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E-Cigarette Use (Vaping) is Associated with Illicit Drug Use, Mental Health Problems, and Impulsivity in University Students

Jon E. Grant[1], **Katherine Lust**[2], **Daniel J. Fridberg**[1], **Andrea C. King**[1], and **Samuel R. Chamberlain**[3]

[1]Department of Psychiatry & Behavioral Neuroscience, University of Chicago, Chicago, IL, USA

[2]Boynton Health Service, University of Minnesota USA

[3]Department of Psychiatry, University of Cambridge; & Cambridge and Peterborough NHS Foundation Trust (CPFT), UK

Abstract

Background—This study examined the prevalence of e-cigarette use ('Vaping') among university students and its associations with psychosocial correlates.

Methods—9,449 students received a 156-item anonymous online survey which assessed the use of e-cigarettes (ever or **past year**), alcohol and drug use, mental health issues, and impulsive and compulsive traits.

Results—3,572 university students (57.1% female) responded to the survey. The prevalence of past 12-month e-cigarette use was 9.2%, with 9.8% reporting having used more than 12 months ago. E-cigarette use was associated with the use of multiple other drugs (e.g., alcohol, opiates). Those who used e-cigarettes were significantly more likely to have mental health histories of ADHD, PTSD, gambling disorder, and anxiety, report low self-esteem, and endorse traits of impulsivity.

Conclusion—Use of e-cigarettes is common in university students and appears to be associated with a variety of mental health and drug use problems. Clinicians should be aware that certain mental health conditions are more common in e-cigarette users. This study indicates the need for longitudinal research into the effects of chronic nicotine consumption on brain function and mental health, especially in young people, since such effects would be common to conventional tobacco smoking and vaping.

Keywords

cigarettes; nicotine; illicit; drugs; addiction; impulsivity; well-being

Address correspondence to: Jon E. Grant, JD, MD, MPH, Professor, Department of Psychiatry & Behavioral Neuroscience, University of Chicago, Pritzker School of Medicine, 5841 S. Maryland Avenue, MC 3077, Chicago, IL 60637, Phone: 773-834-1325; Fax: 773-834-6761; jongrant@uchicago.edu.

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Introduction

Electronic cigarettes (e-cigarettes), also known as electronic nicotine delivery systems (ENDS), are a battery-operated product that delivers nicotine via inhalable aerosol generated from a nicotine-containing solution. Using an e-cigarette (known as 'vaping') gives a sensation similar to smoking a combustible cigarette by providing taste and inhaling sensations that mimic smoking. E-cigarettes are controversial, especially regarding health consequences of long-term use, whether use may help combustible cigarette smokers to reduce or stop smoking, the extent of carcinogens in e-cigarettes, and the role of these products in initiating and perpetuating nicotine dependence in teenagers and young adults [1–3].

In the United States, 6.1% of young adults use e-cigarettes, versus 1.6% of adults aged 25 years and older [4]. A 2013 study of college students found that 4.9% had used e-cigarettes in their lifetimes while 1.5% reported having used them in the past month [5]. A more recent study of 452 undergraduates attending a large, public university reported that almost 40% of participants reported lifetime use of e-cigarettes [6]. The age of most university students reflects a transition period from adolescence to young adulthood, and as such, these students may be susceptible to developing a variety of unhealthy behaviors, most notably the use of alcohol, tobacco and other drugs [7]. Whether e-cigarettes actually reduce conventional cigarette smoking is questionable, with some studies reporting a lower likelihood of abstaining from cigarettes in e-cigarette users [8–9]; as such the use of e-cigarettes may have a number of important public health consequences. There is sparse information, however, on the mental health issues of university students who use e-cigarettes. In two of only a handful of studies to examine other clinical variables associated with e-cigarette use [10–11], e-cigarette use in university students in France (n=1134) and the US (n=1437) was positively associated with use of conventional cigarettes, cannabis use, and binge drinking.

Although touted as innocuous by some, there are health and addiction concerns about the growing use of e-cigarettes in young adults [6, 10–13]. One study has found that risky alcohol use appears to be correlated with use of e-cigarettes, even after controlling for a relationship between e-cigarettes use and cigarette smoking [6]. If we examine the data regarding the use of tobacco products (including e-cigarettes) among young adults, we find that the use of e-cigarettes in those with a mental health diagnosis is associated with greater odds of higher stress, depression, and substance use, particularly marijuana [12–13]. Despite this growing area of research, relatively little is known about the specific associations between e-cigarettes, mental health, and psychosocial functioning.

