

High School Students' Use of Electronic Cigarettes to Vaporize Cannabis

Meghan E. Morean, PhD^{a,b}, Grace Kong, PhD^b, Deepa R. Camenga, MD^c, Dana A. Cavallo, PhD^b, Suchitra Krishnan-Sarin, PhD^b

abstract

BACKGROUND AND OBJECTIVES: Electronic cigarette (e-cigarette) use is increasing rapidly among high school (HS) students. Of concern, e-cigarettes can be used to vaporize cannabis, although use rates among adolescents are unknown. We evaluated lifetime rates of using e-cigarettes to vaporize cannabis among all lifetime e-cigarette users (27.9%), all lifetime cannabis users (29.2%), and lifetime users of both e-cigarettes and cannabis (18.8%); common means of vaporizing cannabis including hash oil, wax infused with Δ -9-tetrahydrocannabinol (THC), and dried cannabis; and demographic predictors of using e-cigarettes to vaporize cannabis.

METHODS: In the spring of 2014, 3847 Connecticut HS students completed an anonymous survey assessing e-cigarette and cannabis use.

RESULTS: Vaporizing cannabis using e-cigarettes was common among lifetime e-cigarette users, lifetime cannabis users, and lifetime dual users (e-cigarette 18.0%, cannabis 18.4%, dual users 26.5%). Students reported using e-cigarettes to vaporize hash oil (e-cigarette 15.4%, cannabis 15.5%, dual users 22.9%) and wax infused with THC (e-cigarette 10.0%, cannabis 10.2%, dual users 14.8%) and using portable electronic vaporizers to vaporize dried cannabis leaves (e-cigarette 19.6%, lifetime cannabis 23.1%, lifetime dual users 29.1%). Binary logistic regression indicated that male students (odds ratio [OR] = 2.05), younger students (OR = 0.64), lifetime e-cigarette users (OR = 5.27), and lifetime cannabis users (OR = 40.89) were most likely to vaporize cannabis using e-cigarettes. Rates also differed by HS attended.

CONCLUSIONS: Rates of vaporizing cannabis using e-cigarettes were high. These findings raise concerns about the lack of e-cigarette regulations and the potential use of e-cigarettes for purposes other than vaping nicotine.



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Dr Morean contributed to the conceptualization and design of the study, conducted the statistical analyses, and drafted the original manuscript; Drs Kong and Cavallo contributed to the conceptualization and design of the study, coordinated and supervised data collection, and critically reviewed and revised the manuscript; Dr Camenga contributed to the conceptualization and design of the study and critically reviewed and revised the manuscript; Dr Krishnan-Sarin led the study conceptualization and design team and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Electronic cigarette use among youth is rising exponentially. Among other concerns, modified electronic cigarettes can be used to vaporize cannabis. However, no scientific data have been published on the rates of using electronic cigarettes to vaporize cannabis among youth.

WHAT THIS STUDY ADDS: This study presents rates of vaporizing cannabis among a sample of high school students ($N = 3847$). Rates of vaporizing cannabis were high among lifetime e-cigarette users (18.0%), lifetime cannabis users (18.4%), and lifetime dual cannabis and e-cigarette users (26.5%).

Electronic cigarettes (e-cigarettes) are battery-powered devices that originally were developed to vaporize a nicotized or denicotized solution via an inhalation-activated heating element. Of particular concern, high school (HS) students are using e-cigarettes at exponentially increasing rates; the 2014 National Youth Tobacco Survey indicated that past-month e-cigarette use tripled among HS students from 4.5% in 2013 to 13.4% in 2014,¹ surpassing all other tobacco use, including traditional cigarettes (9.2%). Similarly, a recent, large survey study conducted in Connecticut indicated that 25.2% of HS students reported lifetime e-cigarette use, and 12.0% reported past-month use.² Exacerbating the cause for alarm, e-cigarettes can be modified to provide an efficient way to vaporize cannabis in the form of highly concentrated liquid hash oil, highly concentrated waxy forms of Δ -9-tetrahydrocannabinol (THC, the primary psychoactive ingredient in cannabis), or dried cannabis buds or leaves. Of note, vaporizing cannabis by using e-cigarettes is less conspicuous than combustible means of smoking cannabis (eg, joints, blunts, pipes), because vaporization results in a less pungent odor. Also of concern, the THC concentrations of vaporized hash oil and waxes can exceed that of dried cannabis by 4 to 30 times.^{3,4} Although a study of >3000 adult e-cigarette users found low rates of using e-cigarettes to vaporize cannabis in 2010 (0.2%),⁵ it is unknown how common this practice is among adolescents.

