Electronic Cigarette Use by College Students

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Abstract

Background—Electronic cigarettes, or ecigarettes, are battery operated devices that deliver nicotine via inhaled vapor. There is considerable controversy about the disease risk and toxicity of ecigarettes and empirical evidence on short- and long-term health effects is minimal. Limited data on e-cigarette use and correlates exist, and to our knowledge, no prevalence rates among U.S. college students have been reported. This study aimed to estimate the prevalence of ecigarette use and identify correlates of use among a large, multi-institution, random sample of college students.

Methods—4,444 students from 8 colleges in North Carolina completed a Webbased survey in fall 2009.

Results—Ever use of ecigarettes was reported by 4.9% of students, with 1.5% reporting past month use. Correlates of ever use included male gender, Hispanic or "Other race" (compared to non-Hispanic Whites), Greek affiliation, conventional cigarette smoking and e-cigarette harm perceptions. Although e-cigarette use was more common among conventional cigarette smokers, 12% of ever e-cigarette users had never smoked a conventional cigarette. Among current cigarette smokers, e-cigarette use was negatively associated with lack of knowledge about e-cigarette harm, but was not associated with intentions to quit.

Conclusions—Although e-cigarette use was more common among conventional cigarette smokers, it was not exclusive to them. E-cigarette use was not associated with intentions to quit

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smoking among a sub-sample of conventional cigarette smokers. Unlike older, more established cigarette smokers, e-cigarette use by college students does not appear to be motivated by the desire to quit cigarette smoking.

Keywords

electronic cigarettes; young adults; college students; nicotine; smoking; tobacco; cigarettes

1. INTRODUCTION

Electronic cigarettes, or ecigarettes, are electronic nicotine delivery devices that were developed to closely approximate the sensory experience of smoking conventional cigarettes. While designs differ slightly between manufacturers, most ecigarettes consist of the same basic components: a battery, an airflow sensor, a vaporizor, and a nicotine cartridge, all contained within a cigarette-like tube (American Legacy Foundation, 2012). These novel tobacco products appear to be growing in popularity, as evidenced by substantial increases in electronic search queries (Ayers et al., 2011) and increasing product awareness (Regan et al., 2011). Additionally, in spring 2012, Lorillard purchased Blu Ecigs, marking the first entry of a major tobacco company into the electronic cigarette market. Later in 2012, the Winston-Salem Journal reported that R.J. Reynolds is testing their own electronic cigarette known as Vuse (July 29, 2012). It appears that as cigarette smoking has continued to decline (Centers for Disease Control and Prevention, CDC, 2011), major tobacco companies are diversifying through the introduction of electronic cigarettes, among other novel products.

At present, there is considerable controversy about the health effects of ecigarettes, especially in comparison to conventional cigarettes. However, research assessing health effects is limited, with no research on the long-term health effects of e-cigarette use, in part because it is a relatively recent phenomenon. Research on the short-term effects of smoking an ecigarette (up to one day of use) suggests that smoking an e-cigarette does not expose the smoker to detectable levels of respiratory carbon monoxide (Bullen et al., 2010; Eissenberg, 2010; Vansickel et al., 2010). In a recent study, Vardavas and colleagues (2012) found that following a 5-minute period of e-cigarette use, participants had increased, albeit small, lung flow resistance. Longer periods of use could be associated with greater deficiencies, but more research is needed. While current evidence, albeit limited, suggests electronic cigarettes pose fewer health risks than conventional cigarettes for the individual user, population-level effects must also be considered.

From a public health perspective, the extent to which ecigarettes may serve as a starter product for nonusers of tobacco is a concern (Cobb and Abrams, 2011; Yamin et al., 2010; Foulds et al., 2011). To hinder marketing to children, the U.S. Food and Drug Administration (FDA) recently banned characterizing flavors (i.e., a distinguishable taste or aroma other than tobacco or menthol) in cigarettes; FDA, 2009). While the FDA is responsible for regulating ecigarettes under the Family Smoking Prevention and Tobacco Control Act of 2009 (Deyton and Woodcock, 2011), rules for ecigarettes are not yet in place. Thus, not surprisingly, ecigarettes are sold in a variety of candy and fruit flavors, including strawberry, mint and chocolate (Wollscheid and Kremzner, 2009). Such flavors, combined with marketing campaigns that extol ecigarettes as being "green" and "healthy" and a lack of tobacco taxation (O'Connor, 2012), may particularly appeal to adolescents and young adults; however, few studies have assessed prevalence of e-cigarette use and factors associated with use among young adults.

