavors is a common strategy to enhance the initial experience and to promote continuing use.

Long-term effects of ENDS remain unknown, and there are limited studies on perceptions related to ENDS use comparing international perspectives. Our study reported significant findings in perceived harm and willingness to quit among young adults across all 3 countries. Those who had no plans to quit vaping perceived ENDS as less harmful compared to those who quit > 6 months ago. These findings correlate to previous studies reporting that beliefs and impressions of novel products plays a part in deter-

ASSOCIATIONS BETWEEN ENDS USERS

Table 3. Associations in Plans to Quit and Perceived Health Status, Harm Perception, and Reasons for First Use

	No Plans to Quit	Plans to Quit	Quit > 6 Months Ago	P
Health rating				.09
Poor	3 (0.8)	3 (1.3)	4 (0.7)	
Fair	32 (8.9)	21 (8.9)	55 (9.0)	
Average	180 (50.1)	121 (51.3)	313 (51.3)	
Excellent	144 (40.1)	91 (38.6)	238 (39.0)	
Perception of secondhand vapor				< .001
Safe for others to be around	222 (67.7)	117 (54.9)	196 (34.1)	
Unsafe for others to be around	10 (3.0)	14 (6.6)	82 (14.3)	
I am not sure	96 (29.3)	82 (38.5)	296 (51.6)	
Perceptions of harm				< .001
Less harmful than cigarettes	296 (82.2)	148 (62.7)	284 (46.5)	
As equally harmful as cigarettes	52 (14.4)	66 (28.0)	220 (36.0)	
More harmful than cigarettes	4 (1.1)	14 (5.9)	52 (8.5)	
I am unfamiliar with these devices	8 (2.2)	8 (3.4)	55 (9.0)	
Reasons for first use				< .001
I am trying to quit regular cigarettes	81 (22.3)	34 (14.2)	43 (7.0)	
Friends vaping	73 (20.1)	67 (28.0)	295 (48.0)	
Looks cool	25 (6.9)	17 (7.1)	53 (8.6)	
Smoke other products and wanted to try it	38 (10.5)	16 (6.7)	73 (11.9)	
To lose weight	5 (1.4)	4 (1.7)	2 (0.3)	
To enjoy the flavors that I love in food	17 (4.7)	13 (5.4)	41 (6.7)	
To relieve stress	121 (33.3)	87 (36.4)	103 (16.7)	
Weight management (not just to lose weight)	3 (0.8)	1 (0.4)	5 (0.8)	

Data are presented as n (%).

mining use. Ever-users and current users of ENDS were more likely to have positive impressions (eg, safer, healthy, believed the vapor has no secondhand effect, and not likely to consider ENDS as tobacco products).^{4,10} A longitudinal evaluation of college students across one state found lower risk perception predicted ENDS use for non-smoking college students. Additionally, research has shown that > 1 of 5 non-users try e-cigarettes in their initial college years.³⁹

There are also public health concerns that the use of ENDS will lead to renormalization of tobacco use in places where cigarette smoking is not acceptable. This may discourage the frequency and success of quit attempts, increase tobacco initiation, and encourage relapse.⁴⁰ Furthermore, ENDS use may also put young adults at high risk of initiating other more harmful nicotine and tobacco products because nicotine exposure during adolescence can cause addiction and harm in a developing brain.^{1,41}

In our study, subjects reported less perceived harm with ENDS compared to traditional cigarettes in certain quit groups more so than others. While we understand that risky behaviors in college students exist, for current users in our study, the college-aged perception was that ENDS vaping is not harmful. Another study documents that college students perceived ENDS, marijuana, and hookah as less harmful to the environment than cigarettes and cigars.³ Evidence obtained from longitudinal studies has de-

bunked such perceptions and portrayed the product as equally harmful or even more harmful than cigarettes among smokers, non-users, and the community as a whole.^{3,19} Another study has reported that about half of the studied subjects believed ENDS were addictive, were not an effective aid for cessation or quitting smoking,^{12,13} and were harmful to the user and bystanders.¹¹ Increased awareness of ENDS is associated with acceptance of smoking in public places, positive attitude toward the product as an innovation, the various flavors used, and risk perception among the users.^{19,33} Young adults and college students in our study generally used e-cigarettes as a form of experimentation rather than for smoking cessation, as claimed by other researchers.⁴² This perception may ultimately affect long-term use of ENDS in the college years.

