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Electronic Nicotine Delivery Systems (E-cigarette/Vape) use and Co-Occurring Health-Risk Behaviors Among an Ethnically Diverse Sample of Young Adults

H. Isabella Lanza and **Heather Teeter**

Department of Human Development, California State University, Long Beach, California, USA

Abstract

Background—Prevalence rates of electronic nicotine delivery systems (ENDS; i.e., e-cigarette/vape) use has grown exponentially in the past few years. College students present a particularly vulnerable group for ENDS use. The current study sought to expand the literature by examining the context in which college students use ENDS, co-occurring health risks beyond traditional tobacco use, and the role of ethnicity in ENDS use.

Methods—Health-risk behavior survey data was collected from 452 undergraduates attending a large, public urban university during the 2015–2016 academic year. Ever ENDS users vs. non-ENDS users were compared across potential demographic, health-risk, and other health-related correlates.

Results—Almost 40% of participants reported lifetime use of ENDS. No ethnic or sex differences were found. The primary source for obtaining ENDS was friends and ENDS were most often used with friends vs. alone or with others not considered friends. Participants engaging in risky alcohol use and cigarette smoking had a higher likelihood of endorsing ENDS use.

Conclusions/Importance—The current study indicated that a large proportion of college students have tried ENDS irrespective of ethnicity or sex. An increasingly normative social context may inform the popularity of ENDS use across ethnicity and sex, but additional research using ethnically diverse samples is warranted. Risky alcohol use appears to be a significant correlate of ENDS use, even after accounting for the robust relationship between ENDS use and cigarette smoking. The robust relationship between alcohol and tobacco use likely extends to ENDS use.

Keywords

Alcohol use; college students; e-cigarette; electronic nicotine delivery systems (ENDS); vaping; young adults

Electronic nicotine delivery systems (ENDS) use (commonly referred to as e-cigarette use or vaping) has surged in popularity since its introduction into the U.S. market in 2007 (McMillen, Gottlieb, Shaefer, Winickoff, & Klein, 2015; Weaver et al., 2016). Less than a

CONTACT H. Isabella Lanza, Ph.D., Isabella.Lanza@csulb.edu, Department of Human Development, California State University, 1250 Bellflower Blvd., Long Beach, CA 90840, USA.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

decade ago ENDS, which include e-cigarettes, vaporizers, and e-hookahs, were relatively unheard of, but their current market presence and growing popularity is undeniable. Recent prevalence rates indicate 22–30% of U.S. young adults report lifetime electronic tobacco use and 5–9% are current electronic tobacco users (Delnevo et al., 2016; Johnson, O'Malley, Bachman, Schulenberg, & Miech, 2016). ENDS use is most prevalent and growing at a faster rate among younger populations (Choi & Forster, 2013; Littlefield, Gottlieb, Cohen, & Trotter, 2015; Pearson, Richardson, Niaura, Vallone, & Abrams, 2012; Wills, Knight, Williams, Pagano, & Sargent, 2015). Moreover, recent studies have noted that a significant proportion of younger ENDS users have never tried cigarette smoking (Bostean, Trinidad, & McCarthy 2015; Sutfin, McCoy, Morrell, Hoeppner, & Wolfson, 2013), suggesting the ENDS industry is effectively recruiting adolescent and young adults that are non-cigarette smokers. Although a growing literature has begun to examine attitudes, behaviors, and motivations surrounding ENDS use, there is much to learn about the context involving use, whether ENDS use co-occurs with health-risks beyond traditional tobacco, and whether use differs across ethnicity and sex.

Research on ENDS use has generated particular interest in e-cigarette use/vaping among college students. College students are known for initiating and developing substance use trends (Lanier & Farley, 2011; Quintero, Peterson, & Young, 2006), as well as experiencing major life transitions that leave them vulnerable to risky behavior (Stone, Becker, Huber, & Catalano, 2012; Willoughby, Good, Adachi, Hamza, & Tavernier, 2014). Although research on ENDS use among college students is still in its infancy, more than a dozen studies have been published between 2013–2016. These studies show an exponential increase in ENDS ever use, with earlier studies (2009–2010) reporting a prevalence rate from 4.9%-8.8% (Miller, Lechner, Meier, Tucker, & Wiener, 2014; Sutfin et al., 2013) and later studies (2013–2014) reporting a prevalence rate between 28–44% (Kenne, Mix, Banks, & Fischbein, 2016; Littlefield et al., 2015; Saddleson et al., 2015; Sutfin et al. 2015). Along with the rise in ENDS use, a steady decline in cigarette smoking among young adults has been observed (SAMHSA, 2016); however, it is important to note that college students are not primarily using ENDS to quit or decrease cigarette smoking and ENDS use may actually contribute to continued cigarette smoking (Loukas, Batanova, Fernandez, & Agarwal, 2015; Saddleson et al., 2015; Sutfin et al., 2013, 2015).