To date, two large, nationally-representative studies have assessed e-cigarette use among adults, including young adults (Pearson et al., 2012; Regan et al., 2011). In both of these samples, prevalence of ever using electronic cigarettes was highest among young adults and age was inversely associated with use (Pearson et al., 2012; Regan et al., 2011). In a third study, Choi and Foster (2013) assessed awareness, use, harm perceptions and beliefs about use as a cessation aid among a cohort of young adults in the Midwest. They found that 7% had ever used an e-cigarette and use was associated with younger age (20–24 vs. 25–28), male gender, conventional cigarette smoking, agreement that ecigarettes can help people quit, and agreement that ecigarettes are less harmful than conventional cigarettes. However, to date, no studies have assessed use among college students.

College students, in particular, are an important population to examine. Young adults are the tobacco industry's youngest legal target, and marketing strategies targeting college students are widespread (Rigotti et al., 2004). Additionally, substance use is high in this population (Arnett, 2005), with concomitant risk to develop harmful alcohol and other drug use and substance use disorders (Substance Abuse and Mental Health Services Administration, 2009). In terms of tobacco use, young adulthood is a critical period for smoking, often marked by escalation (Orlando et al., 2004) or late-initiation (Chassin et al., 2000). From an epidemiological standpoint it is noteworthy that college students are often drawn to novel products and have historically been at the forefront of societal changes in substance use that later materialize within the general population (Johnston et al., 2008). Therefore, college students may be drawn to ecigarettes due, at least in part, to their novelty. Sensation seeking is a personality trait resulting in the need for stimulation, novel experiences and risk taking (Stephenson et al., 2003, Zuckerman, 1979, 1994). Research has shown that sensation seeking is related to conventional cigarette smoking (Zuckerman et al., 1990); however, its association with ecigarettes has not been studied.

Little is known about the correlates of e-cigarette use among young adults. In two of the three studies to date that included young adults, few variables other than demographics and tobacco use were included (Pearson et al., 2012; Regan et al., 2011; Choi and Forster, 2013). Research on tobacco use among college students has shown associations with several contextual and behavioral factors. For example, affiliation with Greek organizations is associated with tobacco use among college students, particularly social smoking (Sutfin et al., 2009, 2012; Morrell et al., 2005). Additionally, type of institution is related to cigarette smoking. Although daily smoking is more common on public versus private campuses, nondaily smoking is equally likely at public and private campuses (Sutfin et al., 2009). Residence location also appears to be associated with cigarette smoking. Students who report smoking only a few puffs in the past month are more likely to live on-campus than heavy, moderate or social smokers (Sutfin et al., 2009). Finally, a large body of research has documented the association of tobacco use and other substance use, including alcohol and illicit drugs (Ridner et al., 2005; Morrell et al., 2005; Harrison et al., 2008). For example, data from the 2001 College Alcohol Study (n=10,924 students; 120 colleges) show that over 98% of current smokers also drink alcohol (Weitzman and Chen, 2005).

This study aims to (1) estimate the prevalence of e-cigarette use among college students in North Carolina (NC); (2) identify correlates of e-cigarette use among a large, multiinstitution, random sample of college students in NC; and (3) assess correlates of e-cigarette use among current smokers, including associations with cigarette smoking quit intentions, sensation seeking, and other substance use. To our knowledge, this is the first study to report on e-cigarette use based on a random sample of U.S. college students.

2. METHODS

2.1. Sample

In fall of 2009, a stratified random sample of undergraduate students attending eight universities in North Carolina were invited to complete a web-based survey as part of a randomized group trial of an intervention to reduce high-risk drinking behaviors and their consequences, the Study to Prevent Alcohol-Related Consequences (SPARC). Participating schools included both public and private universities (seven public and one private), ranging from 5,000 to over 40,000 students. Students from each campus were selected randomly within class year strata from undergraduate enrollment lists provided by each school. The number of students selected to participate was based both on power considerations for the overall SPARC trial, and the expectation from previous studies and previous waves of the survey that approximately 30–35% of the students would complete the survey within the allotted time period (Reed et al., 2007). The web-based College Drinking Survey, from which data in the present report were taken, focused on alcohol use and measured demographics, alcohol consumption behaviors, and consequences of alcohol use. The survey also assessed other health-risk behaviors, including use of tobacco, marijuana, and other drugs. Shortly after the target number from the eight schools was met, the website was closed. The survey was taken by 4,857 students with a response rate of 41.3%. Of these, 4,444 students answered the ecigarette question (91.5%) and form the analysis set for this study.

