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Publication Date

2019-06-01

DOI

10.1016/j.addbeh.2019.01.011

Peer reviewed



Published in final edited form as:

Addict Behav. 2019 June ; 93: 135–140. doi:10.1016/j.addbeh.2019.01.011.

Young adults report increased pleasure from using e-cigarettes and smoking tobacco cigarettes when drinking alcohol

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Abstract

Background: Cigarettes share a high rate of co-use with alcohol, particularly among young adults. Studies have demonstrated greater perceived pleasure from smoking cigarettes when drinking alcohol. However, little is known about co-use of electronic cigarettes (e-cigs) and alcohol. The current study sought to compare extent of use and perceived pleasure from cigarettes and e-cigs when drinking alcohol.

Methods: Young adult bar patrons in California cities (San Diego, Los Angeles, and San Francisco) were recruited in 2015–16 using randomized time-location sampling. Participants completed cross-sectional surveys in bars, reporting the percent of cigarette smoking/e-cig use that occurred under the influence of alcohol, and reported if pleasure from smoking cigarettes/using e-cigs changed when drinking alcohol. Analyses are limited to participants reporting current (past 30-day) use of cigarettes, e-cigs, and alcohol (N=269; M age = 24.1; 40.1% female, 36.1% Non-Hispanic White).

Results: Participants reported a greater percentage of cigarette smoking compared to e-cig use under the influence of alcohol (cigarettes M=63.6%; e-cigs M=46.7%; $p<.001$). Participants also reported increased pleasure both from smoking cigarettes (M=3.9; [compared to midpoint of scale 3 - “no change”] $p<.001$) and using e-cigs (M=3.3; $p<.001$) when drinking alcohol. The increase in pleasure was more pronounced for cigarettes compared to e-cigs ($p<.001$).

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Conclusions: Drinking alcohol is associated with increases in perceived rewarding effects of both cigarettes and e-cigs and thus may increase their abuse liability. This effect may be stronger for cigarettes, which could be an important barrier to switching completely from smoking cigarettes to using e-cigs, or quitting both entirely.

Keywords

cigarettes; electronic cigarettes; ENDS; alcohol; co-use; young adults

1. Introduction

Young adults in the U.S. have the highest rate of current use of tobacco products in the U.S. (Kasza et al., 2017) including electronic cigarettes (e-cigs; Schoenborn & Gindi, 2015) compared to other age groups. While e-cigs are potentially effective nicotine delivery tools (Dawkins, Munafò, Christoforou, Olumegbon, & Soar, 2016; St Helen, Havel, Dempsey, Jacob, & Benowitz, 2016), there is conflicting evidence on their effectiveness for smoking cessation (Hartmann-Boyce et al., 2016; Kalkhoran & Glantz, 2016; Malas et al., 2016). Moreover, e-cigs are frequently used to complement on-going cigarette use (dual use), not solely as a strategy for quitting smoking (Brikmanis, Petersen, & Doran, 2017; Saddleson et al., 2015).

Alcohol use may be a potential barrier to young adult smoking cessation or switching from cigarettes to e-cigs. Smoking cigarettes is strongly associated with alcohol use (SAMHSA, 2014) and these substances are commonly co-used (McKee & Weinberger, 2013). Previous research has shown that individuals report greater smoking satisfaction, including feelings of “pleasure”, “stimulation”, and being “buzzed” when smoking tobacco cigarettes while drinking alcohol (Glautier, Clements, White, Taylor, & Stolerman, 1996; Gubner, Thrul, Kelly, & Ramo, 2018; McKee, Hinson, Rounsaville, & Petrelli, 2004; Piasecki et al., 2011). This suggests that tobacco cigarettes may have greater rewarding effects when used in combination with alcohol. It has been hypothesized that these combined pharmacological effects are due specifically to the combined effects of nicotine, found in tobacco smoke, and alcohol. Preclinical research suggests that nicotine and alcohol in combination can induce greater activation of the mesolimbic reward system, which could support their co-use (Doyon et al., 2013; Gubner, McKinnon, Reed, & Phillips, 2013; Gubner & Phillips, 2015; Tizabi, Bai, Copeland, & Taylor, 2007). However, research studies in humans examining the combined effects of alcohol and nicotine (administered intravenously, or via transdermal patch, gum, or nasal spray) have yielded mixed results. Some found enhanced rewarding effects (Kouri, McCarthy, Faust, & Lukas, 2004; Perkins et al., 1995) and others found attenuated effects (McKee, O’Malley, Shi, Mase, & Krishnan-Sarin, 2008; Ralevski et al., 2012; Udo, Harrison, Shi, Tetrault, & McKee, 2013).