Studies examining motivations for ENDS use have identified differences between younger and older populations. In adult samples (excluding young adults), reasons for e-cigarette and vaping use generally include attempts to quit cigarette smoking (Etter & Bullen, 2014; Rutten et al., 2015); however, college students' common motivations include recreation/ enjoyment (Saddleson et al., 2016) and socializing with peers and friends (Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2015; Sutfin et al., 2013, 2015). Furthermore, recent studies (Bostean et al., 2015; Sutfin et al., 2013) have noted that a significant subgroup of ENDS users had never smoked cigarettes, suggesting ENDS use is attracting younger populations that are experience-seeking and curious about novelty substance use (Kong et al., 2015; Trumbo & Kim, 2015). Identifying the context in which young adults are using ENDS, including the source from which they obtain ENDS, who they use ENDS with, and how many of their friends are engaging in ENDS use is likely to provide amore nuanced understanding of the motivations for ENDS use among younger vs. older populations.

Given that younger populations may find ENDS attractive due to a developmentally normative increase in experience-seeking and risk-taking behavior (Keyes et al., 2015; Steinberg, 2008), the vast majority of studies on ENDS use have examined the co-occurrence of ENDS use with cigarette smoking. There is large consensus among these studies that cigarette smoking is a key correlate of e-cigarette use and vaping (Kenne et al., 2016; Loukas et al., 2015; Sutfin et al., 2013, 2015; Trumbo & Harper, 2013). There is also speculation that ENDS use may co-occur with other health-risk behaviors like risky alcohol use (Hershberger, Karyadi, VanderVeen, & Cyders, 2016; Wills et al., 2015), but it is unclear as the only two available studies examining this co-occurrence among college students have reported mixed findings. Littlefield et al. (2015) indicated that e-cigarette use was related to increased risk of binge drinking; however, Sutfin et al. (2013) did not find e-cigarette users had higher rates of binge drinking. Additional research is warranted to elucidate the relationship between alcohol and ENDS use to determine whether ENDS use is linked to co-occurring health-risks in similar ways as traditional tobacco use.

Another gap in the literature that needs further assessment pertains to previously cited sex and racial/ethnic trends that may underlie ENDS use. Some studies have found that males are more likely than females to have tried ENDS (Kenne et al., 2016; Littlefield et al., 2015; Sutfin et al., 2013). Racial/ethnic trends are less clear, which may in part be due to the fact that almost all previous studies on college students have used majority Caucasian/White participants. Sutfin et al. (2013) reported that Hispanics were more likely to use e-cigarettes than Whites. In contrast, Littlefield et al. (2015) and Sutfin et al. (2015) did not find race/ethnic differences, and Kenne et al. (2016) indicated that White students were more likely than others to have tried e-cigarettes. A call to examine ENDS use among racially/ethnically heterogenous groups has been proposed (Littlefield et al., 2015); utilizing more ethnically-diverse samples is likely to clarify discrepancies observed in prior studies.

Given the increasing rates of ENDS use among younger populations, it is crucial to identify correlates of use in order to inform forthcoming prevention/intervention efforts. The current study aimed to identify contextual factors linked to ENDS use, examine the co-occurrence of ENDS use with risky alcohol use, and assess ethnic and sex differences in ENDS use using an ethnically heterogeneous sample of college students.

Methods

Participants

The study included data from 452 undergraduate students enrolled at California State University, Long Beach, a large, public urban university in the Western U.S. Participants were eligible if they were 18 years or older and an undergraduate at the university. The sample closely represented the sex and ethnic composition of the university's undergraduate population. Participants in the sample included (university Fall 2015 statistics in parentheses): 59.1% (56.2%) female; 36.9% (39.0%) Hispanic/Latino, 26.3% (23.4%) Asian/Pacific Islander, 17.9% (18.7%) Caucasian/White, 4.9% (3.8%) African-American/Black, 5.1% (4.8%) Multiracial; 2.1% (3.6%) other, 0.2% (0.2%) Native American, and 6.6% declined ethnicity response. The average age of participants was 21.26 years ± 2.57. Just over half (52.7%) were living with parents, 32.5% with roommates, 3.8% with a

significant other, and 2.8% alone. Just over a third (36.3%) were transfer students from community colleges. The average time spent in college was 3.44 years ± 1.79, and average time spent at California State University, Long Beach was 2.44 years ± 1.53. A wide range of majors were represented; the top 10 majors included: 11.1% Engineering; 10.5% Psychology; 8.2% Human Development; 7.7% Biological/Life Sciences; 7.7% Communications; 6.4% Business; 5.1% Health Science; 4.4% Kinesiology; 4.0% Nursing; and 3.3% Sociology.

Procedure

The study was approved by the California State University, Long Beach Institutional Review Board. Participants were recruited across public space on campus during the 2015–2016 academic year to take a 15-minute survey on health-risk behaviors. Participants were asked 118 questions pertaining to ENDS use, alcohol use, cigarette smoking, nutrition and physical activity, and psychosocial adjustment. Twenty-four data collections took place across six designated public spaces on campus from September 2015 to March 2016. Individuals walking by designated spaces were recruited to participate. Interested and eligible participants completed a written informed consent and then completed a survey on an electronic tablet. Participants sat at a table with partitions for privacy, and survey responses were anonymous. A $10 gift card (choice of Amazon, itunes, Starbucks, Target) was given for participation. Although 469 surveys were completed, 17 were excluded from analyses due to technical errors with tablets or the high likelihood of being a duplicate response.