To address this research gap, we examined lifetime rates of using e-cigarettes to vaporize cannabis in a sample of HS students in Connecticut. Rates of overall e-cigarette use and cannabis use (eg, vapor, combustible) also were evaluated. All rates were examined first within the total sample ($N = 3847$). To determine the risk

associated with lifetime use of either e-cigarettes or cannabis and the risk associated with lifetime use of both products, we also evaluated rates within the sub samples of all adolescents who reported lifetime e-cigarette use (ie, lifetime e-cigarette users, 27.9%), within the sample of all students who reported lifetime cannabis use (ie, lifetime cannabis users, 29.2%), and within the subsample of students who reported both lifetime e-cigarette and cannabis use (ie, lifetime dual users, 18.8%). To gain insight into what types of cannabis HS students are vaporizing, we evaluated rates of using e-cigarettes to vaporize hash oil or highly concentrated THC-infused wax and rates of using other portable electronic vaporizers to vaporize dried cannabis within the total sample and the aforementioned subsamples. Finally, to better understand the factors that may contribute to students using e-cigarettes to vaporize cannabis, we evaluated the extent to which use was associated with lifetime e-cigarette use, lifetime cannabis use, participant gender, age, socioeconomic status (SES), and the school in which the student was enrolled.

METHOD

Participants

In the spring of 2014, we conducted an anonymous survey study in 5 HSs and 2 middle schools located in southeastern Connecticut to assess adolescents' attitudes toward and use of e-cigarettes and other common substances of use or abuse ($N = 5133$). Because of requests from administrators at both middle schools to exclude questions that explicitly assess cannabis use from the survey, only data from the 5 HSs are presented in the current study. Although our sample did not reflect a random sample of Connecticut HSs, the 5 schools were from 4 different District Reference Groups that group schools based on the SES of the

families in the district. The final analytic sample consists of data from 3847 HS students who completed the entire survey, including the e-cigarette and marijuana questions and who had non-missing data for each of the study variables (51.7% female; mean age 16.00 [SD = 1.26] years).

Procedures

The survey was approved by the Institutional Review Board of the Yale University School of Medicine and the local school administrators. Before administering the survey, we obtained passive consent from parents, informed consent from students ages ≥ 18 years old, and assent from students < 18 years old. Before completing the survey, students were informed that participation was voluntary and anonymous and that their data were confidential. Students completed the brief survey during their homeroom periods.

Measures

Participant Demographics

All students reported demographic information on their biological sex and age. All students also reported on SES (Family Affluence Scale II)⁶ by reporting whether their family owns a vehicle (no/yes), whether they have their own bedroom (no/yes), the number of times in the past year their family had gone on vacation (0, 1, 2, >2 times), and the number of computers their family owns (0, 1, 2, >2 computers). Participants' responses were summed and transformed into a 3-point ordinal scale, whereby scores 0 to 4 were classified as low SES (22.0%), 5 to 6 as moderate SES (46.8%), and 7 to 9 as high SES (31.2%).⁷ A subset of participants also reported on race, but because of the small size of the sample ($n = 1370$; 85.9% Caucasian), these data were excluded from the current study.

E-Cigarette Use Status

We determined e-cigarette use status via the following question: "Have you tried an e-cigarette?" Students who reported that they had never tried an e-cigarette were classified as "never users" (72.1%), and students who reported that they had tried an e-cigarette were classified as "lifetime users" (lifetime e-cigarette users; 27.9%).

Cannabis Use Status

We determined cannabis use status through the following question: "During the past 30 days, on how many days did you use marijuana or hashish?" Students who answered, "I have never tried marijuana/hashish" were coded as never users (70.8%). Students who answered, "I have tried marijuana/hashish but did not use it in the past 30 days" or "I have used marijuana/hashish at least once during the past 30 days" were classified as lifetime cannabis users (29.2%). Students who reported lifetime use of both e-cigarettes and cannabis were classified as lifetime dual e-cigarette and cannabis users (ie, lifetime dual users, 18.8%).

Using E-Cigarettes or Other Portable Electronic Vaporizer to Vaporize Cannabis

We assessed whether students had ever used an e-cigarette to smoke cannabis (response options of yes and no). To better understand how students were using e-cigarettes or other portable vaporizing devices to vaporize cannabis, we asked students, "Which of the following have you used to smoke marijuana?" Answer choices included "e-cigarettes filled with hash oil," "e-cigarettes filled with a wax plug," "portable vaporizers filled with dried marijuana (like a G-pen)," and "other." Students could select as many options as were applicable. Note that the response choice "other" was open-ended such that students could write in other means by which they have used cannabis. The most common response

was blunts (22.7%), followed by bowls or pipes (3%), bongos (2.2%), and joints (1.5%). However, many students who chose the response option "other" did not provide a written open-ended response, so these data are not included in the current study.