Nicotine delivered through an e-cig (similar to a tobacco cigarette) results in rapid uptake of nicotine in the blood and brain from pulmonary absorption (Ramôa et al., 2016; St Helen, Havel, et al., 2016; Vansickel & Eissenberg, 2013). This rapid uptake of nicotine in the blood and brain has been implicated as an important reason why tobacco cigarettes, and potentially e-cigs, have a greater abuse liability compared to other routes of nicotine

administration, including smokeless tobacco or nicotine replacement products (Hukkanen, Jacob, & Benowitz, 2005). However, patterns of e-cig use (e.g. vaping topography) have been found to differ from tobacco cigarettes (St Helen, Ross, et al., 2016), which could result in differences in how they are co-used when drinking alcohol or on their combined pharmacological effects.

While there is a robust literature on the co-use of alcohol and cigarettes, only a few studies have investigated the co-use of alcohol and e-cigs compared to cigarettes; in addition, little is known about why people are co-using alcohol and e-cigs. There is an association between the use of e-cigs and alcohol, as well as heavy drinking, in young adults (Hughes et al., 2015; Saddleson et al., 2015). However, the literature is inconsistent with regards to whether e-cigs or tobacco cigarettes are more likely to be co-used with alcohol. One recent study found that the use of either tobacco cigarettes or e-cigs was associated with higher odds of current alcohol use as well as problematic alcohol use in adults (Conway et al., 2017), and adult e-cig users have reported higher levels of alcohol use than tobacco cigarette users and non-e-cig users (Hershberger, Karyadi, VanderVeen, & Cyders, 2016). Among adults, compared to e-cigs, tobacco cigarettes were more likely to be used in settings with alcohol (Rass, Pacek, Johnson, & Johnson, 2015). Moreover, alcohol use and heavy drinking were higher among dual users of e-cigs and tobacco cigarettes compared to e-cigs only users (Wills, Knight, Williams, Pagano, & Sargent, 2015). On the other hand, other studies found no differences in adolescent alcohol use or heavy drinking between those who solely used e-cigs compared to those using tobacco cigarettes (Wills et al., 2015). Given these conflicting results in the existing literature, more research is needed to clarify the relationship between alcohol and e-cigs, as well as tobacco cigarette co-use (Hershberger & Cyders, 2017).

To address limitations in the existing literature, we investigated the extent of co-use of e-cigs and alcohol as well as the role of perceived pleasure from smoking cigarettes or using e-cigs when drinking alcohol among young adult bar patrons that were current (past 30 day) users of all three of these products/substances.