Among our survey respondents, most users were unsure about the secondhand effects of vapor. Mixed results have been reported from other studies on this finding: some users of ENDS perceived it as safer and not harmful to the environment, bystanders, or other non-smokers (second- or third-hand effects).⁴ However, other users perceived it as a risk for the social environment, bystanders, unborn children, and pregnant mothers due to the unsafe components of the e-liquids.^{19,34} Ever-users and current users of ENDS tended toward positive views of the product and stated they would continue to use it in the future. Most

students used the product as an opportunity to thwart “no-smoking policies” and co-used it with other substances such as alcohol and other drugs.⁴³ The Surgeon General Report of 2016 documented that ENDS contain harmful ingredients, including nicotine, which is addictive. ENDS may harm brain development among young adults and pose danger to pregnant mothers and their unborn babies.¹

This study has several limitations, including the use of data from several universities which may not be generalizable to other populations. Additionally, the study used self-reported data, so we acknowledge the possibility of socially desirable responses that may lead to inaccuracy in responses to the survey questions. However, to mediate this we added a question regarding self-report of honesty in the survey. Lastly, the study was cross-sectional in nature and cannot show behavior changes or longitudinal predictive responses. Strengths of the study are the sample size and multiple country exploration.

Conclusions

The motives for initiation and perception of ENDS use among young adults are of particular concern to clinicians in the field of respiratory care as the popularity and use of ENDS continues to rise in young adults. There is a lack of consistent education and messaging regarding the known negative health effects of ENDS and secondhand vapor in the scholarly literature. Respiratory therapists are in ideal position to become the experts on these novel devices and to develop position statements regarding these products for smoking cessation. Respiratory therapists are valued resources in the community and in the clinical setting. Having firsthand knowledge about these devices is of utmost importance as patients begin to explore options for smoking cessation. Additionally, indoor air ordinances can be influenced by respiratory therapy organizations by sharing sound research on what is known. Most recently, the state of Florida included ENDS products in the indoor air ordinance. Influencing policymakers in other states would be an avenue that therapists and respiratory organizations could take to be at the forefront of advocacy for the respiratory health of the public.