2.2. Procedures

All randomly selected students were sent an email inviting them to participate in a web-based survey. The message included a link to a secured website where the survey could be completed. The email notification protocol, including multiple, frequent reminders for the web-based survey, was based on the approach used by Dillman (2000). Students were sent up to four emails over approximately four weeks. All who completed the survey were sent emails awarding them $15.00 in PayPal dollars. Additionally, from the list of completions one student at each school was randomly selected to receive $100. The study protocol was approved by the Wake Forest School of Medicine Institutional Review Board.

2.3. Measures

2.3.1. Demographic Characteristics—Demographics included gender, age, race, residence location (on/off-campus), and mother's and father's educational level (some college education or less vs. college degree or higher). Participants were also asked about membership in Greek organizations (fraternities or sororities), as a member or a pledge.

2.3.2. Electronic Cigarette Use—Participants were asked: *Have you ever used an e-cigarette or an electronic cigarette*. Response options included *No; Yes, more than a year ago but not in the past year; Yes, in the past year but more than a month ago; Yes, in the past month*. Ever e-cigarette users were characterized as those who responded *yes*. Current e-cigarette users were a subset of ever users who reported smoking an e-cigarette in the past month.

2.3.3. Harm Perceptions—The harm perception item was adapted from Smith and colleagues (2007). Participants were asked: *Compared with a regular cigarette, how harmful do you think ecigarettes are?* Response options were: *less harmful, as harmful, more harmful*, and *don't know* (Smith et al., 2007).

2.3.4. Cigarette Smoking—Using standard items from the Youth Risk Behavior Surveillance System (CDC, 2006), age of smoking initiation (used to gauge if students had ever smoked a whole cigarette) and the number of days smoked in the past month were assessed. Responses to age of initiation were: *I have never smoked a whole cigarette, age 8 or younger, each individual age between 9 and 21*, and *22 or older*. Responses to the number of days smoked were: *0 days, 1–2 days, 3–5 days, 6–9 days, 10–19 days, 20–29 days*, and *all 30 days*. Using these two items, four categories were created to represent cigarette smoking behavior: never smoker (never smoked a whole cigarette), former smoker or experimenter (smoked a whole cigarette in lifetime, but not in the past 30 days), current nondaily (smoked on between 1 and 29 of the past 30 days), and current daily smoker (smoked on all of the past 30 days).

2.3.5. Intentions to Quit—Intentions to quit smoking were measured with one item. Participants were asked: *Are you seriously thinking of quitting smoking?* Responses were coded dichotomously (yes/no).

2.3.6. Health-risk Behaviors—Students were asked about lifetime hookah tobacco smoking (yes/no); past month marijuana use (yes/no); past month binge drinking, defined as four or more drinks in a row for females and five or more drinks in a row for males (yes/no); and lifetime illegal drug use, including any form of cocaine, methamphetamines, hallucinogens, flunitrazepam (Rohypnol), 3–4-methylenedioxymethamphetamine (Ecstasy), or prescription drugs without a prescription (yes/no).

2.3.7. Sensation Seeking—Sensation seeking was measured using the Brief Sensation Seeking Scale (Hoyle et al., 2002). Using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), the eight-item scale measures agreement with statements such as: *I would like to explore new places* and *prefer friends who are exciting and unpredictable*. Total sensation seeking scores were calculated from the average of all items for individuals who answered a minimum of five questions on the scale. Cronbach's alpha for the Brief Sensation Seeking Scale was 0.77 in this sample.

2.4. Statistical Analysis

The goals of the statistical analysis were to (1) estimate the prevalence of ever and current e-cigarette use in our study population; (2) evaluate potential correlates of e-cigarette use from student characteristics and behaviors; and (3) assess correlates of e-cigarette use among current smokers, including associations with cigarette smoking quit intentions. For (1), the proportion of students reporting ever e-cigarette use (yes/no) and current use (yes/no) was estimated along with their 95% Wilson CI (Brown et al., 2001). For (2), bivariate and multivariable analyses using mixed-effects logistic regression were performed to evaluate characteristics and behaviors associated with e-cigarette use. Characteristics significant at $p<.10$ in bivariate analyses were included in multivariable modeling, except for age and race, which were adjusted for regardless of significance. For (3), bivariate and multivariable modeling for ever e-cigarette use among current smokers was undertaken to assess the association with quit intentions. Characteristics significant at $p<.10$ in bivariate analyses were included in multivariable modeling, except for quit intentions which was included regardless of significance because it was the primary predictor of interest. All hypothesis test results presented have one degree-of-freedom (*df*) unless otherwise noted. Adjusted odds ratios (AOR) and their 95% confidence intervals were estimated. All modeling adjusted for within-school clustering of use using a random effect for school (Murray, 1998). All analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC). A two-sided p-value < 0.05 was considered statistically significant.

