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Electronic Cigarette Liquid and Device Parameters and Aerosol Characteristics: A Survey of Regular Users

Arit M. Harvanko, M.S.¹, Andrea K. McCubbin, B.S.², Kristin B. Ashford, Ph.D.³, and Thomas H. Kelly, Ph.D.⁴

¹Department of Behavioral Science, Department of Psychology, 1401 Nicholasville Rd, Lexington, KY 40503

²University of Kentucky College of Nursing, 509C College of Nursing Building, Lexington 40536-0232

³University of Kentucky College of Nursing, 417 College of Nursing Building, Lexington 40536-0232

⁴Department of Behavioral Science, Department of Psychology, University of Kentucky College of Nursing, Department of Psychiatry, Medical Behavioral Science Building, Lexington, KY 40536-0086

Abstract

Introduction—Electronic cigarettes are widely variable devices, typically with user definable liquid and device parameters. Yet, little is known about how regular users manipulate these parameters. There is also limited understanding of what factors drive electronic cigarette use and liquid purchasing, and whether two common ingredients, propylene glycol and vegetable glycerin, alter the subjective effects of these devices.

Methods—During the spring of 2016 522 adults, who reported daily use of electronic cigarettes containing nicotine, completed a survey on electronic cigarettes. Survey questions included an electronic cigarette dependence questionnaire, questions on tobacco and electronic cigarette use, and device and liquid preferences.

Results—Fifty-nine percent of respondents reported using another tobacco product, which was positively associated with level of nicotine dependence. On average, devices were set to 28.3 ($SD=24.2$) watts. Ability to change device voltage, and level of resistance typically used, was significantly associated with level of nicotine dependence. Amount of liquid consumed, nicotine

Correspondence concerning this article should be addressed to: Arit Harvanko, MS., University of Kentucky, 1401 Nicholasville Rd, Lexington, KY 40503, Phone: 859-218-5234, Arit.H@uky.edu.

Contributors

Mr. Harvanko designed the study and wrote the protocol, collected study data, conducted the statistical analyses, and prepared the first draft of the manuscript. Drs. Kelly and Ashford and Mrs. McCubbin assisted in designing the study protocol and contributed to, and have approved, the final manuscript.

Statement 3: Conflict of Interest

All authors declare that they have no conflicts of interest.

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concentration, and milligrams of nicotine used per week, were positively associated with nicotine dependence. Participants rated ‘good taste’ as the most important consideration when using and purchasing liquids, and propylene glycol is associated with undesirable effects and vegetable glycerin with desirable effects.

Conclusions—These data indicate that electronic cigarette users utilize a wide range device parameter settings and liquid variables, and that individuals with greater nicotine dependence favor voltage control devices, and lower resistance heating elements. Taste is a key factor for electronic cigarette selection, and concentrations of propylene glycol and vegetable glycerin may have a significant impact on the reinforcing effects of liquids.

Keywords

Nicotine; Abuse Liability; Propylene Glycol; Vegetable; Glycerin; Wattage; Taste

1. INTRODUCTION

Electronic nicotine delivery systems, and specifically ‘electronic cigarettes’ (ECs), represent a varied group of devices with user adjustable parameters, including heating element variables (such as heater coil configurations and power settings), and concentrations of nicotine, a variety of flavorants, and other ingredients in liquids. Early ECs (i.e. ‘first-generation’ ECs) were relatively simple devices that restricted the user from altering power levels and heater coil configurations, and typically limited liquids to only those sold for a specific device. ECs evolved from these simpler first-generation devices to more sophisticated 2nd and 3rd generation devices. Key changes include heating element control by specifying wattage, voltage, or temperature, adjustable heater coil configurations (e.g. number, diameter, length, and materials of coils), and refillable tanks that allow the user to control liquid composition. Because ECs have many variables, it is necessary to understand how regular EC users utilize their devices and their parameters to construct relevant regulatory policy or maximize efficacy of ECs for smoking cessation.

