

Original investigation

Factors Associated With Electronic Cigarette Users' Device Preferences and Transition From First Generation to Advanced Generation Devices

Jessica M. Yingst MS¹, Susan Veldheer MS, RD¹, Shari Hrabovsky MSN¹, Travis T. Nichols MS², Stephen J. Wilson PhD², Jonathan Foulds PhD¹

¹Department of Public Health Sciences, Penn State University College of Medicine, Hershey, PA; ²Department of Psychology, Penn State University, State College, PA

Corresponding Author: Jessica M. Yingst, MS, Department of Public Health Sciences, Penn State University, 500 University Dr, Hershey, PA 17033, USA. Telephone: 717-531-0003 ext. 289511; Fax: 717-531-0480; E-mail: jyingst@phs.psu.edu

Abstract

Introduction: Electronic cigarettes (e-cigs) are becoming increasingly popular but little is known about how e-cig users' transition between the different device types and what device characteristics and preferences may influence the transition.

Methods: Four thousand four hundred twenty-one experienced e-cig users completed an online survey about their e-cig use, devices, and preferences. Participants included in analysis were ever cigarette smokers who used an e-cig at least 30 days in their lifetime and who reported the type of their first and current e-cig device and the nicotine concentration of their liquid. Analyses focused on transitions between "first generation" devices (same size as a cigarette with no button) and "advanced generation" devices (larger than a cigarette with a manual button) and differences between current users of each device type.

Results: Most e-cig users ($n = 2603$, 58.9%) began use with a first generation device, and of these users, 63.7% subsequently transitioned to current use of an advanced generation device. Among users who began use with an advanced generation device ($n = 1818$, 41.1%), only 5.7% transitioned to a first generation device. Seventy-seven percent of current advanced generation e-cig users switched to their current device in order to obtain a "more satisfying hit." Battery capabilities and liquid flavor choices also influenced device choice.

Conclusion: E-cig users commonly begin use with a device shaped like a cigarette and transition to a larger device with a more powerful battery, a button for manual activation and a wider choice of liquid flavors.

Introduction

Modern electronic cigarettes (e-cigs) were invented in China in 2003,¹ emerged in the United States² and Europe¹ by 2007, and have since increased in popularity worldwide.^{3–6} A 2013 report of the International Tobacco Control Four Country Survey found that 7.6% of current and former smokers had tried an e-cig, and of those, 38.7%

continued use.⁷ Survey research has reported that the most common reasons for initiating use are to reduce or quit conventional smoking,^{7–17} although evidence from randomized controlled trials using e-cigs to aid smoking cessation have shown only modest quit rates.^{18–21}

The number of e-cig brands on the market has rapidly grown^{22,23} and because e-cigs are not currently regulated in most countries,²⁴

the characteristics of the devices vary greatly between brands, making the devices hard to classify and study.²⁵⁻²⁷ Most commonly, devices shaped like a cigarette and without a button to press prior to inhalation are classified as “cigalikes” or first generation devices (FGD) while devices with a larger high-powered battery and a button to press prior to inhalation are classified as advanced generation devices (AGD). By 2009, both FGD brands (eg, Njoy and Blu brands),²⁸ and AGD brands (eg, Joye 510 and eGo brands)²⁹ were available in convenience stores, in “vape shops,” or online in the United States and in Europe.¹¹ A 2014 report on e-cigs found that the market share is 65% FGD and 35% AGD, however sales of AGD are predicted to grow rapidly.³⁰

Few studies have enquired about the types of e-cigs being used or the potential factors influencing a user's choice of device type however one study that did find “ever” users of e-cigs were more likely to use a FGD while “established” users were more likely to use an AGD.³¹ “Ever” users were defined as those who had used an e-cig at least once in their lifetime while “established” users were defined as those who had used an e-cig more than 50 times in their lifetime. One possible factor that may influence device type choice is nicotine delivery, which appears to vary with device characteristics.³² Recent studies of e-cigs have shown that e-cig devices are capable of delivering nicotine more efficiently³²⁻³⁶ and are perceived as providing greater satisfaction and craving reduction,³² when compared to a FGD. In addition, other factors, such as the device's design features or a variety of nicotine liquid flavor choices may influence the user's choice of device type. McQueen et al. found that experienced e-cig users (those interviewed at an e-cig user's conference) wanted their first device to look like a cigarette, an important design feature, and that they preferred tobacco or menthol flavors when initiating e-cig use.³⁷