3. RESULTS

Of the 4,444 participants, the average age was 20.5 years (*SD*=2.9) and 79% were White. There were proportionally more females in our sample (63%), which is similar to the overall undergraduate population at the eight NC universities (60.0% female). About half of participants had mothers with a college degree of higher (49%) and 41% reported fathers with a college degree or higher. Student demographics and self-reported behaviors are shown in Table 1. Analyses for missing data were carried out using multiple imputation methods (Little and Rubin, 2002; Royston, 2004, 2009). First we assessed whether the sample that provided full data differed from those with some missing values who additionally contributed to the multiple imputation analysis. Results revealed that the sample with full data had proportionately fewer binge drinkers and fewer were from public institutions versus those with missing data. We then conducted multiple imputation analysis for our primary outcome predicting ever use of ecigarettes (see below).

Almost 5% of the sample reported ever e-cigarette use (216 of 4,444 (4.9%); 95% Wilson CI [4.3%, 5.5%]). Specifically, 1.5% (95% Wilson CI [1.1%, 1.9%]) reported using ecigarettes in the past month, 2.0% (95% Wilson CI [1.7%, 2.5%]) reported use in the past year but not the past month, and 1.4% (95% Wilson CI [1.1%, 1.7%]) reported use more than a year ago but not in the past year. The rates of ever e-cigarette use across the eight schools ranged from 3.9% to 5.8%, while the rates of current e-cigarette use across the eight schools ranged from 0.9% to 2.0%.

Almost three quarters (72%) of ever e-cigarette users were either former/experimenters (30%), current non-daily cigarette smokers (33%) or current daily cigarette smokers (9%). However, 12% of e-cigarette users had never smoked a conventional cigarette.

When asked how harmful ecigarettes are compared to a regular cigarette, half of the participants (50%) reported "*do not know*". Seventeen percent reported that ecigarettes were as harmful as a regular cigarette, 23% reported they were less harmful, and 2% reported they were more harmful. Additionally, more e-cigarette users reported ecigarettes were less harmful (45%) than did non-users (22%). Conversely, more non-users (51%) reported *"do not know"* than did users (23%).

Bivariate analyses of ever e-cigarette use indicated that being male (*p*<.001), being a Greek member or pledge (*p*=.012), living off-campus (*p*=.010), greater sensation seeking (*p*<.001), smoker status (3 df, *p*<.001), lifetime hookah use (*p*<.001), current binge drinking (*p*<.001), current marijuana use (*p*<.001), lifetime other illegal drug use (*p*<.001), and harm perceptions about ecigarettes (3 df, *p*<.001), were associated with ever e-cigarette use. All other characteristics given in Table 1 were not significantly associated with ever use in bivariate analyses.

Multivariable analyses after multiple imputation presented in Table 2 indicated that males were more likely to report ever e-cigarette use than females (*AOR*=1.54, *p*=.005). Hispanic students (*AOR*=2.02, *p*=.042) and Other Race students (*AOR*=2.06, *p*=.020) were more likely to report ever e-cigarette use compared to non-Hispanic White students. Participants who were affiliated with Greek letter organizations were more likely to report ever use (*AOR*=1.64, *p*=.011). Ever e-cigarette use was also significantly associated with harm perceptions (*p*<.001). Here, lack of knowledge about the harm of ecigarettes compared to regular cigarettes was related to a lower likelihood of use compared to perceptions of similar harm (*AOR*=0.44, *p*<.001). Finally, ever e-cigarette use was strongly associated with cigarette smoking. Compared to never cigarette smokers, e-cigarette use was more likely among smokers, including current daily (*AOR*=5.61, *p*<.001), nondaily (*AOR*=6.55, *p*<.001) and former/experimental (*AOR*=5.66, *p*<.001) smokers. Ever e-cigarette use was not

associated with residence location, sensation seeking, ever hookah smoking, past 30 day binge drinking, past 30 day marijuana use or ever illicit drug use.