2. Methods

2.1 Procedure and Participants

Data were collected as part of a larger tobacco use study in 2015 and 2016. Time-location sampling was used to generate a sample of young adult bar and club goers in Los Angeles, San Diego, and San Francisco. Venues, dates, and times were selected randomly from comprehensive lists of young adult-oriented bars and clubs in order to assign similar probabilities of selection to individuals within the sample. Time location sampling methods used in this study were developed to reach underserved populations, and have been described in previous studies collecting surveys from young adult bar patrons (Jiang, Lee, & Ling, 2014; Ling et al., 2014; Lisha, Neilands, Jordan, Holmes, & Ling, 2016). Briefly, trained study personnel entered randomly selected bars and approached all adults present who appeared to be within the age range (18–26) and invited them to participate in the study. Participants completed verbal informed consent to maximize participants' convenience. Patrons who appeared to be intoxicated or who were unable or unwilling to complete informed consent were not sampled. The surveys used a three-form planned missing data

design (participants answer one of three randomly selected versions of the survey) in which each form includes a certain number of core questions asked of all participants and another group of items that are asked only to two-thirds of participants (Graham, Taylor, Olchowski, & Cumsille, 2006). This design allowed us to reduce participant fatigue and response burden by having each individual answer fewer items while still collecting data from a large number of participants. All study procedures were reviewed and approved by the Committee on Human Research of the University of California, San Francisco.

The larger survey sample consisted of 3,341 observations and the survey response rate (percentage of eligible young adult bar patrons who completed surveys) was 67%. Participants reported age when completing the questionnaire, which was later validated using self-reported date of birth. A total of 49 participants (1.4% of valid questionnaires) were excluded since the age calculated based on date of birth fell outside the range of the current study (18–26 years). An additional 1,095 participants (32.8%) of participants were excluded as only 2 of the 3 survey forms contained alcohol questions. For the current investigation, we selected participants that reported current (past 30-day use) of cigarettes, e-cigs, alcohol, and had complete data on co-use questions. This resulted in a total sample of $N = 269$ participants for the current analyses. Additional robustness checks of primary analyses were conducted based on multiple imputation data (see statistical analyses section for details).

Included and excluded participants had no significant differences regarding age, race/ethnicity, and education. Included participants were more likely to be male (59.9% vs. 51.2% excluded) and report non-straight sexual orientation (26.0% vs. 19.1% excluded).

2.2 Measures

Demographics—Demographic variables included age (continuous measure, 18–26 years old) and sex (male/female). Race/ethnicity was based on participants' responses to two items: Ethnicity (Hispanic or not) and race (African-American, Asian, White, Hawaiian/Pacific Islander, American Indian/Alaskan Native, or More than one race) and recoded into 4 categories (Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Other; Hispanic). Participants reported their educational status, which was recoded into a dichotomous variable (currently in college/graduated versus no college/dropped out), and self-reported sexual orientation which was recoded into a dichotomous variable (straight versus gay/bisexual/other).

Tobacco product and alcohol use—Participants were asked on how many days during the past 30 days they used any of the following: 1) smoked a cigarette, 2) used an e-cig; 3) drank at least one alcoholic beverage.

For e-cigs, we separately assessed different device types including 1) disposable cigalikes (1st generation), 2) rechargeable cigalikes (1st generation), 3) medium sized vape pens (2nd generation), and 4) large tank devices (3rd generation). To improve data quality, each survey item included examples of popular device names/brands and a picture displaying a representative device of each category (see Appendix).

Reasons for e-cig use were assessed with one multiple choice question (“What are your reasons for using e-cigs, vape pens or vapor tanks?”) and 9 different response categories covering different areas including reducing health risks, reducing or quitting smoking, flavors, to perform aerosol cloud tricks, and others. Participants could select multiple responses.

Extent of co-use and changes in perceived pleasure—Participants estimated the percentage of cigarette use as well as e-cig use episodes which occurred under the influence of alcohol (“Estimate what percentage of your cigarette smoking (e-cig/vape pen use) episodes occur while under the influence of alcohol”; responses from 0–100% in 10% increments). Participants were also asked if their pleasure from smoking or using e-cigs changed when they were drinking alcohol (“Does your pleasure from smoking cigarettes (using e-cigs/vape pens) change when you are drinking alcohol?”) on a 5-point Likert scale (strongly decrease to strongly increase, with midpoint no change) (Gubner et al., 2018).