Data Analysis

We calculated lifetime rates (ie, percentages) of using an e-cigarette to vaporize cannabis and lifetime rates of any e-cigarette use and any cannabis use (eg, combustible, vapor) within the total sample, among all lifetime e-cigarette users, among all lifetime cannabis users, and among the subsample of e-cigarette and cannabis lifetime dual users. We similarly calculated rates of using an e-cigarette to vaporize hash oil or THC wax and rates of using other portable vaporizers to vaporize dried cannabis within these groups. Given our interest in examining risk associated with any e-cigarette use, with any cannabis use, and with dual use, we did not conduct statistical comparisons of rates among the 3 groups (ie, all lifetime e-cigarette users, all lifetime cannabis users, and lifetime dual users) because they were not mutually exclusive (eg, some lifetime e-cigarette users also were lifetime cannabis users). Finally, we conducted a binary logistic regression analysis to determine the extent to which using e-cigarettes to vaporize cannabis was associated with lifetime e-cigarette use, lifetime cannabis use, participant gender, age, and SES. We also included the HS in which the student was enrolled as a covariate to examine potential cohort effects by school. All variables were entered simultaneously into the model.

RESULTS

Using e-cigarettes to vaporize cannabis was common among HS students, especially among those who reported lifetime dual use of e-cigarettes and cannabis (ie, total sample 5.4%, lifetime e-cigarette

users 18.0%, lifetime cannabis users 18.4%, lifetime dual users 26.5%; see Table 1 for rates of using e-cigarettes to vaporize cannabis, rates of e-cigarette use, and rates of cannabis use [in any form]). With regard to the type of cannabis adolescents reported vaping, students reported using e-cigarettes to vaporize hash oil (total sample 4.5%, lifetime e-cigarette 15.4%, lifetime cannabis 15.5%, lifetime dual users 22.9%), using e-cigarettes to vaporize wax infused with THC (total sample 3.0%, lifetime e-cigarette 10.0%, lifetime cannabis 10.2%, lifetime dual users 14.8%), and using other portable electronic vaporizers to vaporize dried cannabis leaves (total sample 6.7%, lifetime e-cigarette 19.6%, lifetime cannabis 23.1%, lifetime dual users 29.1%).

When associations between using e-cigarettes to vaporize cannabis and participant demographics, lifetime e-cigarette use, lifetime cannabis use were examined within the total sample, the binary logistic regression model accounted for 89.9% of the variance in using e-cigarettes to vaporize cannabis ($P < .001$; classification accuracy = 94.2%). Lifetime e-cigarette users, lifetime cannabis users, male students, and younger students were more likely to use e-cigarettes to vaporize cannabis than were their respective counterparts (all P values < 0.001). The likelihood that students reported using e-cigarettes to vaporize cannabis also differed by school ($P < .001$; see Table 2 for odds ratios (ORs) and 95% confidence intervals for each variable included in the model). Using e-cigarettes to vaporize cannabis did not differ significantly by students' SES ($P = .23$).

DISCUSSION

The current study is the first to demonstrate that HS students are using e-cigarettes to vaporize cannabis. Of central importance, rates of using e-cigarettes to vaporize cannabis were high among all

TABLE 1 Product Use Rates and Type of Cannabis Vaped Within the Total Sample and Among All Lifetime E-Cigarette Users, All Lifetime Cannabis Users, and Lifetime Dual Users

	Total Sample, % N = 3847	All Lifetime E-Cigarette Users, %, n = 1075	All Lifetime Cannabis Users, %, n = 1123	Lifetime Dual Users (E-Cigarettes and Cannabis), %, n = 724
Lifetime product use				
E-cigarettes	27.9	100.0	64.5	100.0
Cannabis	29.2	67.3	100.0	100.0
Vaporizing cannabis via e-cigarettes	5.4	18.0	18.4	26.5
Type of cannabis being vaped				
E-cigarettes (hash oil)	4.5	15.4	15.5	22.9
E-cigarettes (THC wax)	3.0	10.0	10.2	14.8
Portable vaporizers (dried leaves)	6.7	19.6	23.1	29.1

students who had ever tried an e-cigarette, among all students who had tried any form of cannabis, and among the subsample of students who had experimented with the combination of e-cigarettes and cannabis (5.4% of the total sample, 18.0% of lifetime e-cigarette users, 18.4% of lifetime cannabis users, and 26.5% of lifetime dual users). When compared with rates of using e-cigarettes to vaporize cannabis among adults (ie, 0.2%),⁵ HS adolescents in the current study were 27 times as likely to use e-cigarettes to vaporize cannabis (ie, 5.4% of the total sample).

