

# Patterns, Perception and Behavior of Electronic Nicotine Delivery Systems Use and Multiple Product Use Among Young Adults

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**BACKGROUND:** Electronic nicotine delivery systems (ENDS) are battery-operated devices used to inhale vaporized or aerosolized nicotine. There is increasing research uncovering negative health effects of these devices. Less is known about the social and behavioral aspects among college students. **METHODS:** This cross-sectional study was conducted at a mid-sized private university in Florida. The survey was sent via e-mail to the student body of undergraduates. A final sample size of 989 students was analyzed to understand demographic differences between users and nonusers, initiation factors, and influencers, as well as multiple product behaviors. **RESULTS:** Approximately 51.4% ( $n = 508$ ) of participants reported ever using an ENDS and other tobacco consumption. Males were significantly more likely to be users of ENDS. Polytabacco use, or the use of multiple tobacco products, was also more common among participants who have tried ENDS ( $P < .001$ ). Perceptions of harm of both the primary and secondary vapor were considered to be less than that of conventional cigarettes. Peers were the primary influencer for initial use. A 4-class latent variable model differentiated between usage patterns characterized as abstainers (70%), hookah users only (14%), ENDS only (11%), and polytabacco users (4%). **CONCLUSIONS:** ENDS are not commonly used as a quit tool among college students, but rather as a secondary source of nicotine, most commonly in current smokers. *Key words:* electronic cigarettes; ENDS; e-cigarettes; young adults; college students. [Respir Care 0;0(0):1–. © 0 Daedalus Enterprises]

## Introduction

Electronic nicotine delivery systems (ENDS) are non-combustible, non-tobacco, flavored products that primarily contain liquid nicotine, but also contain propylene glycol and glycerin as propellants.<sup>1,2</sup> Advocates of ENDS usage cite a therapeutic benefit as a titration aid for cigarette smoking cessation. Statistics suggest an increase in

dual users (cigarette smokers who also use ENDS) as well as in initial users since 2011.<sup>3</sup> The U.S. Centers for Disease Control and Prevention report, based on the National Adult Tobacco Survey, indicated that the prevalence of ENDS ever- and current use of ENDS in those age 18–24 years of age was 35.8% and 13.6%, respectively.<sup>4</sup> The National Health Interview Survey has been collecting data regarding ENDS use since 2014; their findings state that the 18–24 years of age cohort is the highest in ever-use and in “every day or some days” use, and ranks second only to non-Hispanic American Indians/African Natives in current use.<sup>5,6</sup> Since its issuance in 2016, the U.S. Food and Drug Administration deeming rule brings ENDS under their purview for forthcoming regulations.<sup>7</sup> These regulations fall in the wake of the increasing prevalence of ENDS use among all populations, but most prominently youth and young adults.

Increasing research is uncovering negative health effects of ENDS products. It is known that the addictive substance, nicotine, poses negative consequences to youth and young adults.<sup>4</sup> Harm due to nicotine exposure and toxicity are real

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concerns. Nicotine content varies across available cartridges and refill solutions.<sup>8,9</sup> Furthermore, user practice influences the quantity of nicotine delivered in a single puff.<sup>10</sup> The higher the concentration of nicotine delivery, the greater the likelihood of addiction. This variability of nicotine makes it especially difficult to determine exposure risks. However, nicotine exposure through the various routes (mucosal, inhalation, transdermal, and gastrointestinal) have resulted in symptoms such as dizziness, nausea, emesis, and eye and airway irritation.<sup>11-13</sup>

Additional case report data have indicated negative respiratory effects, oropharyngeal damage, cardiovascular effects, suicide, and poisonings.<sup>14,15</sup> Associations have been made between ENDS use and depressive symptoms in adolescents and young adults.<sup>16,17</sup> Findings related to respiratory irritants and carcinogens in the aerosols of ENDS are being identified in various brands and types of ENDS. For example, volatile aldehydes, formalin, diacetyl, and heavy metals such as tin, silver, iron, and nickel have been identified.<sup>18-21</sup>

The health risks of ENDS are not limited to users, as non-users risk secondary and tertiary exposure. Secondary exposure to secondhand or environmental vapor risks include air contamination and potential inhalation of aluminum, nicotine, glycerine, and polyaromatic hydrocarbons.<sup>11,22</sup> Tertiary exposure to aerosolized nicotine and to traces of nicotine can occur on fomites.<sup>23</sup> When nicotine mixes with nitrous acid manufactured by household and commercial appliances, tobacco-specific nitrosamines are produced. Tobacco-specific nitrosamines are known carcinogens, and exposure may occur via ingestion, inhalation, or transdermally. Although less is known about tertiary exposure from ENDS, evidence is mounting regarding exposure from conventional cigarettes.<sup>23-25</sup>