Another domain of interest in relation to e-cigarette use are the contrasting concepts of impulsivity and compulsivity, which can be measured using convenient short questionnaires including the Barratt Impulsiveness Scale (BIS), or the Cambridge-Chicago Trait Compulsivity Scale (CHI-T). Impulsivity refers to a tendency towards hasty, risky, inappropriate acts; whereas compulsivity refers to repetitive habitual actions. These concepts are important in frameworks of addictive behaviors [14].

This study sought to examine both the prevalence of the use of e-cigarettes among university students and examine related behaviors and mental health issues. Based on the previous literature, we hypothesized that the use of e-cigarettes would be associated with elevated rates of other substance use (including a range of illicit drug use), mental health issues, trait impulsivity plus compulsivity, and academic impairments compared to students who do not use e-cigarettes.

Materials and Methods

Survey Design

Researchers at the Department of Psychiatry and Behavioral Neuroscience at the University of Chicago and Boynton Health Services at the University of Minnesota jointly developed the *Health and Addictive Behaviors Survey,* an online survey examining the use of alcohol, drugs, and tobacco, as well as mental health issues, in university students.

Participants

10,000 university students (graduate and undergraduate) at a large Midwestern university were chosen by a random, computer-generated selection using their email addresses to complete an online survey during a three-week period in the fall of 2016. Of the 10,000 email invitations, 9449 were successfully received by the recipients. The survey required students to first view and approve an online informed consent page, after which they could complete or opt out of the survey. The survey informed students that all information was both anonymous and confidential. Students were also informed that there was no compensation for the completing the survey but that their email addresses (to maintain anonymity, the email addresses were not linked to questionnaire responses) would be entered into a raffle wherein 10 students would be randomly chosen to receive prizes: 3 would win tablet computers, 4 would win $250 gift certificates to an online retailer, 2 would win $500 gift certificates, and there would be a single winner of a $1000 gift certificate. Participants were required to review all survey questions to be eligible for the prize drawings. Students were not required, however, to answer all questions given the sensitive nature of some items.

Of the 9,449 students who received the invitation to participate, 3,659 (38.7%) completed the survey, a response rate in keeping with other health surveys [15–18]. All study procedures were conducted in accordance with the Declaration of Helsinki and the University of Minnesota’s Institutional Review Board approved the study.

Assessments

The survey consisted of 156 questions and took approximately 30 minutes to complete. The survey assessed demographics, self-reported academic achievement, and a range of behaviors. In terms of the use of e-cigarettes, participants were asked to report whether they had used in the past 12 months, had used in the past (>12 months ago), or had never used. We recorded past year e-cigarette use rather than past month because we felt this would be more likely to capture sustained rather than short-term/more acute associations with other variables.

The study included several reliable and valid measures of interest focusing on three domains: Drug and Alcohol Use; Mental Health Problems; and Impulsivity/Compulsivity:

Drug and Alcohol Use: *Alcohol Use Disorders Identification Test (AUDIT)* (10 questions assessing alcohol use; a score of ≥8 indicating potentially harmful alcohol use [19]); *Drug Abuse Screening Test (DAST-10)*(10 questions and a score of 3 indicates a positive screen for a drug use disorder [20–21]). Additionally, participants were asked if they had ever used an illicit drug (binary); and were asked about whether they had used the following in the past 12 months (each a binary response): amphetamines, cocaine, heroin, hallucinogens, marijuana or hashish, prescription opioid pain medication, or sedatives.

Mental Health Problems: *Patient Health Questionnaire (PHQ-9)* (a 9-item screen with a score of ≥5 indicating significant depressive symptoms [22]); *Generalized Anxiety Disorder 7 (GAD-7)*(7 questions with a score of 10 or greater indicating clinically significant anxiety [23]); *Primary Care PTSD Screen (PC-PTSD)* (4 questions with a score of ≥3 indicating probable posttraumatic stress disorder (PTSD) [24]); *Adult ADHD Self-Report Scale (ASRS-v1.1) Part A* (6 questions screening for attention-deficit/hyperactivity disorder [25]); *Minnesota Impulsive Disorders Interview (MIDI)* (this study used only certain sections of the MIDI to screen for specific impulse control disorders, including compulsive sexual behavior, binge eating disorder, and gambling disorder [26]), and the *Rosenberg Self-Esteem Scale (RSES)* (a 10-item questionnaire focusing on feelings of self-worth with scores <15 indicating low self-esteem [27]).