One key function of ECs is to deliver nicotine, which is influenced by user-adjustable parameters. Previous laboratory research has demonstrated that concentration of nicotine in EC liquids can have a significant impact on the EC-using experience and the composition of the aerosols they produce. Expectedly, increases in liquid nicotine concentration have been shown to increase concentration of nicotine in EC aerosols¹ and plasma nicotine levels following EC use, with plasma nicotine levels following high nicotine concentrations (i.e. 3.6% nicotine) exceeding levels typically achieved from conventional tobacco cigarettes (CC).² The nicotine concentration in EC liquids has also been demonstrated to have a negative relationship with puff topography, such that EC users will take shorter duration puffs from ECs containing higher nicotine concentrations compared to lower concentrations.³ Lastly, previous research showing that liquids with greater proportions of propylene glycol (PG), relative to vegetable glycerin (VG), increases nicotine concentration in EC aerosols, which may suggest that PG/VG concentrations could alter plasma nicotine concentrations following EC use.⁴

It has also been suggested that EC device parameters affect the level of nicotine emitted by ECs. Shihadeh and Eissenberg⁵ provide a framework for understanding the level of nicotine emitted by ECs, emphasizing that many different EC variables impact nicotine emission. Variables in this framework include: liquid container design (e.g. cartomizer, tank, drip tip, disposable), heating element parameters (electrical resistance, voltage, and surface area of the heating coil), liquid variables (nicotine concentration, solvent composition, flavoring, and other additives), and usage behaviors (puff duration, inter-puff interval, and number of puffs). Since these variables likely affect nicotine delivery, they also likely affect the abuse liability of ECs. Additionally, these variables can influence the potential harm of ECs. For example, voltage level (directly associated with wattage when coil resistance is held constant), is associated with emissions of carcinogens from ECs.⁶ Other research has demonstrated that constituents in EC liquids – namely PG and VG – can degrade into carcinogens when used in an EC. Yet, whether regular EC users typically use ECs in a manner that would lead to high levels of carcinogen emission is not well studied.

It is important to know what factors motivate the initiation and continued use of ECs in order to more completely understand their abuse liability and efficacy as potential smoking cessation tools. Farsalinos and colleagues⁷ reported that the majority of EC users in their sample use multiple different flavors within a day, and that the EC would be ‘less enjoyable’ if flavor availability were limited. Therefore, taste might drive both the initiation and continuation of EC use. It is unclear from these data, however, what the relative contribution of taste is compared to other possible motivations for initiation and continuation of EC use. Users of ECs have also identified “throat hit” as an important stimulus characteristic, with reports suggesting that liquid and device parameters (e.g. use of higher liquid nicotine concentrations) may be associated with this effect,⁸ though whether device power (i.e. wattage) is associated with throat hit is not yet known.

In August 2016, a Food and Drug Administration (FDA) rule came into effect that placed ECs under FDA regulation. Now that there is a regulatory mechanism for ECs it is important to study usage patterns of regular EC users. Usage patterns of regular EC users may, for example, highlight common behaviors that put individuals at undue health risk, which would provide an important regulatory target. Knowing common EC settings and usage behaviors will also inform future research, such that studies can utilize the most common EC user settings to determine if these settings confer significant health risks to the user. The extant literature is lacking estimates from a broad sample of regular EC users on key variables that likely influence the reinforcing effects of ECs, their potential harms, and motivations for initiation and continued use of ECs. This poses several problems: 1) it is difficult to conduct generalizable research on ECs without knowing what adjustable parameter settings are commonly used, 2) it is difficult to assess health risks associated with ECs without knowing whether settings that could cause harmful effects are commonly used, and 3) it is difficult to employ meaningful regulation without first understanding how ECs are being used. To address this gap in the extant literature, a survey of regular nicotine-dispensing EC users in the United States was conducted. The primary goal of the survey was to determine how adjustable parameters are typically used, the factors that motivate EC liquid selection, and the factors that influence initiation and continued EC use. Also examined was the association between nicotine dependence and (1) frequency of EC use, (2) adjustable

settings, and (3) liquid preferences. Results of this survey will support the translation of laboratory research findings to the natural ecology, and to inform EC-related public health policy efforts.

2. METHODS

2.1 Participants

A non-EC internet marketplace (Amazon's Mechanical Turk [mTurk]) was used to recruit study participants. A listing on the site invited EC users to complete the survey during the spring of 2016. Participants were first asked 10 screening questions to verify EC use and establish eligibility. To complete the full survey, participants were required to: report daily use of a nicotine containing EC throughout the past month, use ECs as their primary means of administering nicotine, have a 95% or higher approval rating on previously completed mTurk tasks, and be over 18 years of age.