Measures

Demographic characteristics—Participants reported their age in years, biological sex (1 = fe*male*, 0 = *male*), and race/ethnicity. Race/ethnicity variables for African American/Black, Asian/Pacific Islander, Caucasian/White, Hispanic/Latino, Multiracial, and other were dummy coded (e.g., 1 = *African-American/Black*, 0 = *non-African-American/Black*). Participants provided information on years enrolled in college and at *university name removed for blind review*, transfer status (1 = transfer student, 0 = *non-transfer student*), and residential status (dummy coded into 1 = *living with parents*, 0 = *not living with parents*).

Alcohol use—Participants responded to four questions on risky alcohol use. These questions were based on questions asked in The National Longitudinal Study of Adolescent to Adult Health (Add Health), a well-established study on a nationally representative sample of U.S. adolescents followed into adulthood (Harris et al., 2009). Participants were asked, “At what age did you have your first drink (more than a few sips) of alcohol (including beer, wine, hard liquor, cocktails, wine coolers, etc.)?” Given the higher developmental risks associated with alcohol use and cigarette smoking prior to mid-adolescence (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004; Riggs, Chou, Li, & Pentz, 2007), response were recoded as 1 = *early initiation (14 years or younger*) and 0 = *later initiation* (older than 14 years or haven’t consumed alcohol). Participants were then asked questions related to binge drinking (females were asked if they had consumed 4 or more drinks in one sitting; males were asked if they had consumed 5 or more drinks in one sitting) and being drunk, including: “Have you ever drank 5 or more drinks in one sitting?” (1 = *yes*, 0 = *no*); “In the past 30 days, how many times have you consumed 5 or more drinks in one sitting?” and “In

the past 30 days, how many times have you been drunk?" Response choices for the last two questions ranged from 1 = *never* to 5 = *often (more than 7 times*). Because less than 5% of participants responded to these questions with 4=*several times (4–7x)* or 5=*often (more than 7 times)*, responses were recoded as 1 = *engaging in behavior* and 0 = *not engaging in behavior*.

Cigarette smoking—Participants were asked four questions pertaining to cigarette smoking, which were also based on questions from Add Health (Harris et al., 2009). Cigarette smoking questions included: (1) "Have you ever smoked a cigarette?" (1 = *yes*, 0 = *no*); (2) "How old were you when you first smoked a cigarette?", with responses recoded as 1 = *early initiation (14 years or younger*) and 0 = *later initiation* (older than 14 years or haven't smoked a cigarette); (3) "In the past month, have you smoked cigarettes regularly (at least 5 times in the last 30 day period)?" (1 = *yes*, 0 = *no*); and (4) "Have you ever smoked cigarettes regularly (at least 5 times in a 30 day period)?", which was used to identify former regular cigarette smokers (1=*yes*, 0=*no*) by comparing question 4 to question 3.

ENDS use—Participants were asked 11 questions related to ENDS use. These questions were developed for the current study, as there was no available validated questionnaire on young adult ENDS use at the time of survey development and implementation. Questions on prevalence included: (1) "Have you ever tried an electronic tobacco product (like e-cigarettes, vaporizers, e-hookahs)?" (1 = *yes*, 0 = *no*); and (2) "Would you consider yourself a regular user of any electronic tobacco product, like e-cigarettes, vaporizers, or e-hookahs?" (1 = *yes*, 0 = *no*).

Questions on ENDS use behaviors included: (1) "If you have ever used an e-cigarette, vaporizer, or other electronic tobacco products (e.g., e-hookah) did it contain nicotine?" (0 = *no*, 1 = *not sure*, 2 = *yes*); (2) "Which electronic tobacco product do you prefer?" (1 = *I don't have a preference*, 2 = *E-cigarettes*, 3 = *Vaporizers*, 4 = *E-hookah*. 5 = *Other*); (3) "If you have tried any electronic tobacco product (like e-cigarettes, vaporizers, e-hookahs), where did you obtain the product?" (1=*Vape store*, 2 = *Convenience store (e,g., 7-Eleven)*, 3 = *Friend*, 4 = *Off the street*, 5 = *Other*); and (4) "When you have used electronic tobacco products (like e-cigarettes, vaporizers, and e-hookahs), you are usually…" (1 = *By yourself*, 2 = *With friends*, 3 = *With others who use the product but are not friends*, 4 = *Other*). Participants that did not endorse ENDS use were able to respond to these questions with 'I have never tried these products'.

Questions related to ENDS attitudes and motivations included: (1) "Do you think electronic tobacco products like e-cigarettes or vaporizers are healthier to smoke than regular cigarettes" (0 = *no*, 1 = *not sure*, 2 = *yes*); (2) "Would you prefer to smoke a regular cigarette or use an e-cigarette (or vape)?" (1=*e-cigarette (or vape)*, 0=*regular cigarette*); (3) "If you haven't tried e-cigarettes, vaporizers, or other electronic tobacco products, would you like to try them in the future?" (0 = *no*, 1 = *not sure*, 2 = *yes; 'I have already tried them'* was also an option). (4) "What percentage of your friends would you say use electronic tobacco products?" (0–100%); (1) "If you are a regular user of any electronic product (e.g., e-cigarette, vaporizer, e-hookah), why do you like this product?" (open-ended response).