Impulsivity/Compulsivity: *Barratt Impulsiveness Scale, Version 11 (BIS-11)* (30 items assessing three dimensions of impulsivity - attentional, motor, and non-planning) [28]) and the *Cambridge-Chicago Compulsivity Trait Scale (CHI-T)* (15 questions examining compulsive traits [29]).

Data Analysis

Only respondents who answered the question regarding the use of e-cigarettes were included in the analyses (N=3572/3659 survey completers, 98%). Participants were grouped into one of three categories based on their responses: never used, past user (but not within the last 12 months), and had used within the last 12 months, including occasional users as well as daily users. Significant main effects of group were identified using likelihood ratios, chi-square tests, or appropriate parametric tests, as indicated in the tables. Our primary aim was to show how the groups actually presented, rather than to statistically control for potential covariates, as the former approach is intuitive to clinicians and more likely to be relevant practically both to individuals who use e-cigarettes and to healthcare professionals seeing such people. In secondary analysis, we used binary logistic regression to identify statistical predictors of being a past user versus never user, from variables identified as being significant in the primary analysis. SPSS was used for all statistical analyses (version 24; IBM Corp). Raw p values were reported but findings were only deemed statistically significant if they withstood Bonferroni correction at $p<0.05$ two-tailed for the number of measures within categories of interest.

Results

Of the 3,572 participants (57.1% female), the overall prevalence of past 12-month e-cigarette use was 9.2%, while an additional 9.8% reported lifetime use but not in the past year. Of those surveyed, 331 had used e-cigarettes within the past 12 months, 305 had used e-cigarettes more than 12 months ago, and 2936 had never used e-cigarettes. Those who reported use (ever use / past year use) of e-cigarettes were more likely to be males, undergraduates, have lower GPAs, and more likely to be Caucasian (all $p<.001$).

Primary Statistical Analysis

E-cigarette use was significantly associated with higher levels of problematic alcohol and illicit substance use, along with greater likelihood of drug use, even if not problematic (see Table 1).

Table 2 presents the mental health histories of participants. E-cigarettes use was significantly associated with higher rates of PTSD, ADHD, and anxiety. In addition, those who used e-cigarettes had significantly poorer self-esteem. E-cigarette use was not significantly associated with depressive symptoms, compulsive sexual behavior, or binge-eating disorder.

In terms of psychological traits (see Table 3), those who used e-cigarettes reported significantly greater scores of impulsivity on all subscales of the BIS-11, but did not report greater levels of compulsive traits.

Secondary Statistical Analysis

Detailed results from the multivariate logistic regression are shown in Supplementary Table 1. The corrected model was significant (X^2 =676.892, df= 16, $p<.001$), with classification accuracy = 82%. The following variables were significant predictors of lifetime e-cigarette use in the logistic regression model: illicit drug use (both lifetime and current on the DAST), alcohol use (Audit), male gender, being an undergraduate, and being single.

Discussion

This study examined the prevalence of the use of e-cigarettes (‘vaping’) in a large sample of university students; and ways in which e-cigarette use was related to the use of a range of other drugs and alcohol as well as psychosocial functioning. We found that 9.2% of the sample reported past 12-month use of e-cigarettes (with 17.7% having ever used). For recent use, previous studies have tended to use the classification of current or past month use rather than past year use. Rates of current use in previous work have yielded values of 1.3% [30] to 5.7% [10] to 6.1% [4]; whereas past month use was around 1.5% [5]. In terms of lifetime use of e-cigarettes, a large range of rates has been reported, ranging from around 5-10% [10, 30, 5] to 20-40% [6, 10]. Overall, e-cigarette use appears to be more common in young adults compared to older adults [4, 31–33]. The rates found in this study of university students are concerning as the long-term health impact of e-cigarette use remains unclear (for a review, see [33]) and as emerging adulthood is an important time when addictive symptoms may develop.

The current study found that university students who reported use of e-cigarettes (ever use / past year use) had significantly higher rates of several types of substance use and higher Barratt impulsiveness scores. Collectively, these findings suggest a more general impulsive/ risk-taking nature in university students who use e-cigarettes. Contrary to prediction, e-cigarette usage was not associated with significantly elevated trans-diagnostic compulsivity. This may reflect the relatively young nature of the sample and ‘early stages’ if one considers e-cigarette use as being potentially addictive in nature. These findings, however, raise more questions than they answer, particularly about causality. Whether e-cigarette use is the driving force behind the other drug and alcohol use (e.g., the animal literature has found that that exposure to e-cigarette vapors can affect the developing brain in male mice, such as increasing locomotor activity [34]), is itself a result of one or more of these other behaviors, or that e-cigarette use shares a common underlying biological vulnerability with other substance use remains a question.