2.2 Overall Procedure

Participants were required to complete all questions applicable to them, and were not shown questions that did not apply to them (e.g. if a participant indicated not currently using tobacco, they were not presented questions regarding tobacco use). To minimize duplicate entries, the survey could be completed on a specific computer only once. This study was approved by the University of Kentucky Institutional Review Board.

2.3 Measures

The survey was comprised of several sub-sections: a nicotine dependence questionnaire (the Penn State [Electronic] Cigarette Dependence Index), tobacco and electronic cigarette usage history, device preferences, and liquid preferences.

Penn State [Electronic] Cigarette Dependence Index (PSCDI)—This scale contains 10 questions regarding use of electronic and tobacco cigarettes and behaviors associated with nicotine dependence.⁹ Scores range from 0–19, with higher scores indicating greater dependence on electronic and tobacco cigarettes.

Tobacco and Electronic Cigarette Usage History—This experimenter-designed section consisted of seven items assessing quantity and frequency of EC usage, and reasons for initial and continued use. Questions included: 'do you own an electronic cigarette [yes/no],' 'were you a regular tobacco user prior to using an electronic cigarette,' 'are you currently trying to quit using tobacco products,' 'are you currently trying to quit using tobacco products by using electronic cigarettes,' 'how long ago did you begin using an electronic cigarette regularly,' 'why did you first begin using an electronic cigarette,' and 'why do you continue to use an electronic cigarette?' For the last two questions, participants were given a list of possible options to choose from, including an option to write-in an unlisted reason.

Device Preferences—This experimenter-designed section was comprised of six items assessing the type of EC participants typically use and their parameter settings. Questions

included: ‘what is the brand of your preferred electronic cigarette tank,’ ‘can you change the voltage of the electronic cigarette that you typically use,’ ‘what voltage do you typically use,’ ‘what is the typical resistance (in ohms) of the coils,’ ‘how many watts do you typically use,’ ‘is the electronic cigarette you typically use rechargeable?’ In order to facilitate accurate responses an annotated picture of a common EC coil was shown to the participant describing how to determine coil resistance.

Liquid Preferences—This experimenter-designed section was comprised of eight items assessing EC liquid preference. Participants were asked: what types of liquid they purchase (‘pre-filled disposable tanks or cartridges,’ ‘pre-mixed ready-to-use liquids for refillable tanks,’ ‘mix own liquids using basic ingredients’), how much liquid they use per week (in ml or number of cartridges). Participants were also asked if they ‘pay attention to the amount of nicotine’ in the liquids they use and, if so, what the ‘nicotine concentration of the liquids’ they ‘typically use in mg/ml.’ Participants were asked to rate ‘what effects of electronic cigarette liquid are most important to you,’ and ‘when purchasing or making electronic cigarette liquids what factors are most important to you,’ with possible answers based on previous research indicating common factors EC users consider when selecting liquids.¹⁰ Ratings of these factors were entered using a 100-point scale anchored on the left with ‘least important’ and on the right with ‘most important.’ Participants were also asked if they ‘pay attention to the amount of propylene glycol (PG) and vegetable glycerin (VG) in EC liquids’ and, if so, the percentage of PG and VG in the liquids they typically use, and whether liquids with more PG or VG are most closely associated with several effects. Ratings were entered on a 100-point scale anchored on one end with ‘PG,’ and ‘VG’ on the other.

2.4 Data Analysis

Descriptive statistics were used to examine distributions of demographic variables, device parameter preferences, and liquid preferences. Milligrams of nicotine used per week was estimated based on milliliters of liquid used per week and nicotine concentration typically used. To examine possible relationships of nicotine dependence with tobacco usage behaviors, liquid and device preferences, and subjective effects, correlational analyses were conducted between total score on the PSCDI and items from the tobacco and EC usage history, device preferences, and liquid preferences questionnaires. Since the PSCDI includes an item directly related to quantity of EC use (i.e. “How many cigarettes and times per day do you usually smoke or use your electronic cigarette?”), total scores were recalculated omitting this item for correlational analysis involving other direct measures of EC use (i.e. number of milliliters, disposable cartridges, or milligrams of nicotine used per week). Based on previous data indicating that nicotine concentration is associated with “throat hit,”⁸ ratings of “throat hit” and parameters (power, power multiplied by nicotine concentration, and milligrams of nicotine used per week) impacting nicotine exposure were also examined. To examine whether subjective EC effects were more closely associated with PG or VG, differences from the midpoint were evaluated using *t*-tests. The alpha value for all analyses was set at .05.