Statistical Analysis

Descriptive statistics were used to summarize results on ENDS use prevalence and endorsement of ENDS behaviors, attitudes, and motivations. Potential correlates of ENDS use including demographic variables, risky alcohol use and cigarette smoking, and ENDS attitudes/context were examined separately with chi-square tests or simple logistic regressions. Correlates were then concurrently assessed using a mixed effects binary logistic regression model. The regression model was performed using Mplus version 7.4 (Muthén & Muthén, 1998–2015) in order to utilize full-information maximum likelihood estimation. Adjusted odds ratios and their 95% confidence intervals (CI) were computed; a two-tailed p-value <0.05 was considered statistically significant. Chi-square tests also assessed differences between ever ENDS users that had smoked cigarettes vs. those that had not smoked cigarettes.

Results

ENDS prevalence

Almost 40% (39.8%) of participants reported having used ENDS in their lifetime. Of the 180 students that identified as ever ENDS users, 12.2% reported being a regular ENDS user; 2.8% endorsed being both a regular ENDS user and regular cigarette smoker, 3.9% reported being a regular ENDS user and a former regular cigarette smoker, and 5.6% endorsed being a regular ENDS user but not a current or former regular cigarette smoker.

Participants that reported using ENDS were asked specific questions about their use. The majority (59.1%) indicated that their ENDS product(s) contained nicotine (22.7% no nicotine; 18.2% not sure). In terms of ENDS product preference, 44% did not have a preference, 31.4% preferred vaporizers, 13.1% preferred e-hookahs, and 10.9% preferred e-cigarettes. ENDS users were most likely to obtain their ENDS product(s) from friends (68.0%), followed by vape stores (18.9%), convenience stores (6.9%), and other sources (6.3%). When asked about the social context, 82.5% usually used ENDS with friends, 13.5% used ENDS alone, and 2.3% used with others not considered friends. Regular ENDS users (n = 22; 4.9% of the sample) were asked why they liked using ENDS products like e-cigarettes, vaporizers, or e-hookahs. Responses were evaluated for similar content and classified into five overarching themes: (1) feeling high/buzzed (e.g., “It’s like feeling high”, “nicotine buzz”); (2) feeling relaxed/less stressed (e.g., “relaxation”, “alternative sense of relief ”, “calms me down and lowers stress”; (3) tastes good/flavor (e.g., “the taste is better than a regular cigarette”, “taste good”); (4) healthier alternative (e.g., “I feel healthier than when I smoked”, “healthier than cigarettes”); and (5) fun/cool (“fun doing tricks”, “I like doing cool things”).

Whether or not they had tried ENDS products, all participants were asked questions reflecting ENDS attitudes. Almost half (47.0%) of students did not think ENDS products were healthier than cigarettes, 29.1% were not sure, and 23.8% thought ENDS were healthier. When given the choice to smoke a regular cigarette vs. use an e-cigarette (or vape), the majority (76.2%) preferred the ENDS products. On average, participants stated that 17.4% ± 20.99% of their friends had used ENDS products. For those that had not tried

ENDS, 54.1% stated they had no desire to try in the future, 10.0% were not sure, and 4.0% did have a desire.

Ever ENDS users vs. non-ENDS users

Participants that had tried ENDS were compared to those that had not tried ENDS on various correlates, including demographic variables, risky alcohol use and cigarette smoking, as well as ENDS attitudes and context. Chi-square and simple logistic regressions were conducted to assess group differences and presented in Table 1. No demographic variables significantly differed between ever ENDS users and non-ENDS users except for residence. Students that lived with parents were less likely to use ENDS compared to those living with roommates, alone, or with a significant other ($\chi^2 = 4.22$, $p < .05$). As for co-occurring health-risk behaviors, endorsement of every risky alcohol use and cigarette smoking indicator had a higher likelihood of ever ENDS use. Students that had engaged in earlier alcohol use initiation ($\chi^2 = 15.09$, $p < .001$), binge drinking ($\chi^2 = 46.17$, $p < .001$), binge drinking in the past 30 days ($\chi^2 = 35.34$, $p < .001$), and being drunk in the past 30 days ($\chi^2 = 39.16$, $p < .001$) were more likely to have tried ENDS than those not engaging in risky alcohol use. Students reporting earlier cigarette smoking initiation ($\chi^2 = 7.26$, $p < .01$), smoking a cigarette ($\chi^2 = 95.65$, $p < .001$), being current regular smoker ($\chi^2 = 27.49$, $p < .001$), and being a former regular smoker ($\chi^2 = 24.00$, $p < .001$) were also more likely to endorse ever ENDS use. Additionally, participants that had a more positive health perception of ENDS, $t(447) = -4.33$, $p < .001$, and a higher percentage of friends that use ENDS products, $t(447) = -4.21$, $p < .001$, had a higher likelihood of endorsing ENDS use.