REFERENCES

1. U.S. Department of Health and Human Services. E-cigarette use among youth and young adults: a report of the surgeon general. Atlanta: U.S. Department of Health and Human Services, Office on Smoking and Health, 2016. Available at: https://e-cigarettes.surgeongeneral.gov/documents/2016_sgr_full_report_non-508.pdf. Accessed April 7, 2019.
2. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. Monitoring the future national survey results on drug use 1975-2018: overview, key findings on adolescent drug use. Ann Arbor: Institute for Social Research, University of Michigan. Available at: <http://monitoringthefuture.org/pubs/monographs/mtf-overview2018.pdf>. Accessed April 8, 2019.
3. Abadi S, Couch ET, Chaffee BW, Walsh MM. Perceptions related to use of electronic cigarettes among California college students. *J Dent Hyg* 2017;91(1):35-43.
4. Hart EP, Sears CG, Hart JL, Walker KL. Electronic cigarettes and communication: an examination of college students' perceptions of safety and use. *Kentucky J Commun* 2017;36(1):35-51.
5. Littlefield AK, Gottlieb JC, Cohen LM, Trotter DRM. Electronic cigarette use among college students: Links to gender, race/ethnicity, smoking, and heavy drinking. *J Am Coll Heal* 2015;63(8):523-529.
6. Saddleson ML, Kozlowski LT, Giovino GA, Hawk LW, Murphy JM, MacLean MG et al. Risky behaviors, e-cigarette use and susceptibility of use among college students. *Drug Alcohol Depend* 2015;149:25-30.
7. National Department of Health, Statistics South Africa, South African Medical Research Council, and ICF. South Africa Demographic and Health Survey 2016. Available at: <http://dhsprogram.com/pubs/pdf/FR337/FR337.pdf>. Accessed April 8, 2019.
8. Schneider S, Görig T, Schilling L, Diehl K. E-cigarettes on everyone's lips: current representative data on use among adolescents and adults. *Dtsch Medizinische Wochenschrift* 2017;142(22):e156-e166.
9. Eichler M, Blettner M, Singer S. The use of e-cigarettes. *Dtsch Arzteblatt Online*. 2016;113(50):847-854.
10. Cooper M, Loukas A, Harrell MB, Perry CL. College students' perceptions of risk and addictiveness of e-cigarettes and cigarettes. *J Am Coll Heal* 2017;65(2):103-111.
11. Tavolacci MP, Vasiliu A, Romo L, Kotbagi G, Kern L, Ladner J. Patterns of electronic cigarette use in current and ever users among college students in France: a cross-sectional study. *BMJ Open* 2016; 6(5):e011344.
12. Rodriguez E, Parrón T, Alarcón R. Perceptions and use of the e-cigarette among university students. *Arch Bronconeumol* 2017;53(11): 650-652.
13. Wan Puteh SE, Abdul Manap R, Maharani H, et al. The use of e-cigarettes among university students in Malaysia. *Tob Induc Dis* 2018;16:57.
14. Hu SS, Homa DM, Wang T, Gomez Y, Walton K, Lu H, Neff L. State-specific patterns of cigarette smoking, smokeless tobacco use, and e-cigarette use among adults - United States, 2016. *Prev Chronic Dis* 2019;16:E17.
15. Czoli CD, Hammond D, White CM. Electronic cigarettes in Canada: prevalence of use and perceptions among youth and young adults. *Can J Public Health* 2014;105(2):97-102.
16. Kenne DR, Fischbein RL, Tan ASL, Banks M. The use of substances other than nicotine in electronic cigarettes among college students. *Subst Abus Res Treat*. 2017;11:1178221817733736.
17. Patel D, Davis KC, Cox S, Bradfield B, King BA, Shafer P, et al. Reasons for current E-cigarette use among U.S. adults. *Prev Med* 2016;93:14-20.
18. Ruten LJ, Blake KD, Agunwamba AA, Grana RA, Wilson PM, Ebbert JO, et al. Use of e-cigarettes among current smokers: associations among reasons for use, quit intentions, and current tobacco use. *Nicotine Tob Res* 2015;17(10):1228-1234.
19. Romijnders KAGJ, Osch L van, Vries H de, Talhout R. Perceptions and reasons regarding e-cigarette use among users and non-users: a narrative literature review. *Int J Environ Res Public Health* 2018; 15(6):1190.
20. Allen JG, Flanigan SS, LeBlanc M, Vallarino J, MacNaughton P, Stewart JH, Christiani DC. Flavoring chemicals in e-cigarettes: diacetyl, 2,3-pentanedione, and acetoin in a sample of 51 products, including fruit-, candy-, and cocktail-flavored e-cigarettes. *Environ Health Perspect* 2016;124(6):733-739.
21. Dunbar ZR, Das A, O'Connor RJ, Goniewicz ML, Wei B, Travers MJ. Brief report: lead levels in selected electronic cigarettes from