Laypeople ascribe low risk to ENDS use, especially when compared to both combustible and smokeless tobacco products. In a sample of college students classified as ever-smokers, 45% believed that ENDS were safer than combustible cigarettes.<sup>26</sup> Our study was multifaceted in nature. We explored the perception of harm from both firsthand and secondhand vapor. We explored college students' patterns of use, especially differences between ENDS users and non-users, and the particulars of initial use. Finally, we conducted a latent class analysis to further uncover the multidimensional nature of tobacco product and marijuana use.

## Methods

### Participants and Procedures

We developed a cross-sectional survey to assess ENDS use at a mid-sized, independent, liberal arts university in Florida. Situated in downtown Tampa, the University of Tampa is a residential university with a student population

## QUICK LOOK

### Current knowledge

Young adults partake in novel smoking behaviors experimentally and with little knowledge of the health effects. Those who currently smoke other products are more likely to try electronic cigarettes.

### What this paper contributes to our knowledge

ENDS users are often influenced by peers to vape. There were negative physiological effects such as coughing and throat burning associated with this smoking behavior.

of around 10,000 undergraduate and graduate students. E-mail addresses were obtained from the university's Office of Institutional Effectiveness. The survey was sent via e-mail invitation by the primary investigator, and participation was voluntary.

Consent for the study was achieved by describing the study in the recruitment e-mail. If participants voluntarily agreed to participate in the study, they were requested to click on an external link that directed them to the online survey using Google forms. The recruitment e-mail for this survey was sent to all undergraduate students attending the University of Tampa in the fall of 2016. Both ENDS users and non-users were invited to complete the survey.

Data were collected for 1 week during the fall semester to avoid holidays and summer days. Incentives to participate included a drawing for one of ten \$50 gift cards. Participants' e-mail addresses were numbered upon completion of the survey, and a drawing using a random-number generator was utilized to distribute the gift cards. The survey instrument was designed by the first and second authors. Inclusion criteria were current enrollment at the University of Tampa and age  $\geq 17$  y.

Students were excluded if they did not respond to the honesty question at the end of the survey, which asked, "Were you honest in your responses?" Nineteen duplicate e-mail addresses resulted in additional exclusions. This study was approved by the Institutional Review Board at the University prior to study commencement. Survey data were kept on a password-protected computer.

### Analysis

All statistical analyses were conducted with SAS 9.4. A total of 994 participants initiated the survey and met inclusion criteria. Of these, 5 did not respond to the

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Table 1. Characteristics of ENDS Users and Non-Users

Survey Questions	Non-Users, <i>n</i> (%)	Users, <i>n</i> (%)*	Total, <i>n</i> (%)	<i>P</i>
Gender				
Male	109 (35.3)	200 (64.7)	309 (31.3)	< .001
Female	366 (54.7)	303 (45.3)	669 (67.7)	
Transgender/gender non-conforming	5 (50.0)	5 (50.0)	10 (1.0)	
Age, y				.18
18	185 (52.4)	168 (47.6)	353 (36.2)	
19	98 (44.1)	124 (55.9)	222 (22.8)	
20	63 (47.4)	70 (52.6)	133 (13.7)	
21	64 (43.2)	84 (56.8)	148 (15.2)	
22	30 (57.7)	22 (42.3)	52 (5.3)	
23 or older	34 (51.5)	32 (48.5)	66 (6.8)	
Race				.34
White	341 (48.1)	368 (51.9)	709 (72.4)	
Black	25 (46.3)	29 (53.7)	54 (5.5)	
Hispanic	49 (45.8)	58 (54.2)	107 (10.9)	
Asian/Pacific Islander	23 (60.5)	15 (39.5)	38 (3.9)	
Multi-ethnic	21 (46.7)	24 (53.3)	45 (4.6)	
Other	17 (65.4)	9 (34.6)	26 (2.7)	
Sexual identity				.14
Heterosexual	440 (49.5)	449 (50.5)	889 (91.9)	
Gay or lesbian	9 (33.3)	18 (66.7)	27 (2.8)	
Bisexual	21 (41.2)	30 (58.8)	51 (5.3)	
Respiratory health				.46
History of asthma	91 (51.5)	87 (48.9)	178 (18.0)	
No history of asthma	390 (48.1)	421 (51.9)	811 (82.0)	
Perceptions of harm from use				< .001
Less harmful than cigarettes	139 (31.5)	303 (68.6)	442 (44.8)	
Equally as harmful	253 (64.2)	141 (35.8)	394 (39.9)	
More harmful	45 (69.2)	20 (30.8)	65 (6.6)	
Do not know	44 (51.2)	42 (48.8)	86 (8.7)	
Perception of secondhand effects				< .001
It is safe for others to be around	56 (22.2)	196 (77.8)	252 (25.6)	
It is unsafe for others	251 (69.9)	108 (30.1)	359 (36.4)	
Do not know	173 (46.1)	202 (53.9)	375 (38.0)	