3. RESULTS

A total of 1,586 participants answered screening questions, and the 522 individuals that met inclusion criteria completed the entire survey. Participants were comprised of 290 (55.7%) females with an average age of 33.0 ($SD=10.2$). Descriptive statistics are shown in tabular form for usage behaviors and settings (Table 1) and liquid variable preferences (Table 2).

Fifty-nine percent of individuals endorsed currently using at least one other tobacco product in addition to ECs. Endorsement of current use of another tobacco product (i.e. cigarettes, snus or chewing tobacco, cigars, or hookah) was associated with significantly higher scores on the PSCDI (i.e. level of nicotine dependence, Table 1). Not having used other tobacco products besides ECs was negatively associated with PSCDI scores (Table 1), with never other tobacco product users having lower PSCDI scores ($m=6.1$, $SD=4.4$) compared to past other tobacco product users ($m=9.81$, $SD=4.0$) and current other tobacco product users ($m=10.3$, $SD=3.58$), and no significant differences in length of EC use were found between these groups. Two parameter setting preferences were significantly associated with PSCDI scores, heater coil resistance (in ohms) and ability to change voltage on the device (Table 1). Among the 197 individuals who knew the wattage they typically used and who provided ml's of liquid typically used per week, there was a positive correlation between wattage and ml's used ($r=.20$, $p=.005$).

When asked to rate "what effects of liquids are most important to you" from 'most Important' (100) to 'least important' (0), participants rated 'good taste' ($m=87.3$, $SD=15.7$), 'does not cause sore throat' ($m=77.3$, $SD=23.4$), and 'does not cause headache' ($m=76.7$, $SD=26.3$) as the three most important factors (Figure 1). When asked 'when purchasing or making liquids what factors are most important to you' participants again indicated that the most important factor is 'good taste' ($m=88.0$, $SD=13.6$), followed by 'availability' of the liquids ($m=73.8$, $SD=23.0$), and 'decreased health risks, avoid certain ingredients' ($m=73.4$, $SD=27.0$), and 'low price' ($m=72.6$, $SD=24.3$). 'Throat hit' received a more moderate rating of importance ($m=65.8$, $SD=28.0$). A significant correlation was found between ratings of the importance of 'throat hit' and nicotine concentration ($r=.19$, $p<.001$) and milligrams of nicotine consumed per week ($r=.14$, $p<.019$), but not power or nicotine concentration multiplied by power.

The majority of users (74.2%) indicated using liquids purchased for ECs with refillable containers (further separable as 'pre-mixed' liquids [64.8%] or liquids mixed by the end-user from basic ingredients [9.4%]), and while no differences in nicotine dependence scores were observed as a function of type of liquid purchased, amount of liquid used was positively correlated with PSCDI scores (Table 2). Seventy percent of individuals reported paying attention to the nicotine concentration of the liquids they typically used, and nicotine concentration was positively correlated with PSCDI scores (Table 2). Among the 188 (36.0%) individuals who indicated wattage and nicotine concentration typically used, there was a significant negative correlation between these two variables ($r(188)=-.23$, $p=.002$). Among 285 (54.6%) participants who reported paying attention to nicotine concentration and milliliters of liquids used for refillable devices, milligrams of nicotine used per week was positively correlated with PSCDI scores (Table 2). Lastly, 239 (45.8%) individuals

reported paying attention to the amounts of PG and VG in the liquids they typically use, and this was not significantly correlated with PSCDI scores.

When asked to rate which effects were more closely associated with PG or VG, participants indicated that PG was more closely associated with dry mouth ($t[237]=6.232$, $p<.001$), sore throat ($t[237]=7.432$, $p<.001$), headache ($t[237]=6.909$, $p<.001$), and dizziness ($t[237]=4.417$, $p<.001$). VG was significantly associated with large cloud ($t[237]=6.794$, $p<.001$), good smell ($t[237]=8.102$, $p<.001$), and good taste ($t[237]=6.607$, $p<.001$). Throat hit was not significantly associated with PG or VG.