Another variable that could potentially drive the use of e-cigarettes in university students might be found in other mental health problems reported by these students. In this study, the use of e-cigarettes was significantly associated with symptoms of PTSD, anxiety, gambling disorder, and ADHD. Of interest, the conventional cigarette quit rate in PTSD has been reported to be uniquely low as compared to many other mental health disorders, which is thought to reflect anxiety susceptibility and distress intolerance [35]. More generally, anxiety appears to be a risk factor for maintenance and relapse of conventional smoking, which may stem from higher intensity of cravings experienced during times of anxiety [36]. The current data, viewed alongside this other literature, suggest that anxiety may contribute to e-cigarette use in some individuals, as with conventional cigarettes.

Longitudinal studies of e-cigarette use are needed in order to better understand the initiating and maintaining aspects of these associations. There is a substantial body of longitudinal literature examining cigarette use and other typical forms of smoking, which may be of relevance here. For example, cigarette use has been associated with higher risk of subsequent depression longitudinally in some studies, even accounting for confounders (37); and similar relationships may exist for other mental health disorders too (38). The impact of cigarette smoking on risk of later mood and anxiety disorders appears to be more pronounced in younger people (39). Meta-analysis indicates that smoking cessation is associated with reductions in depression, anxiety, and stress, especially in those with mental health diagnoses (40).

On the other hand, other studies report that childhood psychiatric disorders, including depression and those associated with impulsivity (ADHD, oppositional defiant disorder, and conduct disorder), increase the risk of subsequent substance-use disorders including nicotine use (41). Therefore, longitudinal assessment of the impact of e-cigarette use on mental health and impulsivity measures would be extremely valuable in future work. A related area of relatively neglected research is the effects of nicotine consumption itself (integral to vaping and conventional tobacco smoking) on brain development and mental health. Nicotine is a psychoactive substance acting on receptors distributed widely in the brain, and preclinical data have identified long-term effects of adolescent nicotine consumption on aspects of brain structure and function (42). If chronic nicotine consumption has any

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untoward or beneficial effects on brain development and mental health in humans, this would occur both with conventional smoking and with vaping. The present study has several strengths. To our knowledge, this is the first study to examine associations among e-cigarette use, demographic variables, academic performance, mental health problems and substance misuse, and measures of impulsivity and compulsivity in a large university sample. Furthermore, an anonymous survey may have increased openness of study participants to report underlying mental health problems and substance use. Nonetheless, there are several limitations that should be noted. First, as a cross-sectional study the direction of causality cannot be determined. Second, the use of online surveys has inherent limitations such as diagnostic accuracy and veracity. Third, the self-selected nature of participation may have resulted in a lack of representativeness of the larger population. Fourth, e-cigarette use was separated into three broad categories: never, lifetime but not the past 12-months, and the past 12-months use. More detailed inquiry of frequency and pattern of e-cigarette use (e.g. lifetime could mean a single use or daily in the past), type of e-cigarette device(s) used, and constituents of e-liquids (nicotine, flavorings, etc.) would provide a more in-depth analysis of college students' e-cigarette use and psychosocial functioning. This information was not collected in the current study. Lastly, we did not control for cigarette use in the analyses. Such statistical control would be questionable in any event due to the likely rarity of people using e-cigarettes but never smoking; the two are likely to be strongly inter-related and extremely hard to disambiguate within a cross-sectional study. Hence teasing apart possible causative contributions of e-cigarette use to mental health problems, as compared to the impact of cigarette use per se, requires longitudinal research to address.

In summary, this study found e-cigarette use to be relatively common in university students, and use was associated with several issues such as poorer academic performance, greater likelihood of using other substances, and greater rates of anxiety, ADHD, and PTSD. E-cigarette use was also associated with higher rates of impulsivity on the Barratt Impulsivity Scale. The strongest associations with e-cigarette use, which were significant in conservative regression modelling controlling for potential confounds, were illicit drug use (both lifetime and current on the DAST), alcohol use (Audit), male gender, being an undergraduate, and being single. The results indicate that longitudinal assessment of the relationships between these clinical variables and e-cigarette consumption are warranted. Effects of **e-cigarette** consumption on brain development and mental health merit further study.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Disclosures

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Table 1
Drug and Alcohol Use of University Students Based on E-Cigarette Use Status