To gain an understanding of the factors associated with the transition between device types, this study aimed to examine the frequency with which e-cig users transition between device types and to identify device characteristics and user preferences that may influence such transitions.

Methods

Survey

E-cig users were invited to complete a 158 item online survey about their e-cig use and preferences. Participation in this study was voluntary and anonymous, although individuals who wished to volunteer for additional research on e-cigs were invited to enter their contact details at the end of the survey. Study data was collected and managed using REDCap electronic data capture tools hosted at the Penn State Milton S. Hershey Medical Center and College of Medicine.³⁸ REDCap is a secure, web-based application designed to support data capture for research studies. The survey was administered beginning December 2012 and can be found here: <https://redcap.ctsi.psu.edu/redcap/surveys/?s=v94cbA>. Data reported here was collected from December 2012 to August 2014. Links to the survey were posted on a variety of websites including www.webMD.com, and sites frequented by e-cig users, including www.e-cigarette-forum.com, one of the largest e-cig user websites. Visitors to these sites were also able to cross-post the survey link to friends and other websites.

This study was approved by the Penn State University Institutional Review Board.

Subjects

Participants included in analysis were ever cigarette smokers who have used an e-cig at least 30 days in their lifetime and who reported the type of their first and current e-cig device and the nicotine concentration of their liquid.

Six thousand four hundred ninety-five participants submitted the survey. The data set was checked for likely duplications which were identified as (1) those with the same demographics and email address or (2) those with identical state, city, gender, age, race and occupation. Where duplicates were identified, neither case was included, leaving 6201 participants with complete data. Of the participants with complete data, 142 (2.3%) were removed because they were not a current or past cigarette smoker (52.8% [$n = 75$] current FGD user), 769 (12.4%) were removed because they used an e-cigarette less than 30 days in their lifetime (62.6% [$n = 481$] current FGD user), and 189 (3.0%) were removed because they did not report the nicotine concentration of their liquid (52.4% [$n = 99$] current FGD user). Finally, 681 (11.0%) participants who did not report the type of their first and current device were removed. The final data set consisted of 4421 participants.

E-Cigarette Related Questions

Participants were classified into groups for analysis based on the type of their current e-cig device. FGD and AGD groups were determined using the following 2 questions, “Is your e-cig almost exactly the same length and width as a regular cigarette?” (Yes the same size or smaller than a cigarette/ No, larger than a cigarette) and “Does your e-cig have a button that you can press just prior to inhalation/puffing?” (Yes/No). E-cig devices that were the same size or smaller than a regular cigarette that did not have a button to press prior to inhalation were classified as FGD. E-cig devices larger than a regular cigarette or with a button to press prior to inhalation were classified as AGD (Note: E-cig device size is directly related to the size of the battery).

Participants provided the flavor type, or the liquid brand name, and the liquid nicotine concentration (measured in mg/ml) in open-ended questions. If flavor types or brand names did not clearly indicate the flavor (eg, Papa Smurf), internet searches were conducted to identify and categorize the flavor. Tobacco or menthol flavors were considered traditional flavors. Non-traditional flavors were considered any liquid that was a fruit (eg, cherry, berry, apple) sweet (eg, chocolate, vanilla, desserts, candies), or a beverage (eg, coffee, alcoholic drinks, soda).

Finally, questions about user preferences included “Did you switch to your current preferred type of e-cig because it gives you a more satisfying “hit” than previous e-cigs you tried?” (Yes/ No) and “Which of the following e-cig characteristics (long battery life, fast battery charge, variety of liquid flavor, shaped like a cigarette) are important to you?” All device characteristics were rated as not important, a little important, or very important. For analysis, responses a little important and very important were combined to compare important versus not important.