We also assessed ever e-cigarette use among a subsample of current cigarette smokers (N=772; 82 e-cigarette users). In bivariate analyses presented in Table 3, ever e-cigarette use by current cigarette smokers was associated with being male (*OR*=1.95, *p*=.005), having higher sensation seeking scores (*OR*=1.75, *p*=.002), current binge drinking (*OR*=1.85, *p*=.045), ever other illicit drug use (*OR*=1.74, *p*=.019) and harm perceptions of ecigarettes (3 *df, p*<.001). Again, lack of knowledge about the harm of ecigarettes compared to regular cigarettes was related to a lower likelihood of use compared to perceptions of similar harm (*OR*=0.23, *p*<.001). Additionally, reporting ecigarettes were more harmful compared to regular cigarettes was associated with increased odds of use compared to perceptions of similar harm (*OR*=3.67, *p*<.05). Marijuana use was marginally significant, such that current marijuana users were more likely to be ever e-cigarette users (*OR*=1.60, *p*=.06). All other covariates given in Table 3 were not significantly associated with ever use among current smokers.

Multivariable results of ever e-cigarette use among current smokers again revealed harm perceptions were significant (see Table 4). Again, lack of knowledge about the harm of ecigarettes compared to regular cigarettes was related to a lower likelihood of use compared to perceptions of similar harm (*AOR*=0.23, *p*<.001). Increased perceptions of harm was marginally significant, such that reporting ecigarettes were more harmful compared to regular cigarettes was associated with increased odds of use, though not significant, compared to perceptions of similar harm (*AOR*=3.10, *p*=.06). No other variables, including quit intentions, were related to e-cigarette use among cigarette smokers.

4. CONCLUSIONS

The results of the study indicate 4.9% of the sample reported ever electronic cigarette use, with current use reported by 1.5% of respondents. These estimates are higher than the prevalence rates of ever e-cigarette use reported among two large national samples of adults (Pearson et al., 2012; Regan et al., 2011), as would be expected given that college students are often at the forefront of societal changes in substance use (Johnston et al., 2008), as previously mentioned. Specifically, Pearson and colleagues (2012) found that 3.4% of adults and Regan and colleagues (2011) found that 2.7% of adults, aged 18 and older reported ever use of ecigarettes. In both of these studies, young adults had the highest rates of use. Our findings are similar to Choi and Forster (2013) who found 7% of young adults ages 20–28 had ever used an e-cigarette and highlight that young adults may be at greater risk for use than older adults. Additionally, Regan and colleagues (2011) found increases in awareness and use of ecigarettes from 2009 to 2010. Therefore, our prevalence estimates may underestimate the *current* rates of use among college students because our data were collected in fall 2009.

Although e-cigarette use was more common among cigarette smokers than non-smokers, 12% of e-cigarette ever users had never smoked a cigarette. Moreover, even among current cigarette smokers, e-cigarette use was not related to intentions to quit cigarette smoking. This finding is contrary to two previous studies, which reported that e-cigarette users claim to use the product to quit smoking and to avoid relapse (Etter, 2010; Etter and Bullen, 2011). Thus, while the use of ecigarettes may be driven by the desire to quit smoking in populations of older, more established smokers, findings suggest that quit intentions do not play a critical role in e-cigarette use in the college student population.

An alternative motivation for e-cigarette use in this population may be that ecigarettes attract novelty seekers who may be new tobacco users. In line with this idea was our finding that affiliation with Greek letter organizations, which is often associated with risk-taking behaviors (O'Brien et al., 2012; Manning et al., 2009) was a significant predictor of ever e-cigarette use. Ever use was also associated with male gender, which is consistent with research on other novel tobacco products such as hookah smoking (Sutfin et al., 2011; Eissenberg et al., 2008). While e-cigarette use was associated with sensation seeking and other substance use in bivariate models, they were not significant, independent predictors in multivariable models. In fact, the marginally significant finding that current cigarette smokers who perceive ecigarettes as more harmful than conventional cigarettes are *more* likely to use ecigarettes, may suggest a risk-taking motivation. Given these findings, more research is necessary to understand the motivational factors underlying e-cigarette use in this population.

It is also important to note that we found race/ethnicity was associated with e-cigarette use. Hispanic students and students who reported "other race" were more likely to have used an e-cigarette than non-Hispanic White students. Choi and Forster (2013) compared non-Hispanic Whites with other races as one group and didn't find any differences. However, Regan and colleagues (2011) found that Hispanic adults were less likely to have heard of ecigarettes than non-Hispanic Whites, but found no differences in use. Finally, using a panel of adult conventional cigarette smokers, Pearson and colleagues (2012) found that African Americans were less likely to have used ecigarettes than non-Hispanic Whites. Research should continue to investigate the relationships between race/ethnicity and e-cigarette use.