4. DISCUSSION

This study addresses critical gaps in our understanding of EC use by providing detailed information on EC usage behaviors, device parameter settings, and liquid variables among regular (i.e. daily) EC users. EC users utilize a wide variety of devices, power levels (i.e. watts, volts, ohms) and nicotine concentrations. Our data suggest that no predominant combinations of user-adjustable products have emerged from the broad range of commercial options. Consistent with previous findings,¹⁰ taste was identified as the most important variable when using ECs or purchasing liquids. Desirable effects were associated with the ingredient VG, and undesirable effects with PG, suggesting that these ingredients might influence the reinforcing effects of ECs.

One of the primary goals of this survey was to determine the adjustable parameter settings typically used. Key among these settings is wattage, a measure of power output that is

arithmetically related to voltage and resistance by the equation: $wattage = \frac{Voltage^2}{Resistance}$. The

median wattage reported is approximately 10 watts, but many individuals reported setting their ECs to power levels of up to 10 times greater (100 watts), indicating that a wide range of power levels are utilized. Many individuals indicated not knowing the wattage of their device (57.7%), which is comparable to previous research where most participants reported not knowing the voltage (51.5%) or resistance (63.6%) of their devices.¹¹ This indicates a need for more reliable, and potentially objective, approaches to determining common EC parameter settings. It should be noted that the wattage scale was limited to 0–100 watts, as at the time of this survey few, if any, popular EC manufacturers offered devices capable of delivering more than 100 watts. For example, in late 2015 the most commonly used brand of device by participants in this survey (Kangertech, used by 15.5% of participants) offered power supplies rated to a maximum of 60 watts.¹² More recently, however, this brand began offering products capable of delivering up to 200 watts.¹³ A recent study by Wagener and colleagues¹⁴ also measured wattage ratings of a small sample of third-generation ECs and found power levels exceeding 100 watts. Thus, 100 watts may have been too low of a threshold, and greater power levels may have been used at the time of this survey, or since the completion of this survey. Despite this potential limitation, data on power levels has a right skewed distribution with a mean of 28.3 watts and *SD* of 24.2 (Figure 3), suggesting that most users utilized power levels below 100 watts. Future research should closely monitor changes in power settings since previous research has indicated a positive

relationship between power levels and amount of potentially harmful chemicals in EC aerosols.^{6,15}

Overall scores on the PSCDI in the current study were slightly higher than scores among exclusive EC users in a previous study ($m=8.1$).¹⁶ Participants in Foulds and colleagues were exclusive EC users with a history of CC use. Comparing ex-CC smokers from the current study, average PSCDI scores were still slightly higher (i.e. $m=9.8$, $SD=4.0$). It could be speculated that this is because use of newer ECs (i.e. those introduced following Foulds et al.¹⁶) is associated with higher levels of nicotine dependence, particularly if ECs are used in a manner that causes plasma nicotine concentrations to exceed those typically seen following CC use (e.g. Ramoa et al.²) This is a concern shared by Cobb and colleagues,¹⁷ who speculate that sole use of ECs may engender greater nicotine dependence than use of CCs. Yet, participants from the current study who reported no previous use of non-EC tobacco products reported significantly lower PSCDI scores compared to current or ex-CC smokers, suggesting that sole use of ECs with no CC history does not engender greater nicotine dependence.

Interestingly, wattage was not significantly associated with level of nicotine dependence (Table 1), but there were associations with ability to change voltage on the device and resistance of the heater coil. This may be related to type of device, as typically only 2nd or 3rd generation devices allow the user to adjust voltage and coil resistance, while 1st generation do not. The positive correlation between heater coil resistance and nicotine dependence may seem counterintuitive because lowering heater coil resistance while holding voltage constant would produce higher power levels. Additional research is required to further explore the relationships between use of a device with variable voltage and greater nicotine dependence, and between heater coil resistance and nicotine dependence.