E-cig dependence was measured using the Penn State Electronic Cigarette Dependence Index.³⁹

Statistical Analysis

The data were analyzed using the SAS 9.3 statistical package. Means and percentages were calculated in order to identify differences between current FGD and AGD users. T tests (two-tailed) were used

to compare continuous variables and chi-squared tests were used to compare categorical variables. A *P* value of less than .05 was used as the cut off for determining statistical significance.

Results

Participants in this study were primarily white (91.8%) and male (71.2%) with a mean age of 40 years. These participants were experienced e-cig users of approximately 1 year and used their e-cig about 22 times per day. Only 18% of participants were current cigarette smokers.

Figure 1 illustrates how participants transitioned from their first e-cig device to their current e-cig device. Two thousand six hundred three (58.9%) participants reported their first device as a FGD and 1818 (41.1%) reported their first device as an AGD. Among those whose first device was a FGD, 945 (36.3%) reported continuing to use a FGD while 1658 (63.7%) participants reported transitioning to an AGD. Among those whose first device was an AGD, 1715 (94.3%) reported continuing to use an AGD while only 103 (5.7%) reported transitioning to a FGD. This means that 1048 participants are current users of a FGD and 3373 participants are current users of an AGD.

Results showing the differences between current users of FGD and AGD are displayed in Table 1. Those currently using an AGD were younger ($t(1603) = 10.6, P < .0001$), more likely to be male ($\chi^2 = 174.7, P < .0001$), and more likely to be educated beyond high school ($\chi^2 = 4.5, P = .0345$). Also, they used their e-cig more times per day (FGD 11.7 times/day vs. AGD 24.8 times/day, $t(2685) = -19.2, P < .0001$) and had used an e-cig device for a longer period of time (FGD 8.3 months vs. AGD 12.9 months, $t(2174) = -12.0, P < .0001$).

The Penn State Electronic Cigarette Dependence Index indicated that participants currently using an AGD exhibited greater e-cig dependence (FGD 7.1 vs. AGD 8.3, $t(1534) = -9.0, P < .0001$), despite using a liquid with a lower nicotine concentration (FGD 19.1 mg/ml vs. 15.1 mg/ml, $t(1223) = 9.8, P < .0001$), when compared with FGD users. Seventy-seven percent of AGD users stated that they switched to their current device because it delivers a more satisfying hit (FGD 58.6% vs. AGD 77.1%, $\chi^2 = 137.3, P < .0001$). In addition, these users were less likely to be currently smoking conventional cigarettes (FGD 39% vs. AGD 10.5%, $\chi^2 = 454.4, P < .0001$).

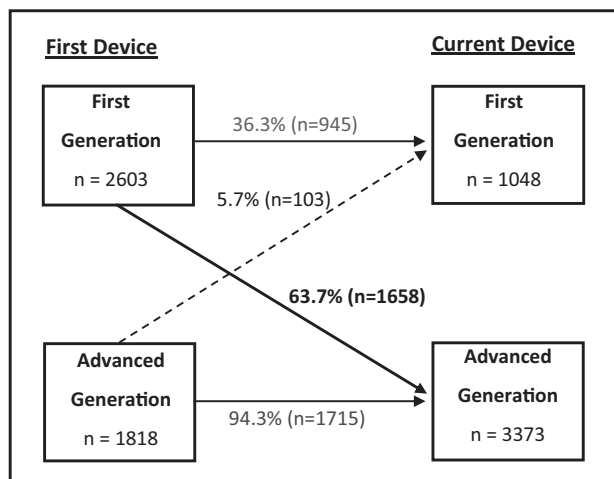


Figure 1. Participant transition from first to current device.