The above correlates were then entered simultaneously into a binary logistic regression model to assess which variables were most predictive in identifying ever ENDS users vs. non-ENDS users (Table 2). Demographic variables were not significantly different between ever ENDS users and non-ENDS users. Of the four risky alcohol behaviors, only binge drinking was significant. Participants endorsing binge drinking had a higher likelihood of having tried ENDS ($AOR = 2.53$, $p < .001$). Cigarette smoking significantly predicted ever ENDS use, with those that had smoked a cigarette ($AOR = 8.39$, $p < .001$), were a current regular smoker ($AOR = 4.59$, $p < .05$), or a former regular smoker ($AOR = 8.90$, $p < .01$) having a higher likelihood of endorsing ENDS use. In terms of ENDS attitudes and social context, having a more positive health perception of ENDS ($AOR = 1.42$, $p < .05$), preferring an e-cigarette (or vape) over cigarette smoking ($AOR = 2.95$, $p < .01$), and having a higher percentage of friends that had used ENDS ($AOR = 1.02$, $p < .01$) were all significantly related to a higher likelihood of ever ENDS use.

Cigarette smoking vs. non-cigarette smoking among ever ENDS users

Due to the small number of participants endorsing regular use of ENDS (n = 22; 4.9% of sample), there was insufficient power to compare regular ENDS users by regular cigarette smoking behavior. However, because a substantial proportion of ever ENDS users did not endorse ever cigarette smoking (33.0%), we examined whether certain ENDS behaviors differed between ever ENDS users that had tried vs. not tried cigarette smoking. Four ENDS questions (presence of nicotine, product preference, source, and social context) were assessed with chi-square tests. ENDS product preference, the source from which participants

obtained ENDS product(s), and the social context in which participants used ENDS did not significantly differ between ever ENDS users that had smoked a cigarette vs. not smoked a cigarette. Ever ENDS users that had tried cigarette smoking had a higher likelihood of reporting that their ENDS product(s) contained nicotine ($\chi^2 = 10.06$, $p < .01$); conversely, ever ENDS users that had not tried cigarette smoking had a higher likelihood of being unsure about the presence of nicotine in their ENDS product(s) ($\chi^2 = 5.54$, $p < .05$).

Discussion

The current study sought to expand empirical work on ENDS use (i.e., e-cigarette use/vaping) by examining contextual factors linked to use, assessing whether ENDS use co-occurs with risky alcohol use, and evaluating ethnic and sex differences among a sample of ethnically diverse college students. The high prevalence of ever ENDS use (40%) corroborates previous studies indicating that the popularity of ENDS among young adults has grown substantially in just under a decade (Kenne et al., 2016; Littlefield et al., 2015, Saddleson et al., 2015; Sutfin et al., 2015). An examination of contextual factors revealed that friends are largely involved in ENDS use among college students. The vast majority of participants that had used ENDS products reported obtaining and using ENDS with their friends, as opposed to obtaining products at a vape shop or using alone. Those that had tried ENDS also had a greater number of friends that had used ENDS compared to those that had never tried ENDS. Given that social acceptance among peers continues to be vital during the transition from adolescence to young adulthood (Nelson et al., 2008; Steinfield, Ellison, & Lampe, 2008), social approval of ENDS by college students is likely driving the rapid pace of ENDS use (Pokhrel, Little, Fagan, Muranaka, & Herzog, 2014; Trumbo & Harper, 2013).

Moreover, ENDs' growing popularity and acceptance could be due to its novelty as a 'risk-taking' behavior and its potential utility in decreasing negative emotional states. Very few self-identified regular ENDS users indicated using ENDS as an attempt to quit regular tobacco use; instead, motivations for use underscored experience-seeking behaviors (getting 'high' or 'buzzed') or as a coping strategy ('to relax' or 'decrease stress'). Other studies have noted that young adults use ENDS to satisfy a need for experimentation, curiosity, or for recreation/enjoyment (Saddleson et al., 2016; Sutfin et al., 2013, 2015; Trumbo et al., 2015). Surprisingly, one-third of participants that had tried ENDS had never smoked a cigarette, suggesting this subgroup of young adults may have tried ENDS as a result of its branding as cool, trendy, and uniquely different from traditional tobacco use.

Even with a third of ever ENDS users reporting never having smoked a cigarette, the expected association between ENDS use and cigarette smoking (Kenne et al., 2016; Loukas et al., 2015; Sutfin et al., 2013, 2015; Trumbo & Harper, 2013) was found in this study as well. Regular current and former cigarette smokers were more likely to have engaged in ENDS use; additionally, participants that reported just having tried cigarette smoking were also more likely to have tried ENDS products. Going beyond the relationship between ENDS and cigarette smoking, this study extended work on co-occurring health-risks by examining the association between ENDS use and risky alcohol use. After accounting for cigarette smoking behaviors and other correlates, the endorsement of binge drinking remained a significant correlate of ever ENDS use. Although cigarette smoking appears to

be a more robust correlate of ENDS use, binge drinking may potentially be a noteworthy risk factor of ENDS use. Considering that binge drinking is a common experience-seeking behavior among college students (Patrick & Schulenberg, 2011; Schulenberg & Maggs, 2002), the greater endorsement of binge drinking among ever ENDS users may signify that ENDS is beginning to be perceived as a normative experience-seeking behavior among young adults.

Unlike other studies reporting males were more likely than females to have tried ENDS products (Kenne et al., 2016; Littlefield et al., 2015; Sutfin et al., 2013), no significant sex differences were found in this study. It is possible that as ENDS use has become more socially normative among college students, females' desire to use and ease of access to ENDS products (through friends) has increased. The sample's racial/ethnic heterogeneity may also explain why sex differences were not found. Studies that have reported sex differences have been largely comprised of Caucasian/White participants, and the only previous study without a majority Caucasian/White sample (Loukas et al., 2015) did not report significant sex differences. We also did not find any ethnic differences between ever ENDS users and non-ENDS users. Although the current study was comprised of an ethnically diverse sample of college students, the lack of ethnic differences in ever ENDS use cannot be generalized to the widespread college population. Additional studies using representative samples of the U.S. college population are crucial, but the present findings do suggest that public health concern over ENDS use should not be limited to specific demographic groups.