The distribution of nicotine concentrations (Figure 3) indicates that the most common concentration is 3 milligrams/milliliter (.3%) with peaks at commonly sold nicotine concentrations (multiples of 3). Mean nicotine concentration was 9.1 ($SD=7.2$), which is comparable to an estimate of 9.5 ($SD=7.3$) by Rudy and colleagues.¹¹ While there was not a significant correlation between wattage and nicotine dependence, there was a significant negative correlation between wattage and nicotine concentration, indicating that while individuals use a variety of power levels, nicotine concentration is decreased when power levels are increased. It should be noted, however, that more powerful devices may alter the rate of nicotine delivery.¹⁸ Amount of liquid used per week was positively associated with power levels. As such, it could be hypothesized that power level selections may impact weekly nicotine intake. There were significant correlations between nicotine dependence and (1) the amount of liquid typically used per week (as measured by disposable cartridges or milliliters of liquid), (2) typical nicotine concentration, and (3) quantity of nicotine used per week, with quantity of nicotine use per week serving as a better predictor of nicotine dependence than milliliters of liquid used per week (Table 2). These findings suggest that weekly intake of nicotine is a potentially useful measure for future EC research.

When asked “what effects of e-cig liquid are most important to you” or “when purchasing or making electronic cigarette liquids what factors are most important to you” respondents

indicated that taste was most important. This is consistent with previous research indicating taste as the most important motive for EC use¹⁹ and that regular EC users modify their devices primarily to improve taste.²⁰ Though “throat hit” was not ranked highly in importance among other stimulus characteristics in this study, consistent with Etter,⁸ it was positively correlated with nicotine concentration and additionally amount of nicotine consumed per week. This suggests that individuals who value throat hit may modulate nicotine concentration and overall consumption to optimize this characteristic. When participants were asked which effects were most closely associated with PG and VG, PG was significantly related to potentially undesirable effects (dry mouth, sore throat, headache, and dizziness), while VG was associated with potentially desirable effects (large cloud, good smell, good taste). These results suggest that liquids with greater VG concentrations may have greater reinforcing effects, particularly since taste was indicated as the most important factor in liquid preference. It should be noted, however, that although participants indicated VG being more closely associated with desirable effects, on average participants used liquids containing approximately 1:2 ratios of PG and VG, suggesting that choice of PG/VG concentrations may not be driven exclusively by associated stimulus characteristics. One other possibility is that PG has been shown to increase nicotine yield in EC aerosols.²¹

Several limitations of this survey should be noted. First, participants in this study may not be representative of all regular EC users in the United States. A recent survey of EC users in the United States indicated that 89.2% of EC users used CCs in the past year, while 95.4 had used them in their lifetime and 4.6% had never used another tobacco product.²² Participants were required to use ECs containing nicotine to participate in this survey and therefore these results may not generalize to use of non-nicotine containing ECs. Second, not all EC users paid attention to certain device parameters (e.g. wattage, voltage, resistance) or liquid (e.g. nicotine concentration, PG/VG ratios) variables. As such, it is possible there were systematic differences between users who did or did not pay attention to these variables (e.g. individuals using early generation ECs may have been less likely to pay attention to device characteristics that are not modifiable or displayed on the device itself). Third, although careful steps were taken to increase reliability of reports on device and liquid characteristics (e.g. first confirming that users ‘pay attention’ to the variable in question before asking them to report the value, showing a picture of where heater coil resistance values are typically found on the device), it is still possible that users were inaccurate on reports of adjustable parameter settings. Lastly, although detailed information on EC parameters was collected, additional variables (e.g. heater coil configuration or heater coil materials) should be considered in future studies.

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HIGHLIGHTS

- This study provides unprecedented detail on the power levels (i.e. watts, volts, ohms) and nicotine concentrations preferred by daily e-cigarette users and demonstrates that a wide variety of settings are utilized, with ability to change device voltage, level of resistance typically used, amount of liquid consumed, nicotine concentration of preferred liquid, and milligrams of nicotine used per week associated with nicotine dependence.
- When using and purchasing liquids, ‘taste’ was considered the most important factor, followed by not causing ‘headache’ or ‘sore throat.’
- Propylene glycol was associated with undesirable subjective effects, and vegetable glycerin with desirable effects, suggesting that these ingredients may affect the abuse liability of electronic cigarettes.

Figure 1. “What effects of liquids are most important to you?”

Participants were asked to rate all effects by placing a slider on a scale anchored on the left at 0 (“Least Important”) and on the right at 100 (“Most Important”). Columns represent mean values and error bars represent standard error of the mean.