*N* = 989 subjects, with 481 (48.6%) non-users and 508 (51.4%) smoking device users.

\* Users are defined as those who have ever used electronic smoking devices.

ENDS use question and were removed from further analyses. The analytic sample was 989 participants. Item-level missing data were < 5%, so list-wise deletion was used in bivariate comparisons.

Differences in sample characteristics, risk perceptions, and tobacco use between ENDS users and non-users were compared using chi-square analysis. Latent class analysis was used to explore the multidimensional nature of tobacco product and marijuana use. The likelihood ratio chi-square test, the Akaike information criterion, and the Bayesian information criterion were used to examine model fit along with the interpretability of 1–5 latent classes. A 4-class model was selected, interpreted (ie, classes were given descriptive labels), and used to examine latent class prevalence.

## Results

Demographic characteristics of the study sample are reported in Table 1. The sample was mostly female (67.7%), non-Hispanic white (72.4%), and heterosexual (91.9%). Nearly three quarters (72.7%) of users were 18–20 y old.

Approximately 51.4% (*n* = 508) of subjects reported ever using an ENDS product. ENDS users were most likely to be male, to perceive e-cigarettes as less harmful than traditional cigarettes, and to perceive ENDS to pose fewer secondhand effects (*P* < .001).

Comparisons of current tobacco use behaviors among ENDS device users and non-users are reported in Table 2.

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Table 2. Comparison of Tobacco Use Behaviors Among Electronic Device Users and Non-Users

Survey Questions	Non-Users, <i>n</i> (%)	Users, <i>n</i> (%)*	Total, <i>n</i> (%)	<i>P</i>
Number of products used				< .001
0	443 (62.6)	265 (37.4)	708 (71.6)	
1	30 (16.0)	157 (84.0)	187 (18.9)	
2	6 (11.1)	48 (88.9)	54 (5.5)	
3 or more	2 (5.00)	38 (95.0)	40 (4.0)	
Currently use cigarettes				< .001
Yes	6 (7.7)	72 (92.3)	78 (7.9)	
No	475 (52.1)	436 (47.9)	911 (92.1)	
Currently use cigars				< .001
Yes	8 (12.7)	55 (87.3)	63 (6.4)	
No	473 (51.1)	453 (48.9)	926 (93.6)	
Currently use cigarillos				< .001
Yes	1 (2.7)	36 (97.3)	37 (3.7)	
No	480 (50.4)	472 (49.6)	952 (96.3)	
Currently use hookah				< .001
Yes	6 (6.4)	88 (93.6)	94 (9.5)	
No	475 (53.1)	420 (46.9)	895 (90.5)	
Currently use marijuana				< .001
Yes	27 (17.1)	131 (82.9)	158 (16.0)	
No	454 (54.6)	377 (45.4)	831 (84.0)	

*N* = 1,014 subjects, with 497 (49.0%) non-users and 517 (51.0%) smoking device users.

\* Users are defined as those who have ever used electronic smoking devices.

Polytobacco use, or the use of multiple tobacco products, was more common among subjects who have tried ENDS ( $P < .001$ ). Trying ENDS was very common among current users of cigarettes, cigars, cigarillos, hookah, and marijuana ( $P < .001$ ); 97.3% of cigarillo users, 93.6% of hookah users, 92.3% of cigarette users, 87.3% of cigar users, and 82.9% of marijuana users have at least tried ENDS.

Smokers were assessed with regard to how often they vaped, the type of device they used, and the location of vaping (Table 3). Among those who have tried an ENDS, 35.1% vaped from an electronic device within the past 30 d, and 17% smoked at least once a day. Approximately a quarter (26.1%) of ENDS users have been using them for a year or longer. The majority of the subjects used a rechargeable device (70.0%) and smoked in multiple locations. ENDS use at bars or clubs was common (23.6%), as was smoking while consuming alcoholic beverages (26.2%).