Most participants rated long battery life and a fast battery charge as important characteristics, however a greater proportion of participants currently using an AGD rated long battery life as important (FGD 90.6% vs. AGD 98.6%, $\chi^2 = 157.6, P < .0001$). Also, participants using an AGD were more likely to rate a variety of flavor choices as important (FGD 54.6% vs. AGD 94.9%, $\chi^2 = 1033.4, P < .0001$) but were less likely to rate the devices' resemblance to a cigarette as important (FGD 84.0% vs. AGD 8.7%, $\chi^2 = 2306.9, P < .0001$).

Discussion

This study is the first to demonstrate that e-cig users are likely to report initiating use with a device resembling a cigarette and later transition to a larger device with a more powerful battery and a manual button. In addition, this study found that when compared with current users of a FGD, current AGD users are more dependent on e-cigarettes and less likely to be smoking conventional cigarettes, despite using a nicotine liquid with a lower nicotine concentration.

This finding that the majority of e-cig users initiated use with a FGD, but that most users are currently using an AGD, is consistent with findings from a representative sample of current and former cigarette smokers surveyed in 2013.³¹ This study found that while 47% of participants had tried an e-cig ("ever" users), 16% has used in the last month ("current" users), and only 3.8% had used both in the past month and at least 50 times ("established" users). Among "ever users," over 70% had tried one of the five leading FGD brands and only 38% had tried another brand that could include an AGD brand. Among "established" users, over 70% had tried one of the leading FGD brands but 64% had also tried a device that could include an AGD brand. Also of interest, 35% of "established" users with a preferred brand used a "vaporizer" style, which is another term for an AGD. This is consistent with the idea that smokers who have just tried e-cigs a few times have typically used a FGD, whereas those who become a more regular established user are more likely to have transitioned to using an AGD.

The present study also identified differences between current users of FGDs and AGDs that may provide insight into the reasons that users choose their device or transition to different type. One of the most notable differences was that participants using an AGD were more dependent on their e-cig device and less likely to be currently smoking traditional cigarettes, in comparison to users of a FGD. Also, users of an AGD, who exhibited greater dependence, were using liquid with a lower nicotine concentration than users of a FGD, who exhibited lesser dependence. This could be explained in multiple ways.

First, a lab study by Farsalinos et al. suggested that AGDs produce higher peak plasma nicotine levels, and a shorter time to peak, than FGDs, when loaded with the same nicotine concentration.³² Also, a series of studies at Virginia Commonwealth University found that FGDs deliver very low nicotine levels but that AGDs can deliver blood nicotine levels similar to those resulting from smoking a cigarette.^{33-36,40} These studies suggest that if the device can efficiently deliver nicotine, users can absorb a satisfying dose of nicotine even when using a liquid with a lower nicotine concentration. This finding is also supported by the present study which found 77% of current AGD users switched to their current device because it gives a more satisfying hit, a sensation related to nicotine delivery.^{32,41}

Second, it is possible that users of AGDs, who have used an e-cig for an extended period of time, have learned how to get the most

Table 1. Descriptive Characteristics of the Sample, Overall and by Current E-Cig Device Type