Variable	Students who have used e-cigarettes within the past 12 months (n= 331)	Students who have used e-cigarettes more than 12 months ago (n=305)	Students who have never used e-cigarettes (n=2936)	Likelihood ratio $\chi 2^{\#}$	P-value	Effect size Cramer's V
Illicit drug use (lifetime)	84.8 (273)	72.1 (214)	31.1 (902)	498.781	<.001*	.374
Drug use (past 12 months)						
Amphetamines	5.7 (18)	2.0 (6)	0.3 (9)	54.785	<.001*	.162
Cocaine	14.9 (47)	5.8 (17)	1.6 (45)	111.144	<.001*	.224
Heroin	1.9 (6)	1.4 (4)	0.1 (4)	20.023	<.001*	.092
Hallucinogens	23.8 (76)	10.2 (30)	2.0 (59)	210.570	<.001*	.305
Marijuana or hashish	72.0 (231)	50.3 (150)	20.9 (607)	408.612	<.001*	.359
Rx opioid pain medication	9.7 (31)	6.1 (18)	0.9 (27)	87.752	<.001*	.191
Sedatives	11.0 (35)	4.1 (12)	0.9 (25)	93.827	<.001*	.209
AUDIT score ≥8 (%)	57.5 (187)	44.0 (132)	18.9 (551)	266.224	<.001*	.292
DAST-10 score ≥3 (%)	32.0 (103)	23.5 (70)	3.9 (114)	299.383	<.001*	.340

#Degree of freedom=2; All numbers are % (N) unless otherwise stated.

*p value significant with Bonferroni correction (critical p = 0.05/11 = 0.00455).

Data refer to percentage and (N).

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Table 2
Mental Health Problems of University Students Based on E-Cigarette Use Status

Variable	Students who have used e-cigarettes within the past 12 months (n= 331)	Students who have used e-cigarettes more than 12 months ago (n=305)	Students who have never used e-cigarettes (n=2936)	Likelihood ratio $\chi^{2\#}$	P-value	Effect sizeCramer's V
PHQ-9 score ≥10 (%)	6.4 (20)	6.6 (19)	4.1 (114)	5.917	.052	.044
PC-PTSD score ≥3 (%)	16.9 (53)	21.0 (61)	13.4 (376)	12.986	.002*	.064
GAD-7 score ≥10 (%)	23.6 (74)	22.3 (64)	16.4 (452)	13.993	.001*	.066
Compulsive sexual behavior	5.9 (18)	5.0 (14)	3.2 (88)	6.491	.039	.047
Binge eating disorder	1.6 (5)	3.1 (9)	2.4 (68)	1.601	.449	.021
Gambling disorder	**0.9 (3)**	**0.7 (2)**	**0.3 (7)**	**37.183 df=4**	**.000**	**.081**
ADHD	22.2 (70)	24.4 (70)	16.1 (446)	16.778	<.001*	.073
Rosenberg Self Esteem, below 15 score (%)	80.0 (248)	80.7 (226)	86.2 (2350)	12.477	.002*	.063

#Degree of freedom=2.

*p value significant with Bonferroni correction (critical p = 0.05/7 = 0.0071).

Data refer to percentage and (N).

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Table 3

Impulsivity and Compulsivity of University Students Based on E-Cigarette Use Status

Variable	Students who have used e-cigarettes within the past 12 months (n= 331)	Students who have used e-cigarettes more than 12 months ago (n=305)	Students who have never used e-cigarettes (n=2936)	Statistic	P-value	Effect Size (Cohen's d)
Cambridge-Chicago Compulsivity Trait Scale Mean (sd)	10.10 (13.94)	9.46 (13.54)	9.21 (13.47)	F= (2,3414) =0.632	.532	.043
Barratt Impulsiveness Scale (BIS-11)						
Attentional impulsiveness Mean (sd)	17.52 (3.88)	17.59 (4.15)	15.89 (3.89)	F= (2,3274) =42.915	<.001 *	.4219
Non-planning impulsiveness Mean (sd)	24.97 (4.44)	24.02 (4.55)	22.57 (4.72)	F= (2,3268) =44.064	<.001 *	0.414
Motor impulsiveness Mean (sd)	21.62 (4.00)	21.78 (3.99)	20.00 (3.88)	F= (2,3283) =45.234	<.001 *	0.433

* p value significant with Bonferroni correction (critical p = 0.05/4 = 0.0125).

Data refer to mean and (standard deviation).