2.3 Statistical analyses

We used t-tests to compare the extent of cigarette smoking and e-cig use under the influence of alcohol as well as for the analyses of changes in perceived pleasure. T-tests and regression analyses were used to test associations between sociodemographic participant characteristics, extent of cigarette smoking and e-cig use under the influence of alcohol, and changes in perceived pleasure.

For secondary analyses, we sub-divided the sample into three user groups based on their e-cig device type: Participants were categorized according to device type used as 1st generation only, 2nd or 3rd generation only, and mixed use of 1st and 2nd/3rd generation devices. We repeated all analyses for extent of e-cig episodes under the influence of alcohol and changes in perceived pleasure from using e-cigs when using alcohol stratified by user group.

As 1/3 of the larger sample were not asked any alcohol related questions due to the 3-form planned missingness design, we conducted additional robustness checks using multiple imputation with chained equations in Stata (20 imputed datasets), which resulted in an increased sample size ranging from N=407–418 participants. Significance tests with imputed data (not shown) confirmed findings from analyses reported here.

3. Results

3.1 Sample description

Sample characteristics are displayed in Table 1. Participants were on average 24.1 (SD=1.9) years old, predominantly male (59.9%), and one quarter reported non-straight sexual orientation (26.0%). The largest racial/ethnic groups were non-Hispanic white (36.1%) and Hispanic/Latino (35.7%) and the majority reported currently being in college or having a college degree (74.7%).

Daily cigarette smoking (21.9%) and daily e-cig use (7.8%) was reported by a minority of participants. A total of 21.6% reported smoking within the first 30 minutes after waking.

Participants reported smoking cigarettes on 13.1 (SD=11.1) days, e-cig use on 8.8 (SD=8.6) days, and alcohol use on 13.8 (SD=8.7) of the past 30 days. Participants predominantly reported using 2nd or 3rd generation e-cigs (42.8%) or a mix of 1st and 2nd/3rd generation devices (39.8%). A minority used only 1st generation devices (17.5%).

The predominant reasons for e-cig use included to reduce health risks (33.8%), flavors (32.7%), to reduce or quit cigarette smoking (30.9%), to use at time when one cannot smoke cigarettes (29.4%), because of less odor (27.9%), and to perform cloud tricks (e.g., blowing rings; 23.1%).

3.2 Extent of co-use and changes in perceived pleasure

Participants reported an average of 63.6% (SD=24.8) of cigarette smoking episodes and 46.7% (SD=27.8) of e-cig use episodes under the influence of alcohol. This difference was statistically significant ($t(268)=9.3$; $p<.001$). Participants currently enrolled in college or who had a college degree reported significantly fewer e-cig use episodes under the influence of alcohol compared to participants with less than college education (college: 44.1% (SD=27.1); no college: 54.3% (SD=28.7); $t(269)=2.6$; $p<.01$). No other associations between sociodemographic characteristics and extent of cigarette smoking and e-cig use under the influence of alcohol were significant.

Participants reported an increase in perceived pleasure from smoking when drinking alcohol, $M=3.9$ (SD=1.1) and this value was significantly different from the midpoint of the scale which indicated no change in pleasure ($t(268)=13.5$; $p<.001$). Effect size d was .82, which corresponds to a large effect. Participants also reported an increase in perceived pleasure from e-cig use when drinking alcohol, $M=3.3$ (SD=0.9), which was also significantly different from no change ($t(268)=5.1$; $p<.001$). Effect size d was .31, which corresponds to a small to medium effect. When drinking alcohol, perceived pleasure was significantly more pronounced for cigarettes compared to e-cigs ($t(268)=8.4$; $p<.001$; Figure 1). Hispanic participants reported a significantly lower increase in perceived pleasure from smoking cigarettes when drinking alcohol compared to Non-Hispanic Whites (Hispanic: $M=3.7$ (SD=1.2); Non-Hispanic White: $M=4.1$ (SD=1.0); $t=2.1$; $p<.05$), with no significant differences for other groups. However, in analyses stratified for race, the increase in perceived pleasure from smoking when drinking alcohol was consistently significant for all race/ethnicity groups (data not shown).