Characteristic	Overall (<i>n</i> = 4421)	Current first generation e-cig device user (<i>n</i> = 1048)	Current advanced generation e-cig device user (<i>n</i> = 3373)	<i>P</i>
Mean age (in years) (<i>SD</i>)	40.1 (12.7)	43.9 (13.6)	39.0 (12.2)	<.0001
Male, % (<i>n</i>)	71.2 (3148)	55.1 (577)	76.2 (2571)	<.0001
White, % (<i>n</i>)	91.8 (4057)	91.2 (956)	91.9 (3101)	.4623
>High school diploma, % (<i>n</i>)	83.8 (3704)	81.7 (856)	84.4 (2848)	.0345
Current smoker, % (<i>n</i>)	17.9 (764)	39.0 (409)	10.5 (355)	<.0001
Mean Penn State Electronic Cigarette Dependence Index (<i>SD</i>)	8.0 (3.5)	7.1 (4.0)	8.3 (3.3)	<.0001
Mean use time (months) (<i>SD</i>)	11.8 (12.4)	8.3 (10.1)	12.9 (12.8)	<.0001
Mean use times per day (<i>SD</i>)	21.7 (24.5)	11.7 (16.8)	24.8 (25.7)	<.0001
Mean time to first use after waking (in minutes) (<i>SD</i>)	45.5 (78.0)	67.3 (116.1)	38.7 (60.0)	<.0001
Mean number of devices purchased prior to current device (<i>SD</i>)	3.5 (2.7)	2.3 (2.0)	3.9 (2.8)	<.0001
First device purchased was a first generation, % (<i>n</i>)	58.9 (2603)	90.2 (945)	49.2 (1658)	<.0001
Mean nicotine concentration of liquid (in mg/ml) (<i>SD</i>)	16.0 (8.6)	19.1 (12.7)	15.1 (6.6)	<.0001
Intended to quit smoking when starting e-cig use, % (<i>n</i>)	74.7 (3301)	70.9 (743)	75.8 (2558)	.0013
Stated they felt e-cig helped them to quit smoking, % (<i>n</i>)	92.4 (4085)	76.5 (802)	97.3 (3283)	<.0001
Using flavored liquid, % (<i>n</i>) (<i>n</i> = 3080)	53.5 (1649)	19.6 (125)	62.4 (1524)	<.0001
Find variety of flavor choices important, % (<i>n</i>) (<i>n</i> = 4402)	85.4 (3761)	54.6 (566)	94.9 (3195)	<.0001
Find long battery life important, % (<i>n</i>) (<i>n</i> = 4391)	96.7 (4246)	90.6 (933)	98.6 (3313)	<.0001
Find fast battery charge important, % (<i>n</i>) (<i>n</i> = 4394)	76.4 (3358)	78.6 (813)	75.7 (2545)	.0562
Find resemblance to a cigarette important, % (<i>n</i>) (<i>n</i> = 4402)	26.6 (1169)	84.0 (874)	8.7 (295)	<.0001
Switched to current device because of more satisfying hit, % (<i>n</i>)	72.7 (3213)	58.6 (614)	77.1 (2599)	<.0001

E-cig = electronic cigarette.

Comparisons between means were calculated with two-tailed *t* tests and comparisons between percentages were calculated using Chi-square analysis.

nicotine from their device.^{34,35,37,42,43} Hajek et al. determined that e-cig users obtained higher blood nicotine levels from the same e-cig device after practicing with the device for 4 weeks.⁴² In addition, interviews with e-cig users revealed that they found e-cigs to be complex and stated that they had to learn the best vaping techniques.³⁷ As there appears to be a learning curve with e-cig devices, it is not surprising that studies have found that many smokers try e-cigs, most likely FGDs,³¹ but only a small proportion continue to use them.^{7,31,44} Also, it is possible that users who initiate with a FGD (reported to deliver 2–3 ng/ml after 5 minutes)⁴⁵ return to smoking partly because their e-cig delivers a relatively small amount of nicotine when compared to cigarette (reported to deliver 14 ng/ml in the same time).⁴⁵

In regards to device characteristics, the majority of all users thought that long battery life and fast battery charge were important characteristics of an e-cig. Specifically, users of an AGD rated having a variety of flavor choices as important and were more likely to be using a flavored liquid than users of a FGD. This result was not unexpected as it has been reported that more flavor choices are available to users of AGD.²³ Because of the flavor choices associated with AGDs, it is possible that some users transition from their FGD to an AGD because they want to have more flavor choices. In addition, AGD users did not find the device's resemblance to a cigarette to be important, however, the majority of FGD users did. A qualitative interview by McQueen et al. found that e-cig users preferred their first e-cig device to resemble a cigarette³⁷ and that may be why a large number of e-cig users start with a FGD.

It should be noted that the participants completing this survey were experienced and enthusiastic e-cig users. It is expected that these participants may have a more positive view of e-cigs as they are long term users who self-selected themselves to complete the survey. Users of e-cigs who did not complete the survey may have stopped use due to negative experiences, such as experiencing side effects, or they may not be interested in completing the survey. In addition, this survey was cross-sectional in nature and therefore relied on the retrospective report of the participants to detail the transition from their first device to their current device.