Limitations of the study need to be considered. Although self-report surveys were anonymous and confidential, participants may have been influenced by social desirability or felt uncomfortable responding to questions on substance use even with the exclusion of illicit drug questions. The study was also cross-sectional; thus, the effect and directionality of correlates on ENDS use was not assessed. Furthermore, although the survey contained several questions on ENDS attitudes, behaviors, and motivations, the survey lacked questions establishing frequency and severity of ENDS use. For instance, the survey did not define 'regular' ENDS use and did not inquire specifically about past month use, which limits the impact of the work. Additionally, the survey used the term 'electronic tobacco use' vs. the commonly referenced 'electronic nicotine delivery systems (ENDS)', which is problematic because e-cigarettes and vaporizers contain nicotine but not tobacco. However, references in the survey to 'electronic tobacco use' were followed with specific ENDS examples (e.g., e-cigarettes, vaporizers, e-hookahs); thus, participants most likely comprehended that they were being asked about e-cigarette use or vaping. Finally, although the study was comprised of an ethnically-diverse sample, the sample did not include a large proportion of African-American/Blacks (5%). The sample also represented only a small region on the U.S., one in which ENDS policies and attitudes may differ substantially from other regions. Consequently, further study is needed on a more representative sample of U.S. college students.

Despite these limitations, the current study brings to the forefront the need to consider the context in which ENDS use takes place, move beyond co-occurring traditional tobacco use to other health-risks, and move forward with more ethnically diverse and representative

samples of U.S. college students. Public health efforts may be successful in using strategies that effectively targeted traditional tobacco use (Dobbins, DeCorby, Manske, & Goldblatt, 2008). Additionally, a greater focus on the processes and pathways by which ENDS use co-occurs with other health-risk behaviors like binge drinking is needed to better understand the initiation, course, and consequences of ENDS use. Undertaking longitudinal studies with more representative samples of U.S. young adults is critical for creating effective prevention/intervention strategies prior to ENDS use becoming more prevalent and normative.

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References

Bostean G, Trinidad DR, McCarthy WJ. E-cigarette use among never-smoking California students. American Journal of Public Health. 2015; 105:2423–2425. [PubMed: 26469671]

Choi K, Forster J. Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young US Midwestern adults. American Journal of Public Health. 2013; 103:556–561. [PubMed: 23327246]

Delnevo CD, Giovenco DP, Steinberg MB, Villanti AC, Pearson JL, Niaura RS, Abrams DB. Patterns of electronic cigarette use among adults in the United States. Nicotine & Tobacco Research. 2016; 18:715–719. [PubMed: 26525063]

Dobbins M, DeCorby K, Manske S, Goldblatt E. Effective practices for school-based tobacco use prevention. Preventive Medicine. 2008; 46:289–297. [PubMed: 18093639]

Etter J, Bullen C. A longitudinal study of electronic cigarette users. Addictive Behaviors. 2014; 39:491–494. [PubMed: 24229843]

Flory K, Lynam D, Milich R, Leukefeld C, Clayton R. Early adolescent through young adult alcohol and marijuana use trajectories: Early predictors, young adult outcomes, and predictive utility. Development and Psychopathology. 2004; 16:193–213. [PubMed: 15115071]

Harris, KM., Halpern, CT., Whitsel, E., Hussey, J., Tabor, J., Entzel, P., Udry, JR. The National longitudinal study of adolescent to adult health: Research design [WWWdocument]. 2009. URL:Available at: http://www.cpc.unc.edu/projects/addhealth/design

Hershberger AR, Karyadi KA, VanderVeen JD, Cyders MA. Combined expectancies of alcohol and e-cigarette use relate to higher alcohol use. Addictive Behaviors. 2016; 52:13–21. [PubMed: 26334561]

Johnson, LD., O'Malley, PM., Bachman, JG., Schulenberg, JE., Miech, RA. Monitoring the Future National Survey Results on Drug Use, 1975–2014: Volume 2, College students and adults ages 19–55. Ann Arbor, MI: Institute for Social Research, The University of Michigan; 2016.

Kenne DR, Mix D, Banks M, Fischbein R. Electronic cigarette initiation and correlates of use among never, former, and current tobacco cigarette smoking college students. Journal of Substance Use. 2016; 21(5):491–494. Epub ahead of print.