We conducted secondary analyses for extent of e-cig use episodes under the influence of alcohol and changes in perceived pleasure from using e-cigs when using alcohol by e-cig device type. There were no significant differences for extent of e-cig use under the influence of alcohol (1st generation only: $M=43.8$, $SD=32.4$; 2nd or 3rd generation only: $M=45.5$, $SD=25.2$; mixed use of 1st and 2nd/3rd generation devices: $M=49.3$, $SD=28.4$; $F(2,266)=0.8$; $p=0.4$). There were also no significant differences in changes in perceived pleasure from using e-cigs when using alcohol by e-cig device type (1st generation only: $M=3.3$, $SD=1.0$; 2nd or 3rd generation only: $M=3.3$, $SD=0.7$; mixed use of 1st and 2nd/3rd generation devices: $M=3.3$, $SD=1.1$; $F(2,266)=0.1$; $p=0.9$).

4. Discussion

This study investigated the extent of cigarette smoking and e-cigs use as well as changes in perceived pleasure of using these tobacco products when drinking alcohol among a sample of young adult bar patrons, who had used e-cigs, cigarettes, and drank alcohol in the past 30 days. Participants reported smoking cigarettes under the influence of alcohol significantly more frequently than e-cigs. Moreover, compared to using e-cigs, participants reported a stronger increase in perceived pleasure from smoking cigarettes when drinking alcohol. Overall findings were consistent across different e-cig device types.

Our data are consistent with individuals reporting greater pleasure from smoking cigarettes when drinking alcohol (Gubner et al., 2018; McKee et al., 2004). Both nicotine and alcohol can induce dopamine efflux in the nucleus accumbens, suggesting these drugs may share a common mechanism of action though activate the mesolimbic dopamine pathway (Verplaetse & McKee, 2017). Previous studies are mixed on self-reported pleasure during co-use of alcohol and nicotine administered intravenously, via transdermal patch, gum, or nasal spray (Kouri et al., 2004; McKee et al., 2008; Perkins et al., 1995; Ralevski et al., 2012; Udo et al., 2013). This suggests that the route of nicotine administration may influence the subjective effects when combined with alcohol. In addition, the effect of nicotine on alcohol self-administration has been found to be dependent on both dose and timing of drug administration (see Kohut, 2017 for review). Our data indicate that individuals report greater pleasure from using e-cigs when drinking alcohol, however, to a lower extent than when smoking cigarettes. Smoking cigarettes when drinking alcohol may have greater rewarding effects, which could make it more difficult for individuals to quit smoking. The relatively smaller increase in self-reported pleasure from using e-cigs when drinking alcohol compared to cigarettes may indicate that e-cigs have a lower abuse potential compared to cigarettes when used in combination with alcohol. Among new users of either product, use when drinking alcohol could increase abuse liability. This increase in pleasure from using may provide a potential explanation for associations between e-cigs and alcohol use, as well as heavy drinking, in young adults reported in previous studies (Hughes et al., 2015; Saddleson et al., 2015). However, there is a need for continued research on the combined effects of e-cigs and alcohol to understand the abuse liability of these products.

There are several reasons why pleasure from using e-cigs may be lower than cigarettes when drinking alcohol. It has been hypothesized that the high rate of co-use of cigarettes and alcohol is due to the combined pharmacological effects of nicotine, found in tobacco smoke, and alcohol (Cross, Lotfipour, & Leslie, 2017). However, there are over 5,000 different compounds found in tobacco smoke, some of which (in addition to nicotine) are psychoactive, including compounds such as monoamine oxidase inhibitors and acetaldehyde (Thielen, Klus, & Müller, 2008). It is possible that other compounds in tobacco smoke may result in enhanced pharmacological effects when combined with alcohol, compared to e-cig aerosol.