Conclusion

This study is the first to illustrate how experienced e-cig users' transition between different device types and to directly compare current users of FGD and AGD. It was found that e-cig users are likely to begin use with a FGD shaped like a cigarette and transition to a larger advanced generation device with a manual button, but not vice versa. The results suggest that e-cig users' transition to advanced generation may be related to their experience that such devices deliver a "more satisfying hit."

Funding

This work was supported by an internal grant from Penn State Social Science Research Institute & Cancer Institute (PI: SJW). JF, SV, JMY, and SH are primarily funded by the National Institute on Drug Abuse of the National Institutes of Health and the Center for Tobacco Products of the US Food and Drug Administration (under award numbers P50-DA-036107-01, P50-DA-036105) and has a research grant funded by Pfizer. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the Food and Drug Administration.

Declaration of Interests

JF has done paid consulting for pharmaceutical companies involved in producing smoking cessation medications, including GSK, Pfizer, Novartis, J&J, and Cypress Bioscience.

References

- CASAA. E-cigarette history. 2012. http://casaa.org/E-cigarette_History.html. Accessed November 2014.
- Giovenco DP, Hammond D, Corey CG, Ambrose BK, Delnevo CD. E-cigarette market trends in traditional us retail channels, 2012–2013. *Nicotine Tob Res*. 2014. doi:10.1093/ntr/ntu282.
- McMillen RC, Gottlieb MA, Shaefer RM, Winickoff JP, Klein JD. Trends in electronic cigarette use among U.S. Adults: use is increasing in both smokers and nonsmokers. *Nicotine Tob Res*. 2014. doi:10.1093/ntr/ntu213.