This study also revealed young adults' lack of knowledge about the health effects of ecigarettes. When asked to compare how harmful an e-cigarette is to a regular cigarette, half of the sample reported "*do not know*". Almost a quarter of ever e-cigarette users (23%) reported uncertainty in comparing an e-cigarette to a conventional cigarette. Additionally, 45% of ever e-cigarette users reported they are safer than conventional cigarettes. These results are not surprising, given the limited data available on the health effects of ecigarettes. Compared to participants who reported that ecigarettes were about as harmful as conventional cigarettes, reporting *"don't know"* was associated with decreased likelihood of e-cigarette use among the full sample and among a sub-sample of current cigarette smokers. It may be the case that harm perceptions are a proxy for familiarity with the product, such that individuals who have not heard of or tried the product were more likely to report lack of knowledge about the harms associated with the product. It may also be the case that respondents are familiar with the product but recognize the lack of clear scientific evidence as to the health effects of use and therefore are reflecting on the current state of the science by responding "*don't know*". Future research, including qualitative studies, should further investigate students' perceptions of e-cigarette harms and health risks.

The current study should be interpreted in light of several limitations. The response rate for the web survey was relatively low; however, it was similar to rates in other studies of college students' health-risk behaviors (Reed et al., 2007; McCabe et al., 2006). Historically, response rates have been considered an indicator of sample representativeness; however, recent research suggests that response rates are not the sole indicator of nonresponse bias (Lee et al., 2009; Curtin et al., 2000; Ketter et al., 2000; Merkle and Edelman, 2002; Groves and Peytcheva, 2008). To estimate possible nonresponse bias, we compared demographics of our sample with publicly available school-level demographics for each participating university, using data from the Statistical Abstracts of Higher Education in North Carolina. Our sample was quite similar to the overall student population at each participating school with respect to gender and percent of freshmen. On average, our sample schools had only 3.5% less male students than in the population (*mean*=3.52%, *median*=3.86%) and 4.9%

more freshmen students than in the population (*mean*=4.92%, *median* =4.59%). Furthermore, the demographic profile of this sample generally reflects that of undergraduate students in the United States (U.S. Department of Education, 2011). Although the demographic profiles may be similar, important cultural differences may exist between tobacco growing or producing states, such as North Carolina, and other regions of the country that may have longstanding tobacco prevention programs, such as California. At least one study has shown regional variation in tobacco use among college students (Wechsler et al., 1998). Therefore, the ability to generalize our results may be limited. Future research should consider regional differences based on state-level variables such as tobacco control and tobacco production. The items used to measure smoking status (age of initiation and past month smoking) do not allow us to differentiate between those who were former smokers and those who merely experimented with cigarettes (i.e., smoked a few times but never with any regularity). Because former/experimenter smoking status was associated with higher likelihood of e-cigarette use, it is important to disentangle these two groups. It may be the case that former smokers have switched to ecigarettes or that those who just experimented with conventional cigarette smoking are also experimenting with ecigarettes. More research is needed to better understand this association. Finally, while this study provides valuable new information on e-cigarette use among college students, it utilized a cross-sectional design. Longitudinal studies are needed to track trends in e-cigarette use over time as the product becomes more widely recognized and available.

To our knowledge, this is the first study to report on prevalence and correlates of e-cigarette use among a large, multi-institution, random sample of college students. Several surveillance studies, such as CDC's Youth Risk Behavior Surveillance, Monitoring the Future and the American College Health Association's National College Health Assessment have yet to add these items to their annual assessments. While the National Youth Tobacco Survey has added items measuring electronic cigarettes, they will capture data only from youth and not young adults. As ecigarettes gain popularity in the marketplace, especially in the online market, their use needs to be measured, and national prevalence estimates are needed (O'Connor, 2012; Ayers et al., 2011; Yamin et al., 2010). Our findings highlight the general lack of knowledge of the health effects of e-cigarette use. As the FDA moves to establish rules for regulating ecigarettes, clarifying the health effects, perhaps through product warning labels, should be a high priority. However, more research is needed to fully understand the health effects of e-cigarette use. While other studies have found that e-cigarette users reported a desire to quit smoking and avoid relapse as a reason for use (Etter, 2010; Etter and Bullen, 2011), results from this study suggest that e-cigarette use was not associated with quit intentions among college student cigarette smokers.

Our study also underscores the need for longitudinal data assessing whether ecigarettes may serve as a starter product for non-smokers, especially since 12% of e-cigarette users had never smoked a conventional cigarette. ecigarettes appear to be gaining popularity, and as such, may pose the potential for considerable harm. As discussed previously, to date only limited research has been done to evaluate the harm of ecigarettes. Moreover, much of this evidence base consists of industry-sponsored research (e.g., Cahn and Siegel, 2010). Even though this research suggests that ecigarettes pose less risk to the individual than conventional cigarette smoking (Cahn and Siegel, 2010), population effects must also be considered, including whether ecigarettes may serve as a gateway to nicotine for those who have not yet tried tobacco products.