It is also possible that patterns of how e-cigs are used may differ from cigarettes, resulting in different peak nicotine levels or pharmacokinetic profiles of nicotine over time, which could result in lower combined effects when drinking alcohol. In addition, e-cig products vary

widely in both their nicotine concentration and ability to deliver nicotine. It is possible that, among participants in our sample, e-cig use resulted in lower levels of nicotine compared to cigarettes, which may explain the relatively smaller increase in perceived pleasure compared to cigarettes. However, data indicate that e-cigs, particularly 2nd generation tank type e-cigs, which were primarily used by this population, can effectively deliver similar levels of nicotine compared to cigarettes (Hajek, Przulj, Phillips, Anderson, & McRobbie, 2017; Ramôa et al., 2016; St Helen, Havel, et al., 2016; Vansickel & Eissenberg, 2013). The range in how effectively different e-cig devices deliver nicotine could mean that some e-cigs may not have a lower abuse potential than cigarettes. Yet, in our secondary analyses, we did not observe differences in perceived pleasure by e-cig device type. Laboratory based human pharmacology studies are needed to investigate the relationship between different e-cig products and nicotine delivery and the subjective effects when drinking alcohol. Moreover, research needs to address novel pod-style e-cig devices (e.g., Juul), which have recently taken over the U.S. market (Huang et al., 2018; Kavuluru, Han, & Hahn, 2018).

4.1 Limitations

A limitation of this study is that we did not assess the nicotine content of the e-cigs used, or in fact actual nicotine delivery to study participants. It is possible that concentration of nicotine or other e-liquid ingredients (flavors, PG/VG ratio) in an e-cig used when drinking alcohol, other device characteristics (e.g., wattage/voltage), or user experience with device use could be important factors influencing combined subjective effects. Since we recruited young adults in bars and selected a subset of current users of cigarettes, e-cigs, and alcohol, who were predominantly non-daily smokers. Therefore, our findings may not be generalizable to the entire population of young adults. Lastly, we used retrospective self-reported data, which may be biased and cannot establish a causal inference between alcohol use and perceived pleasure from smoking cigarettes or using e-cigs. Laboratory-based human pharmacology studies or intensive longitudinal event-level designs (e.g., Ecological Momentary Assessment), are needed to replicate our findings and advance this area of research.

4.2 Conclusions

To the best of our knowledge, this is the first study comparing changes in perceived pleasure from smoking cigarettes and using e-cigs when drinking alcohol among young adults. We found that drinking alcohol is associated with an increase in perceived pleasure from smoking cigarettes and using e-cigs. Our results also suggest that this association may be stronger for tobacco cigarettes compared to e-cigs. Drinking alcohol may increase the abuse liability of cigarettes and e-cigs, and could be a barrier to switching completely from smoking cigarettes to using e-cigs, or quitting both products entirely.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Little is known about co-use of electronic cigarettes (e-cigs) and alcohol
- Young adult bar patrons in California cities completed cross-sectional surveys
- More cigarette smoking than e-cig use was reported under the influence of alcohol
- Drinking alcohol increased pleasure for both smoking cigarettes and using e-cigs
- Increase in pleasure was more pronounced for cigarettes compared to e-cigs