Figure 2. Are Vegetable Glycerin or Propylene Glycol More Closely Associated with These Effects?

Participants were asked to rate whether these effects were more closely associated with propylene glycol or vegetable glycerin on a scale of -50 to +50, respectively, with 0 indicating neither. All effects except 'Throat Hit' were significantly different than 0 ($p < .05$).

Figure 3. Distributions of Wattages and Nicotine Concentrations.

Information displayed is only from participants that reported knowing the wattage their device is typically set at ($N=221$) (left figure), or those who pay attention to the nicotine concentration of the liquids they use ($N=366$) (right figure).

Table 1.

Usage Behaviors and Settings

		Relationship with PSCDI, r (p)
Currently using ECs and other tobacco products, N (%)	308 (59.1)	.070 (.111)
Portion of other tobacco product users trying to quit, N (%)	261 (84.7)	.022 (.616)
Former regular user of other tobacco products, N (%)	180 (34.4)	-.678 (<.001)
Began regular other tobacco product use after ECs, N (%)	7 (1.3)	.003 (.952)
Never used tobacco products besides ECs, N (%)	34 (6.5)	-.203 (<.001)
Types of non-EC tobacco Used		
Tobacco cigarettes, N (%)	285 (54.6)	.710 (<.001)
Snus or chewing tobacco, N (%)	34 (6.5)	.172 (<.001)
Cigars, N (%)	52 (10.0)	.190 (<.001)
Hookah, N (%)	61 (11.7)	.266 (<.001)
Months of EC use, mean (SD)	13.9 (7.9)	-.007 (.876)
Penn State [Electronic] Cigarette Dependence Index Score, mean (SD)	10.0 (4.0)	--
Can you change the voltage on the EC you typically use, N (%)	315 (60.4)	.257 (<.001)
Typical power settings*		
Wattage (N = 221), mean (SD)	28.3 (24.2)	.031 (.555)
Resistance in Ohms (N = 255), mean (SD)	1.1 (0.8)	.096 (.035)
Voltage (N = 371), mean (SD)	2.9 (1.8)	.041 (.262)

EC= electronic cigarette.

* Based on responses only from individuals indicating they knew what the wattage, voltage, or resistance they typically used was (N of these individuals indicated after each setting).

Table 2.

Electronic Cigarette Liquid Variables

		Association with PSCDI, Statistic (<i>p</i>)
Type of liquid/container typically used		
Disposable container, <i>N</i> (%)	131 (25.7)	$F = .871$ (.419)
Pre-mixed for refillable devices, <i>N</i> (%)	330 (64.8)	--
Liquid mixed by user from basic ingredients, <i>N</i> (%)	48 (9.4)	--
Amount of liquid typically used per week		
Number of disposable cartridges (25.7% of users), <i>mean</i> (<i>SD</i>)	3.7 (2.9)	$r = .288$ (<.001)
Milliliters of liquid for refillable devices (74.2% of users), <i>mean</i> (<i>SD</i>)	22.9 (26.0)	$r = .112$ (.029)
Typical nicotine concentration used (mg/ml) (<i>N</i>=366),[*] <i>mean</i> (<i>SD</i>)	9.1 (7.2)	$r = .214$ (<.001)
Milligrams of nicotine used per week (<i>N</i>=285),[†] <i>mean</i> (<i>SD</i>)	192.5 (254.0)	$r = .244$ (<.001)
Typical percentage of propylene glycol and vegetable glycerin (<i>N</i>=239)[‡]		
Vegetable Glycerin, <i>mean</i> (<i>SD</i>)	63.3 (20.6)	$r = -.060$ (.388)
Propylene Glycol, <i>mean</i> (<i>SD</i>)	36.7 (20.6)	--

PSCDI= Penn State [Electronic] Cigarette Dependence Index.

^{*} Represents only individuals who reported paying attention to the nicotine concentration they typically used.

[†] Calculated by multiplying reported mg/ml liquid nicotine concentration by milliliters of liquids typically used per week and represents only users who do not use disposable containers and who pay attention to the amount of nicotine in their liquids.

[‡] Amounts include only individuals who indicated that they “pay attention” to the amount of propylene glycol and vegetable glycerin in liquids.