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Table 1

Sample characteristics of the 2009 CDS sample overall and by ever e-cigarette use

Characteristic N (%) or *Mean ± SD*	Overall N=4,444	Ever E-Cigarette Users N=216 (4.9%)	Never E-Cigarette Users N=4,228 (95.1%)
Age (yrs.)	20.5 ± 2.9	20.7 ± 2.9	20.5 ± 2.9
Gender ***			
Female	2,800 (63)	98 (45)	2,702 (64)
Male	1,622 (37)	115 (53)	1,507 (36)
Year in school			
Freshman	1,179 (27)	47 (22)	1,132 (27)
Sophomore	1,039 (23)	58 (27)	981 (23)
Junior	1,139 (26)	59 (27)	1,080 (26)
Senior/5th yr.	1,062 (24)	51 (24)	1,011 (24)
Race & Ethnicity			
Asian/Pacific Islander	126 (3)	5 (2)	121 (3)
Black	366 (8)	11 (5)	355 (8)
Hispanic	149 (3)	11 (5)	138 (3)
White	3,515 (79)	169 (78)	3,346 (79)
Other	197 (4)	14 (6)	183 (4)
Mother's education			
College degree or higher	2,160 (49)	104 (48)	2,056 (49)
Some college or less	1,872 (42)	87 (40)	1,785 (42)
Father's education			
College degree or higher	1,801 (41)	83 (38)	2,051 (49)
Some college or less	2,156 (49)	105 (49)	1,718 (41)
Greek status **			
Member/Pledge	639 (14)	45 (21)	594 (14)
Non-Greek	3,550 (80)	157 (73)	3,393 (80)
Residence location **			
On-campus	2,239 (50)	89 (41)	2,150 (51)
Off-campus	1,834 (41)	105 (49)	1,729 (41)
Sensation seeking ***	3.4 ± 0.8	3.7 ± 0.8	3.4 ± 0.7
Smoker status ***			
Never	2,253 (51)	26 (12)	2,227 (53)
Former/experimenter	882 (20)	65 (30)	817 (19)
Current nondaily	663 (15)	72 (33)	591 (14)
Current daily	204 (5)	20 (9)	184 (4)

Characteristic N (%) or *Mean* ± *SD*	Overall N=4,444	Ever E-Cigarette Users N=216 (4.9%)	Never E-Cigarette Users N=4,228 (95.1%)
Lifetime hookah use [***]	1,596 (36)	118 (55)	1,478 (35)
Current binge drinking [***]	1,893 (43)	145 (67)	1,748 (41)
Current marijuana use [***]	1,033 (23)	92 (43)	941 (22)
Lifetime other illegal drug use [***]	601 (14)	58 (27)	543 (13)
E-cigarette harm perception [***]			
As harmful	697 (17)	37 (17)	660 (16)
Less harmful	1,042 (23)	97 (45)	945 (22)
More harmful	107 (2)	7 (3)	100 (2)
Do not know	2,226 (50)	50 (23)	2,176 (51)
Type of Institution			
Private	618 (14)	31 (14)	587 (14)
Public	3,471 (78)	164 (76)	3,307 (78)

[*]
$p < 0.05$,

[**]
$p < 0.01$, and

[***]
$p < 0.001$ from mixed-effects logistic regression for ever e-cigarette users vs. never with row characteristic as only covariate in model.

Table 2

Multivariable mixed-effects logistic regression of ever e-cigarette use after multiple imputation[*]

Covariate	AOR[*]	95% CI for AOR	p-value
Age (years)	0.98	(0.92, 1.04)	0.521
Male vs. Female	1.54	(1.14, 2.08)	0.005
Race & Ethnicity			0.044 (df=4)
White (reference)	-	-	-
Asian/Pacific Islander	1.24	(0.48, 3.21)	0.664
Black	1.54	(0.50, 2.98)	0.200
Hispanic	2.02	(1.03, 3.98)	0.042
Other Race	2.06	(1.12, 3.77)	0.020
Greek vs. Non-Greek	1.64	(1.12, 2.39)	0.011
Off-campus vs. On-campus residence	1.24	(0.88, 1.73)	0.215
Sensation seeking	1.19	(0.93, 1.51)	0.162
Smoker status			<0.001 (df=3)
Never smoked (reference)	-	-	-
Former/experimenter smoker	5.66	(3.37, 9.51)	<0.001
Current nondaily smoker	6.55	(3.81, 11.2)	<0.001
Current daily smoker	5.61	(2.70, 11.6)	<0.001
Lifetime hookah use: Yes vs. No	1.13	(0.79, 1.61)	0.515
Current binge drinking: Yes vs. No	1.38	(0.96, 1.97)	0.079
Current marijuana use: Yes vs. No	0.94	(0.64, 1.37)	0.746
Lifetime other illegal drug use: Yes vs. No	0.83	(0.56, 1.23)	0.352
E-cigarette harm perception			<0.001 (df=3)
As harmful as cigarette (reference)	-	-	-
Less harm than cigarette	1.40	(0.92, 2.13)	0.115
More harmful than cigarette	1.29	(0.55, 3.02)	0.561
Don't know	0.44	(0.29, 0.69)	<0.001