4. Ayers JW, Ribisl KM, Brownstein JS. Tracking the rise in popularity of electronic nicotine delivery systems (electronic cigarettes) using search query surveillance. *Am J Prev Med.* 2011;40(4):448–453. doi:10.1016/j.amepre.2010.12.007.
5. King BA, Alam S, Promoff G, Arrazola R, Dube SR. Awareness and ever-use of electronic cigarettes among U.S. Adult, 2010–2011. *Nicotine Tob Res.* 2013;15(9):1623–1627.
6. Gravely S, Fong GT, Cummings KM, et al. Awareness, trial, and current use of electronic cigarettes in 10 countries: findings from the ITC project. *Int J Environ Res Public Health.* 2014;11(11):11691–11704. doi:10.3390/ijerph111111691.
7. Adkison SE, O'Connor RJ, Bansal-Travers M, et al. Electronic nicotine delivery systems: International Tobacco Control Four-Country Survey. *Am J Prev Med.* 2013;44(3):207–215. doi:10.1016/j.amepre.2012.10.018.
8. Harrell PT, Simmons VN, Correa JB, Padhya TA, Brandon TH. Electronic nicotine delivery systems (“e-cigarettes”): review of safety and smoking cessation efficacy. *Otolaryngol Head Neck Surg.* 2014;151(3):381–393. doi:10.1177/0194599814536847.
9. Dawkins L, Turner J, Roberts A, Soar K. ‘Vaping’ profiles and preferences: an online survey of electronic cigarette users. *Addiction.* 2013;108(6):1115–1125. doi:10.1111/add.12150.
10. Etter JF. Electronic cigarettes: a survey of users. *BMC Public Health.* 2010;10:231. doi:10.1186/1471-2458-10-231.
11. Etter JF, Bullen C. Electronic cigarettes: users profile, utilization, satisfaction and perceived efficacy. *Addiction.* 2011;106(11):2017–2028. doi:10.1111/j.1360-0443.2011.03505.x.
12. Farsalinos KE, Romagna G, Tsiapras D, Kyrzopoulos S, Voudris V. Characteristics, perceived side effects and benefits of electronic cigarette use: a worldwide survey of more than 19,000 consumers. *Int J Environ Res Public Health.* 2014;11(4):4356–4373. doi:10.3390/ijerph110404356.
13. Goniewicz ML, Lingas EO, Hajek P. Patterns of electronic cigarette use and user beliefs about their safety and benefits: an internet survey. *Drug Alcohol Rev.* 2013;32(2):133–140. doi:10.1111/j.1465-3362.2012.00512.x.
14. Vickerman KA, Carpenter KM, Altman T, Nash CM, Zbikowski SM. Use of electronic cigarettes among state tobacco cessation quitline callers. *Nicotine Tob Res.* 2013;15(10):1787–1791. doi:10.1093/ntr/ntt061.
15. Siegel MB, Tanwar KL, Wood KS. Electronic cigarettes as a smoking-cessation: tool results from an online survey. *Am J Prev Med.* 2011;40(4):472–475. doi:10.1016/j.amepre.2010.12.006.
16. King BA, Patel R, Nguyen KH, Dube SR. Trends in awareness and use of electronic cigarettes among U.S. Adults, 2010–2013. *Nicotine Tob Res.* 2014;17(2):219–227. doi:10.1093/ntr/ntu191.
17. Caponnetto P, Polosa R, Russo C, Leotta C, Campagna D. Successful smoking cessation with electronic cigarettes in smokers with a documented history of recurring relapses: a case series. *J Med Case Rep.* 2011;5:585. doi:10.1186/1752-1947-5-585.
18. Bullen C, Howe C, Laugesen M, et al. Electronic cigarettes for smoking cessation: a randomised controlled trial. *Lancet.* 2013;382(9905):1629–1637. doi:10.1016/S0140-6736(13)61842-5.
19. Caponnetto P, Campagna D, Cibella F, et al. 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):e66317. doi:10.1371/journal.pone.0066317.
20. Biener L, Hargraves JL. A longitudinal study of electronic cigarette use in a population-based sample of adult smokers: association with smoking cessation and motivation to quit. *Nicotine Tob Res.* 2014;17(2):127–133. doi:10.1093/ntr/ntu200.
21. Grana RA, Popova L, Ling PM. A longitudinal analysis of electronic cigarette use and smoking cessation. *JAMA Intern Med.* 2014;174(5):812–813. doi:10.1001/jamainternmed.2014.187.
22. Bagcchi S. E-cigarette market expands online. *Lancet Oncol.* 2014;15(8):e313. www.ncbi.nlm.nih.gov/pubmed/25121182. Accessed January 2015.
23. Zhu SH, Sun JY, Bonnieve E, et al. Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tob Control.* 2014;23(suppl 3):iii3–9. doi:10.1136/tobaccocontrol-2014-051670.
24. Benowitz NL, Goniewicz ML. The regulatory challenge of electronic cigarettes. *JAMA.* 2013;310(7):685–686. doi:10.1001/jama.2013.109501.
25. Trtchounian A, Talbot P. Electronic nicotine delivery systems: is there a need for regulation? *Tob Control.* 2011;20(1):47–52. doi:10.1136/tc.2010.037259.