Reasons, influencers, and physiological experiences were evaluated (Table 4). The most commonly reported reason for initiating ENDS use was peer influence (36.9%). Most did not experience any negative effects during initial use (56.3%); however, some reported coughing (19.7%), throat burn (10.8%), and headache (7.1%).

Four latent classes were selected based on the likelihood ratio chi-square test, Akaike information criterion, Bayes-

ian information criterion, and interpretability (see Table 5). Current use of 5 tobacco products and marijuana were examined (ENDS, cigarette, cigar, cigarillo, hookah, and marijuana). Use of each product was considered a part of the class membership if item-response probabilities were  $\geq 0.40$  as noted in Table 6. The 4-class model differentiated between usage categories that we labeled as Abstainers (70%), Hookah users only (14%), ENDS users only (11%), and Poly tobacco users (4%). Percentages in parentheses represent the distribution of our sample according to class membership.

## Discussion

This exploratory, descriptive study sought to understand intricacies about ENDS users. We found that using ENDS to quit smoking regular cigarettes was reported by a minority of subjects, despite being advertised as a quit aid. Our study found that concurrent use of cigarettes and ENDS was common. More non-users felt that the primary vape effects were more harmful than the effects of secondhand vape. This could be because the vapor dissipates faster than smoke when exhaled from the smoker's mouth, resulting in less secondhand vapor and thus a weaker effect. There is a dearth of literature on the effects of secondhand vapor, so understanding perceptions is valuable to add to the body of knowledge.<sup>22</sup>

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Table 3. Patterns of Use Among ENDS Users

Survey Questions	<i>n</i> (%)
Use in the past 30 d ( <i>n</i> = 507)	178 (35.1)
Frequency of Daily Use ( <i>n</i> = 507)	
Not used everyday	421 (83.0)
1 to 5 times	26 (5.1)
6 to 10 times	13 (2.6)
11 to 19 times	11 (2.2)
20 or more times	36 (7.1)
Duration of Use ( <i>n</i> = 498)	
Less than a week	232 (46.6)
1 week to 1 month	35 (7.0)
1 to 3 months	45 (9.0)
6 months to 1 year	56 (11.2)
Over one year	130 (26.1)
Type of device used most frequently ( <i>n</i> = 493)	
Rechargeable	345 (70.0)
Disposable	105 (21.3)
Both	43 (8.7)
Place where typically smoke ( <i>n</i> = 508)*	
Everywhere it is allowed	96 (18.9)
Work	15 (3.0)
Home	181 (35.6)
Car	89 (17.5)
Restaurant	8 (1.6)
Outside	148 (29.1)
Class	4 (1.0)
At bars or clubs	120 (23.6)
When most routinely smokes from electronic device ( <i>n</i> = 481)	
After a meal	16 (3.3)
With alcoholic beverages	126 (26.2)
When stressed	83 (17.3)
First thing in the morning	8 (1.7)
Whenever I can	96 (20.0)
Other	151 (31.5)

\* Respondents could choose > 1 option.

The latent classes identified are consistent with previous research in this college population. The largest group were abstainers, followed by subjects who were most likely experimenting with tobacco products like Reflections on Initial ENDS Use and hookah in social situations. Hookah use was very common in this college population, and we found that a majority of hookah users were also trying ENDS.<sup>27</sup> A smaller subset of users were using only ENDS. This could indicate that ENDS are a gateway to tobacco product use, or that they are used as replacements or substitutions for other types of tobacco products. While we could not test these hypotheses directly in this study, examination of the primary reasons for ENDS initiation suggest that the appeal of ENDS is not to serve as a replacement for other products, at least in this college sample of young adults. Previous studies support the initiation into

Table 4. Reflections on Initial ENDS Use

Survey Questions ( <i>n</i> Respondents)	<i>n</i> (%)
Primary reason to smoke the first time ( <i>n</i> = 504)	
Trying to quit smoking regular cigarettes	43 (8.5)
Friends smoking	186 (36.9)
Looks cool	45 (8.9)
I smoke other products and wanted to try it	47 (9.3)
To lose weight	3 (1.0)
To enjoy the flavors that I love in food	40 (7.9)
To relieve stress	76 (15.1)
Weight management	1 (< 1)
Other	63 (12.5)
Who or what influenced to try ( <i>n</i> = 505)	
Friend who smokes one	339 (67.1)
Family member	17 (3.4)
Advertisement	10 (2.0)
Teacher	2 (< 1)
No one	108 (21.4)
Other	29 (5.7)
Experience during initial use ( <i>n</i> = 508)	
Headache	36 (7.1)
Throat burned	55 (10.8)
Stomach ache	10 (2.0)
Sinus issues	4 (1.0)
Coughing	100 (19.7)
Lungs hurt	4 (1.0)
I did not experience any bad effects	286 (56.3)
Other	13 (2.6)