[*] Results after multiple imputation with 20 imputations each with N=4,444;

AOR is adjusted odds ratio; all covariates entered simultaneously in single multivariable model.

Table 3

Bivariate analysis [*] of ever e-cigarette use among current smokers only (N=772; 82 e-cigarette users [10.6%])

Covariate	OR[*]	95% CI for OR	p-value
Age (years)	0.93	(0.85, 1.02)	0.132
Male vs. Female	1.95	(1.22, 3.12)	0.005
Year in school			0.155 (df=3)
Freshman (reference)	-	-	-
Sophomore	1.46	(0.77, 2.78)	0.250
Junior	1.30	(0.69, 2.45)	0.425
Senior/5th yr.	0.68	(0.32, 1.43)	0.305
Race & Ethnicity			0.524 (df=4)
White (reference)	-	-	-
Asian/Pacific Islander	2.16	(0.45, 10.4)	0.336
Black	0.41	(0.05, 3.11)	0.389
Hispanic	1.08	(0.24, 4.80)	0.920
Other	1.88	(0.69, 5.10)	0.216
Mother's education			
Some college or less (reference)	-	-	-
College degree or higher	1.41	(0.88, 2.26)	0.147
Father's education			
Some college or less (reference)	-	-	-
College degree or higher	1.05	(0.66, 1.66)	0.850
Greek vs. Non-Greek	1.22	(0.67, 2.22)	0.514
Off-campus vs. On-campus residence	0.93	(0.59, 1.47)	0.750
Sensation seeking	1.75	(1.24, 2.48)	0.002
Lifetime hookah use: Yes vs. No	1.48	(0.85, 2.60)	0.166
Current binge drinking: Yes vs. No	1.85	(1.01, 3.36)	0.045
Current marijuana use: Yes vs. No	1.60	(0.98, 2.61)	0.060
Lifetime other illegal drug use: Yes vs. No	1.74	(1.10, 2.76)	0.019
E-cigarette harm perception			<0.001 (df=3)
As harmful as cigarette (reference)	-	-	-
Less harm than cigarette	1.30	(0.70, 2.42)	0.412
More harmful than cigarette	3.67	(1.18, 11.4)	0.025
Don't know	0.23	(0.10, 0.52)	<0.001
Cigarette smoking quit intentions	1.13	(0.68, 1.87)	0.633

Covariate	OR[*]	95% CI for OR	p-value
Not thinking of quitting vs. Any intentions			
Type of Institution			
Public (reference)	-	-	-
Private	1.59	(0.85, 2.96)	0.144

[*] OR is odds ratio (unadjusted for other covariates); Each variable is the only covariate present in each bivariate mixed-effects logistic regression model presented above.

Table 4

Multivariable [*] mixed-effects logistic regression of ever e-cigarette use among current cigarette smokers (N=737)

Covariate	AOR[*]	95% CI for AOR	p-value
Male vs. Female	1.55	(0.92, 2.59)	0.097
Sensation seeking	1.29	(0.88, 1.91)	0.194
Current Binge drinking: Yes vs. No	1.42	(0.75, 2.70)	0.283
Current Marijuana use: Yes vs. No	1.02	(0.58, 1.80)	0.944
Lifetime other illegal drug use: Yes vs. No	1.48	(0.88, 2.52)	0.142
Cigarette smoking quit intentions Not thinking of quitting vs. Any intentions	1.15	(0.68, 1.97)	0.600
E-cigarette harm perception			<0.001 (*df*=3)
As harmful as cigarette (reference)	-	-	-
Less harm than cigarette	1.14	(2.49, 10.4)	0.680
More harmful than cigarette	3.10	(1.91, 10.3)	0.056
Don't know	0.23	(4.12, 45.7)	<0.001

[*] AOR is adjusted odds ratio; all covariates entered simultaneously in single multivariable model.