- Canada and the United States. *Int J Environ Res Public Health* 2018; 15(1):154.
22. Tierney PA, Karpinski CD, Brown JE, Luo W, Pankow JF. Flavour chemicals in electronic cigarette fluids. *Tob Control* 2016;25(E1): e10-e15.
 23. Klager S, Vallarino J, MacNaughton P, Christiani DC, Lu Q, Allen JG. Flavoring chemicals and aldehydes in e-cigarette emissions. *Environ Sci Technol* 2017;51(18):10806-10813.
 24. Jensen RP, Luo W, Pankow JF, Strongin RM, Peyton DH. Hidden formaldehyde in e-cigarette aerosols. *N Engl J Med* 2015;372(4): 392-394.
 25. Kosmider L, Sobczak A, Fik M, Knysak J, Zaciera M, Kurek J, Goniewicz ML. Carbonyl compounds in electronic cigarette vapors: effects of nicotine solvent and battery output voltage. *Nicotine Tob Res* 2014;16(10):1319-1326.
 26. Meernik C, Williams FN, Cairns BA, Grant EJ, Goldstein AO. Burns from e-cigarettes and other electronic nicotine delivery systems. *BMJ* 2016;354:i5024.
 27. Brownson EG, Thompson CM, Goldsberry S, Chong HJ, Friedrich JB, Pham TN, et al. Explosion injuries from e-cigarettes. *N Engl J Med* 2016;375(14):1400-1402.
 28. Daynard R. Public health consequences of e-cigarettes: a consensus study report of the national academies of sciences, engineering, and medicine. *J Public Health Policy* 2018;39(3):379-381.
 29. McConnell R, Barrington-Trimis JL, Wang K, Urman R, Hong H, Unger J, et al. Electronic cigarette use and respiratory symptoms in adolescents. *Am J Respir Crit Care Med* 2017;195(8):1043-1049.
 30. Primack BA, Soneji S, Stoolmiller M, Fine MJ, Sargent JD. Progression to traditional cigarette smoking after electronic cigarette use among us adolescents and young adults. *JAMA Pediatr* 2015;169(11): 1018-1023.
 31. Leventhal AM, Strong DR, Kirkpatrick MG, Unger JB, Sussman S, Riggs NR, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA* 2015;314(7):700-707.
 32. Wang MP, Ho SY, Leung LT, Lam TH. Electronic cigarette use and respiratory symptoms in Chinese adolescents in Hong Kong. *JAMA Pediatr* 2016;170(1):89-91.
 33. Trumbo CW, Harper R. Use and perception of electronic cigarettes among college students. *J Am Coll Health* 2013;61(3):149-155.
 34. Bhatnagar A, Whitsel LP, Ribisl KM, Bullen C, Chaloupka F, Piano MR, et al. Electronic cigarettes: a policy statement from the American Heart Association. *Circulation* 2014;130(16):1418-1436.
 35. Grana RA, Popova L, Ling PM. A longitudinal analysis of electronic cigarette use and smoking cessation. *JAMA Intern Med* 2014;174(5): 812-813.
 36. Caponnetto P, Campagna D, Cibella F, Morjaria JB, Caruso M, Russo C, Polosa R. Efficiency and safety of an electronic cigarette (ECLAT) as tobacco cigarettes substitute: a prospective 12-month randomized control design study. *PLoS One*. 2013;8(6):e0066317.
 37. Al-Delaimy WK, Myers MG, Leas EC, Strong DR, Hofstetter CR. E-cigarette use in the past and quitting behavior in the future: a population-based study. *Am J Public Health* 2015;105(6):1213-1219.
 38. Martinasek MP, Bowersock A, Wheldon CW. Patterns, perception and behavior of electronic nicotine delivery systems use and multiple product use among young adults. *Respir Care* 2018;63(7):913-919.
 39. Loukas A, Marti CN, Perry CL. Trajectories of tobacco and nicotine use across young adulthood, Texas, 2014-2017. *Am J Public Health* 2019;109(3):465-471.
 40. Fairchild AL, Bayer R, Colgrove J. The renormalization of smoking? E-cigarettes and the tobacco "endgame." *N Engl J Med* 2013;370(4): 293-295.
 41. Kandel ER, Kandel DB. A molecular basis for nicotine as a gateway drug. *N Engl J Med* 2014;371(10):932-943.
 42. Perikleous EP, Steiropoulos P, Paraskakis E, Constantinidis TC, Nena E. E-cigarette use among adolescents: an overview of the literature and future perspectives. *Front Public Health* 2018;6:86.
 43. Levy DT, Warner KE, Cummings KM, Hammond D, Kuo C, Fong GT, et al. Examining the relationship of vaping to smoking initiation among US youth and young adults: a reality check. *Tob Control* 2018;1-7.