26. Cobb NK, Byron MJ, Abrams DB, Shields PG. Novel nicotine delivery systems and public health: the rise of the “e-cigarette.” *Am J Public Health.* 2010;100(12):2340–2342. doi:10.2105/AJPH.2010.199281.
27. Brown CJ, Cheng JM. Electronic cigarettes: product characterisation and design considerations. *Tob Control.* 2014;23(suppl 2):ii4–10. doi:10.1136/tobaccocontrol-2013-051476.
28. Rose SW, Barker DC, D'Angelo H, et al. The availability of electronic cigarettes in U.S. Retail outlets, 2012: results of two national studies. *Tob Control.* 2014;23(suppl 3):iii10–16. doi:10.1136/tobaccocontrol-2013-051461.
29. Joyetech. The development path of the joytech. 2014. www.joyetech.com/about/history.php. Accessed November 2014.
30. Herzog B, Gerber J, Scott A. *Equity Research—Tobacco: Vapor World Expo—Key Takeaways.* Wells Fargo Securities; 2014.
31. Giovenco DP, Lewis MJ, Delnevo CD. Factors associated with e-cigarette use: a national population survey of current and former smokers. *Am J Prev Med.* 2014;47(4):476–480. doi:10.1016/j.amepre.2014.04.009.
32. Farsalinos KE, Spyrou A, Tsimopoulou K, Stefopoulos C, Romagna G, Voudris V. Nicotine absorption from electronic cigarette use: comparison between first and new-generation devices. *Sci Rep.* 2014;4:4133. doi:10.1038/srep04133.
33. Vansickel AR, Weaver MF, Eissenberg T. Clinical laboratory assessment of the abuse liability of an electronic cigarette. *Addiction.* 2012;107(8):1493–1500. doi:10.1111/j.1360-0443.2012.03791.x.
34. Vansickel AR, Eissenberg T. Electronic cigarettes: effective nicotine delivery after acute administration. *Nicotine Tob Res.* 2013;15(1):267–270. doi:10.1093/ntr/ntt316.
35. Spindle TR, Breland AB, Karaoghlanian NV, Shihadeh AL, Eissenberg T. Preliminary results of an examination of electronic cigarette user puff topography: the effect of a mouthpiece-based topography measurement device on plasma nicotine and subjective effects. *Nicotine Tob Res.* 2014;17(2):142–149. doi:10.1093/ntr/ntu186.
36. Eissenberg T. Electronic nicotine delivery devices: ineffective nicotine delivery and craving suppression after acute administration. *Tob Control.* 2010;19(1):87–88. doi:10.1136/tc.2009.033498.
37. McQueen A, Tower S, Sumner W. Interviews with “vapers”: implications for future research with electronic cigarettes. *Nicotine Tob Res.* 2011;13(9):860–867. doi:10.1093/ntr/ntt088.
38. Institute TPSCaTR. Penn State Clinical & Translational Research Institute, Pennsylvania State University CTSA, NIH/NCATS Grant Number UL1 TR000127.
39. Foulds J, Veldheer S, Yingst J, et al. Development of a questionnaire to assess dependence on electronic cigarettes in a large sample of ex-smoking e-cig users. *Nicotine Tob Res.* 2014;17(2):186–192. doi:10.1093/ntr/ntu204.
40. Vansickel AR, Cobb CO, Weaver MF, Eissenberg TE. A clinical laboratory model for evaluating the acute effects of electronic “cigarettes”: nicotine delivery profile and cardiovascular and subjective effects. *Cancer Epidemiol Biomarkers Prev.* 2010;19(8):1945–1953. doi:10.1158/1055-9965.EPI-10-0288.
41. Etter JF, Eissenberg T. Dependence levels in users of electronic cigarettes, nicotine gums and tobacco cigarettes. *Drug Alcohol Depend.* 2015 February;147:68–75. doi:10.1016/j.drugalcdep.2014.12.007.
42. Hajek P, Goniewicz ML, Phillips A, Myers Smith K, West O, McRobbie H. Nicotine intake from electronic cigarettes on initial use and after 4 weeks of regular use. *Nicotine Tob Res.* 2014;17(2):175–179. doi:10.1093/ntr/ntu153.
43. Farsalinos KE, Romagna G, Tsiapras D, Kyrzopoulos S, Voudris V. Evaluating nicotine levels selection and patterns of electronic cigarette use in a group of “vapers” who had achieved complete substitution of smoking. *Substance Abuse.* 2013;7:139–146. doi:10.4137/SART.S12756.
44. Pearson JL, Richardson A, Niaura RS, Vallone DM, Abrams DB. E-cigarette awareness, use, and harm perceptions in us adults. *Am J Public Health.* 2012;102(9):1758–1766. doi:10.2105/AJPH.2011.300526.
45. Yan XS, D’Ruiz C. Effects of using electronic cigarettes on nicotine delivery and cardiovascular function in comparison with regular cigarettes. *Regul Toxicol Pharmacol.* 2015;71(1):24–34. doi:10.1016/j.yrtph.2014.11.004.