Table 5. Fit Statistics for LCA Models of Current Tobacco Product and Marijuana Use With 1–5 Latent Classes

Number of Classes	Likelihood Ratio Chi-Square Test	Akaike Information Criterion	Bayesian Information Criterion	Entropy
1	332.54	342.54	367.05	1.00
2	49.08	71.08	125.00	0.69
3	38.97	72.97	156.30	0.57
<b>4</b>	<b>20.92</b>	<b>66.92</b>	<b>179.66</b>	<b>0.74</b>
5	15.81	73.81	215.96	0.67

Bold text indicates the best-fitting model.  
LCA = latent class analysis

ENDS use as a gateway to the use of combustible cigarettes in similar age cohorts.<sup>28,29</sup>

Results indicated demographic differences, with ENDS users being predominantly male compared to non-users. Most subjects who have used an ENDS do not use it every day and have used it for < 1 week. This may indicate that more ENDS users are experimenters as opposed to continuous users. Cost is not a barrier in this sample, as most subjects reported purchasing the rechargeable units. This could indicate the desire for a device that does not look like a cigarette-shaped device. Smoking cigarettes at home



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Table 6. Item Response Probabilities for 3, 4, and 5 Classes

	3 Classes			4 Classes <sup>a</sup>				5 Classes				
	1	2	3	1	2	3	4	1	2	3	4	5
ENDS	0.28	<b>0.79</b>	0.03	0.29	<b>0.72</b>	<b>0.92</b>	0.00	<b>0.44</b>	<b>0.68</b>	<b>0.95</b>	0.01	0.36
Cigarette	0.16	0.34	0.01	0.17	<b>0.57</b>	0.18	0.01	0.39	<b>0.66</b>	0.07	0.00	0.03
Cigar	0.01	0.37	0.03	0.01	<b>0.48</b>	0.20	0.03	0.00	0.46	<b>0.51</b>	0.03	0.00
Hookah	0.24	0.33	0.01	<b>0.42</b>	<b>0.70</b>	0.02	0.00	0.19	<b>0.64</b>	0.05	0.01	0.23
Marijuana	0.26	<b>0.53</b>	0.06	0.28	<b>0.77</b>	0.30	0.07	0.04	<b>0.77</b>	0.33	0.04	<b>0.50</b>

Bold values indicate item response probabilities  $\geq 0.40$ .

<sup>a</sup> The 4-class model differentiated between usage categories as follows: Class 1 (Hookah users only), Class 2 (Poly users), Class 3 (ENDS users only), Class 4 (Abstainers).

ENDS = electronic nicotine delivery systems

and outside were most popular in conjunction with vaping and drinking.

This study was limited to data collected from one university, so the findings may differ in other geographic regions or universities. The study did not explore people who do not attend college. The data collected were self-reported and from a single university in Florida, so the results may not be generalizable to other institutions. However, in previous tobacco-related studies, we have found the characteristics to be similar between two colleges in the same town. The large sample size provided robust power to the study. The study explored many aspects that fill gaps in the literature and add previously unreported details to the body of knowledge on ENDS use among young adults. In particular, polytobacco use among users and non-users indicated that users of ENDS had a greater propensity to smoke other tobacco products, including marijuana.

## Conclusions

This study helps uncover reasons for initiation of vaping in a college student population as well as information to inform health messaging in hospitals and among respiratory therapists in community settings. This formative research can lead to the development of social marketing campaigns to educate college students in making informed decisions about their choice to vape and provides the university with information on multiple product usage. Additionally, this study emphasizes the importance of sharing the negative health effects of ENDS use. Future research should seek to determine whether vaping and alcohol consumption are co-occurrences similar to traditional smoking and alcohol consumption. Future research should also consider longitudinal data collection to determine whether ENDS products are a gateway across colleges. Additionally, studies should consider following the progression of nicotine titration or nicotine dose dependence to under-

stand how these products are used to achieve nicotine abstinence in college students.

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