In addition to demonstrating elevated risk associated with lifetime e-cigarette use or cannabis use, our results indicated that male students

and younger students were more likely to use e-cigarettes to vaporize cannabis than were female students and older students. Also of note, the use of e-cigarettes to vaporize cannabis differed by school but was unrelated to SES (which also varied across schools). These results indicate that factors such as the acceptability of cannabis use within a school (ie, “cannabis culture”) or the extent to which a school has explicit policies prohibiting e-cigarette use may play a more important role in encouraging or deterring vaporizing cannabis than students’ SES. However, future research is needed to investigate specific school-related factors that may account for differences in vaporizing cannabis across schools.

For example, it is plausible that implementing harsher punishments for using e-cigarettes (eg, confiscation of e-cigarettes and suspension vs detention) may result in fewer students using e-cigarettes to vaporize cannabis. Conversely, rates of vaporizing cannabis may be higher in schools whose students view e-cigarettes and cannabis as less harmful than other commonly used substances such as cigarettes or alcohol.

Finally, the results provide important insight into the ways in which adolescents are vaporizing cannabis. Within the total sample, students reported using e-cigarettes to vaporize hash oil (4.5%) and THC-infused wax (3.0%) and using portable vaporizers to vaporize dried cannabis leaves (6.7%). Rates of vaporizing cannabis in each form were elevated among all lifetime e-cigarette users, all lifetime cannabis users, and lifetime dual e-cigarette and cannabis users, respectively.

The novel study findings should be considered in light of several limitations. First, study results were based on self-report, which was limited by adolescents’ willingness and ability to respond honestly and accurately. Thus, the current results may be underestimates. However, it bears noting that these concerns are mitigated by the fact that students were informed that the survey was anonymous and that their answers were confidential. Second, we collected data from only 5 HSs in

TABLE 2 Odds of Lifetime Use of E-Cigarettes to Vaporize Cannabis by Participant Characteristics

	Adjusted OR (95% confidence interval)
Gender	
Female	1 (reference)
Male	2.05 (1.48–2.85)
Age (treated as a continuous variable)	0.64 (0.61–0.67)
SES	
Low	1 (reference)
Moderate	0.82 (0.55–1.23)
High	1.13 (0.74–1.73)
School	
1	1 (reference)
2	2.54 (1.56–4.13)
3	1.18 (0.60–2.34)
4	2.34 (1.48–3.72)
5	1.18 (0.71–1.96)
E-cigarette use	
Never	1 (reference)
Any lifetime use	5.27 (3.27–8.49)
Cannabis use	
Never	1 (reference)
Any lifetime use	40.89 (20.15–82.98)

Connecticut, which may limit generalizability to other schools both within and outside Connecticut. Third, the data were cross-sectional, so it was not possible to determine temporal relationships between e-cigarette use, cannabis use, and use of e-cigarettes to vaporize cannabis. Future research is needed to determine whether e-cigarette use may serve as a gateway to cannabis use, specifically via the use of e-cigarettes to vaporize cannabis. It also is possible that cannabis users may transition to e-cigarette use via using an e-cigarette to vaporize cannabis. Fourth, the demographic predictors examined in relation to vaporizing cannabis included only gender, age, SES, and school in the current study. Future research examining the importance of other variables including race is needed. Finally, the rates presented in the current study were calculated in a state in which both cannabis and the sale of e-cigarettes to people under the age of 18 are illegal. Future research is needed to determine whether rates

are higher in states in which cannabis has been legalized for recreational use by adults (eg, Colorado, Washington) or in states in which sales of e-cigarettes to minors remains legal.

CONCLUSIONS

Despite the limitations, the results of this study provide important evidence that HS students are using e-cigarettes to vaporize cannabis. At this time, the relative safety of using e-cigarettes for vaping cannabis versus smoking combustible cannabis is not well established. However, a recent study indicated that adults who vaporize hash oil experience greater subjective tolerance and evidence of dependence compared with those smoking combustible cannabis.³ This greater risk probably is linked to the greater potency of hash oil and THC-infused waxes compared with combustible cannabis.^{3,4} In addition to potential negative health outcomes, the fact that adolescents

are vaporizing cannabis may have other consequences. Although scientific data on the topic currently are lacking, the popular media have reported higher rates of students using e-cigarettes to vaporize cannabis in locations in which its use is prohibited (eg, in class, while walking around the neighborhood, at home).⁸⁻¹⁰ Furthermore, police and parents report difficulty in detecting vaporized cannabis use because it is easily concealed by the absence of the pungent and characteristic odor of smoked cannabis.⁸⁻¹⁰ As e-cigarettes and related devices continue to gain popularity among youth, it will be important to monitor rates of using these products to vaporize cannabis.

ABBREVIATIONS

e-cigarettes: electronic cigarettes
HS: high school
OR: odds ratio
SES: socioeconomic status
THC: tetrahydrocannabinol

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