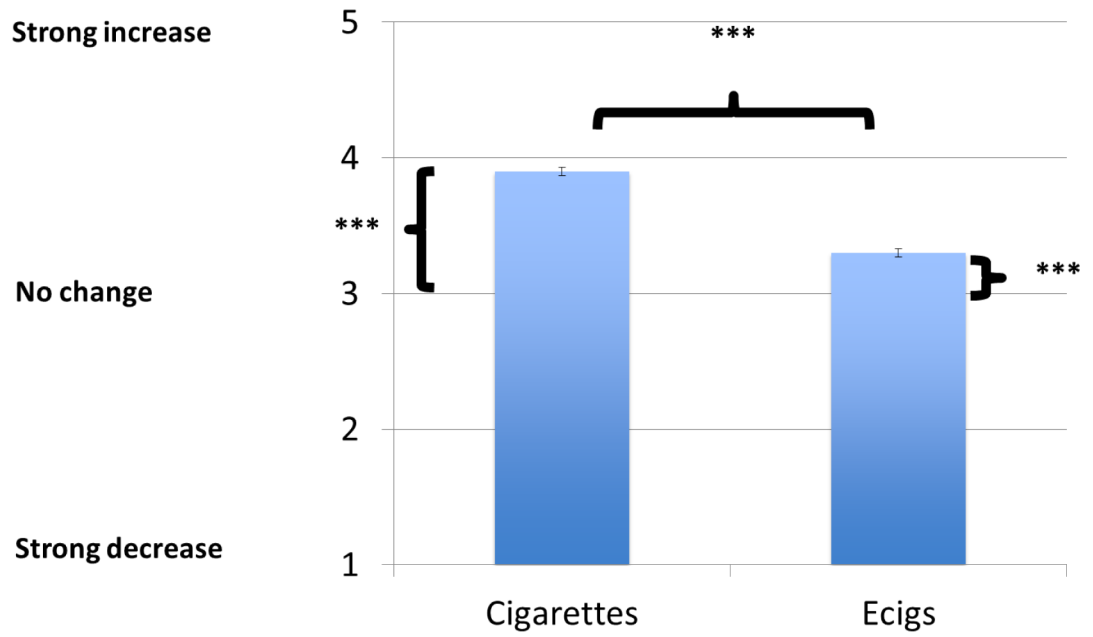


Figure 1:
Changes in perceived pleasure from smoking cigarettes or using e-cigs when drinking alcohol (***) $p < .001$)

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Table 1:

Sample characteristics (N=269)

	Number (%); M (SD)
City of Survey	
Los Angeles	106 (39.4%)
San Diego	73 (27.1%)
San Francisco	90 (33.5%)
Age (years; M (SD))	24.1 (1.9)
Gender	
Female	97 (36.1%)
Male	161 (59.9%)
Trans	4 (1.5%)
Other	7 (2.6%)
Race	
Non-Hispanic White	97(36.1%)
Non-Hispanic Black	16 (6.0%)
Non-Hispanic Other	60 (22.3%)
Hispanic	96 (35.7%)
Sexual Orientation	
Straight	198 (73.6%)
Gay	18 (6.7%)
Lesbian	8 (3.0%)
Bisexual	26 (9.7%)
Other	19 (7.1%)
Education	
Less than college or dropped out of college	68 (25.3%)
In college or graduated college	201 (74.7%)
Past 30-day Cigarette Use (number of days; M(SD))	13.1 (11.1)
Daily cigarette smokers	59 (21.9%)
Cigarette smoking within first 30 mins after waking	58 (21.6%)
Past 30-day Electronic Cigarette Use (number of days; M(SD))	8.8 (8.6)
Daily Electronic Cigarette Use	21 (7.8%)
Past 30-day Alcohol Use (number of days; M (SD))	13.8 (8.7)
Electronic Cigarette Type	
Cigalike	47 (17.5%)
2 nd or 3 rd Generation	115 (42.8%)
Mix	107 (39.8%)
Reasons for Using Electronic Cigarettes	
To reduce health risks	91 (33.8%)
Because they have good flavors	88 (32.7%)
To reduce or quit cigarette smoking	83 (30.9%)
At times when you cannot smoke a cigarette	79 (29.4%)

	Number (%); M (SD)
Because they don't leave you smelling badly	75 (27.9%)
For smoke/cloud tricks	62 (23.1%)
For a different reason	37 (13.8%)
Because they give the same "buzz" or "hit" as combustible	29 (10.8%)
Because they cost less than combustible cigarettes	23 (8.6%)

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