Keyes KM, Jager J, Hamilton A, O'Malley PM, Miech R, Schulenberg JE. National multi-cohort time trends in adolescent risk preference and the relation with substance use and problem behavior from 1976 to 2011. Drug and Alcohol Dependence. 2015; 155:267–274. [PubMed: 26254018]

Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. Nicotine and Tobacco Research. 2015; 17:847–854. [PubMed: 25481917]

Lanier C, Farley EJ. What matters most? Assessing the influence of demographic characteristics, college-specific risk factors, and poly-drug use on nonmedical prescription drug use. Journal of American College Health. 2011; 59:721–727. [PubMed: 21950253]

Littlefield AK, Gottlieb JC, Cohen LM, Trotter DRM. Electronic cigarette use among college students: Links to gender, race/ethnicity, smoking, and heavy drinking. Journal of American College Health. 2015; 63:523–529. [PubMed: 26057365]

Loukas A, Batanova M, Fernandez A, Agarwal D. Changes in use of cigarettes and non-cigarette alternative products among college students. Addictive Behaviors. 2015; 49:46–51. [PubMed: 26046401]

McMillen RC, Gottlieb MA, Shaefer RW, Winickoff JP, Klein JD. Trends in electronic cigarette use among U.S. adults: Use is increasing in both smokers and nonsmokers. Nicotine and Tobacco Research. 2015; 17:1195–1202. [PubMed: 25381306]

Miller MB, Lechner WV, Meier E, Tucker RP, Wiener JL. Dual tobacco use among college students: Contexts of use, self-perceptions, and attitudes toward quitting. Substance Use and Misuse. 2014; 49:700–707. [PubMed: 24328841]

Nelson LJ, Padilla-Walker LM, Badger S, McNamara C, Carroll JS, Madsen SD. Associations between shyness and internalizing behaviors, externalizing behaviors, and relationships during emerging adulthood. Journal of Youth and Adolescence. 2008; 37:605–615.

Patrick ME, Schulenberg JE. How trajectories of reasons for alcohol use relate to trajectories of binge drinking: National panel data spanning late adolescence to early adulthood. Developmental Psychology. 2011; 47:311–317. [PubMed: 21219061]

Pearson JL, Richardson A, Niaura RS, Vallone DM, Abrams DB. E-cigarette awareness, use, and harm perception in US adults. American Journal of Public Health. 2012; 102:1758–1766. [PubMed: 22813087]

Pokhrel P, Little MA, Fagan P, Muranaka N, Herzog TA. Electronic cigarette use outcome expectancies among college students. Addictive Behaviors. 2014; 39:1062–1065. [PubMed: 24630824]

Quintero G, Peterson J, Young B. An exploratory study of socio-cultural factors contributing to prescription drug misuse among college students. Journal of Drug Issues. 2006; 36:903–931.

Riggs NR, Chou CP, Li C, Pentz MA. Adolescent to emerging adulthood smoking trajectories: when do smoking trajectories diverge, and do they predict early adulthood nicotine dependence? Nicotine & Tobacco Research. 2007; 9:1147–1154. [PubMed: 17978988]

Rutten LJ, Blake KD, Agunwamba AA, Grana RA, Wilson PM, Ebbert JO, … Leischow SJ. Use of e-cigarettes among current smokers: Associations among reasons for use, quit intentions, and current tobacco use. Nicotine and Tobacco Research. 2015; 17:1228–1234. [PubMed: 25589678]

Saddleson ML, Kozlowski LT, Giovino GA, Goniewicz ML, Mahoney MC, Homish GG, Arora A. Enjoyment and other reasons for electronic cigarette use: Results from college students in New York. Addictive Behaviors. 2016; 54:33–39. [PubMed: 26704429]

Saddleson ML, Kozlowski LT, Giovino GA, Hawk LW, Murphy JM, MacLean MG, … Mahoney MC. Risky behaviors, e-cigarette use and susceptibility of use among college students. Drug and Alcohol Dependence. 2015; 149:25–30. [PubMed: 25666362]

SAMHSA, Center for Behavioral Health Statistics and Quality. Key substance use and mental health indicators in the United States: Results from the 2015 National Survey on Drug Use and Health. 2016. (HHS Publication No. SMA 16–4984, NSDUH Series H-51). Retrieved from http://www.samhsa.gov/data/

Schulenberg JE, Maggs JL. A developmental perspective on alcohol use and heavy drinking during adolescence and the transition to young adulthood. Journal of Studies on Alcohol. 2002; (Suppl 14):54–70. [PubMed: 12022730]

Steinberg L. A social neuroscience perspective on adolescent risk-taking. Developmental Review. 2008; 28:78–106. [PubMed: 18509515]

Steinfield C, Ellison NB, Lampe C. Social capital, self-esteem, and use of online social network sites: A longitudinal analysis. Journal of Applied Developmental Psychology. 2008; 29:434–445.

Stone AL, Becker LG, Huber AM, Catalano RF. Review of risk and protective factors of substance use and problem use in emerging adulthood. Addictive Behaviors. 2012; 37:747–775. [PubMed: 22445418]

Sutfin EL, McCoy TP, Morrell HER, Hoeppner BB, Wolfson M. Electronic cigarette use by college students. Drug and Alcohol Dependence. 2013; 131:214–221. [PubMed: 23746429]

Sutfin EL, Reboussin BA, Deblinski B, Wagoner KG, Spangler J, Wolfson M. The impact of trying electronic cigarettes on cigarette smoking by college students: A prospective analysis. American Journal of Public Health. 2015; 105:e83–e89.

Trumbo CW, Harper R. Use and perception of electronic cigarettes among college students. Journal of American College Health. 2013; 61:149–155. [PubMed: 25158012]

Trumbo CW, Kim SS. The effect of electronic cigarette advertising on intended use among college students. Addictive Behaviors. 2015; 46:77–81. [PubMed: 25827334]

Weaver SR, Majeed BA, Pechacek TF, Nyman AL, Gregory KR, Eriksen MP. Use of electronic nicotine delivery systems and other tobacco products among USA adults, 2014: Results from a national survey. International Journal of Public Health. 2016; 61:177–188. [PubMed: 26560309]

Willoughby T, Good M, Adachi PJC, Hamza C, Tavernier T. Examining the link between adolescent brain development and risk taking from a social-developmental perspective. Brain and Cognition. 2014; 89:70–78. [PubMed: 25113660]

Wills TA, Knight R, Williams RJ, Pagano I, Sargent JD. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. Pediatrics. 2015; 135:e43–e51. [PubMed: 25511118]

Table 1

Sample characteristics overall and by ENDS use (N=452).

Characteristic	Overall	Ever ENDS Use	No ENDS Use
N(%) or *Mean* ± *SD*			
Age (years)	21.3 ± 2.6	21.4 ± 2.6	21.2± 2.5
Biological sex †			
Female	267(59.1%)	97(53.9%)	168(62.2%)
Male	185(40.9%)	83(46.1%)	102(37.8%)
Ethnicity			
African-American/Black	22(4.9%)	6(3.4%)	16(6.0%)
Asian/Pacific Islander	119(26.3%)	53(31.2%)	65(26.0%)
Caucasian/White	81(17.9%)	39(22.9%)	42(16.8%)
Hispanic/Latino	167(36.9%)	60(35.3%)	107(42.8%)
Multiracial	23(5.1%)	9(5.3%)	13(5.2%)
Years in college			
1 year	77(17.0%)	27(15.7%)	50(19.8%)
2 years	74(16.4%)	33(19.2%)	40(15.8%)
3 years	71(15.7%)	28(16.3%)	43(17.0%)
4 years	76(16.8%)	25(14.5%)	51(20.2%)
5 years	69(15.3%)	31(18.0%)	38(15.0%)
6 or more years	60(13.3%)	28(16.3%)	31(12.3%)
Transfer status			
Transfer	164(36.3%)	62(34.4%)	101(37.5%)
Non-transfer	287(63.5%)	118(65.6%)	168(62.5%)
Residence			
Parents *	238(52.7%)	86(50.0%)	152(60.0%)
Roommates †	147(32.5%)	67(39.0%)	78(30.8%)
Significant Other	17(3.8%)	9(5.2%)	8(3.2%)
Alone	17(3.8%)	6(3.5%)	11(4.3%)
Alcohol Use			
Early initiation ***	75(16.7%)	45(25.1%)	30(11.2%)
Binge drinking ***	264(58.4%)	140(77.8%)	123(45.6%)
Binge past month ***	130(28.7%)	80(44.4%)	50(18.5%)
Drunk past month ***	179(39.6%)	103(57.2%)	75(27.8%)
Cigarette Smoking			
Early initiation **	34(7.5%)	21(11.7%)	13(4.8%)
Ever cigarette ***	177(39.2%)	120(66.7%)	56(20.7%)
Current smoker ***	35(7.7%)	28(15.6%)	6(2.2%)
Former smoker ***	34(7.5%)	27(15.1%)	7(2.6%)
ENDS Attitudes/Context			

Characteristic	Overall	Ever ENDS Use	No ENDS Use
Health perception***	.77 ± .81	.97 ± .85	.64 ± .76
Prefer over cigarettes	317(76.2%)	130(73.4%)	186(78.5%)
Friends' use(%)***	17.4 ± 21.0	22.5 ± 23.6	13.97 ± 18.3

† $p < .10$;

* $p < .05$;

** $p < .01$;

*** $p < .001$.

Table 2

Binary logistic regression of ever ENDS use vs. no ENDS use (N = 450).

Covariate	Adjusted Odds Ratio *(AOR)*	95% *CI* for *AOR*	*p*-value
Age	.87	.71–1.07	.191
Female vs. male	.91	.52–1.58	.734
African American	.94	.11–8.01	.956
Asian/Pacific Islander	1.43	.22–9.31	.707
Caucasian/White	.73	.11–4.85	.742
Hispanic/Latino	.89	.14–5.67	.898
Multiracial	1.43	.17–12.38	.745
Years in college	1.22	.97–1.53	.089
Transfer	.47	.20–1.08	.075
Reside with parents	.99	.56–1.74	.961
Early alcohol initiation	1.30	.59–2.89	.515
Binge drinking	2.53	1.33–4.86	.005**
Binge drinking past month	.73	.33–1.60	.430
Drunk past month	2.00	.97–4.14	.061
Early cigarette initiation	.58	.18–1.84	.351
Smoked a cigarette	8.39	4.18–16.83	.000***
Current smoker	4.59	1.40–15.11	.012*
Former smoker	8.90	2.35–33.73	.001**
ENDS healthier	1.42	1.01–1.99	.045*
Prefer e-cigarette (vape)	2.95	1.31–6.66	.009**
ENDS friends	1.02	1.01–1.03	.006**

* $p < .05$;

** $p < .01$;

*** $p < .001$.

Note. All covariates categorical except age, years in college, ENDS healthier, ENDS friends.