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The Social Patterning of Electronic Nicotine Delivery System Use among US Adults

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Abstract

There is little research examining the social patterning of electronic nicotine delivery system (ENDS) use. This study investigated the association between socioeconomic status (SES) (education, income, and employment status) and current and former ENDS use. Data were collected from 2561 participants from the American Heart Association Tobacco Regulatory and Addiction Center (A-TRAC) online survey. Participants were 18–64 years old and reported demographic, SES, and ENDS use. Poisson regression was used to estimate prevalence ratios (PR 95% confidence interval-CI) of participants' current and former (vs. never) ENDS use. Models were adjusted for age, sex, sexual orientation, race/ethnicity, marital status, and reasons for ENDS use. In the unadjusted analysis, ENDS use was primarily patterned by education and employment status. College educated persons (versus those with less than a high school diploma) had a 37% greater prevalence of current ENDS use (PR 1.37, 95% CI 1.20–1.55), and a 16% greater prevalence of former ENDS use (PR 1.16, 95% CI 1.06–1.28) in the fully-adjusted model. Persons with household incomes above \$90K (versus less than \$20,000) had a greater prevalence of current (PR 1.30, 95% CI 1.19–1.41) and former (PR 1.17, 95% CI 1.05–1.30) ENDS use. Those who were employed (versus not employed) had a 13% greater prevalence of current ENDS use (PR: 1.13, 95% CI 1.07–1.19) after full adjustment. Higher SES (versus lower SES) persons were more likely to use ENDS.

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Keywords

ENDS; E-cigarettes; Vaping; Socioeconomic Status; social patterning; A-TRAC

Introduction

Cigarettes are decreasing in use, but e-cigarettes or electronic nicotine delivery systems (ENDS) are becoming more popular in the U.S. population.^{1,2} The Centers for Disease Control and Prevention estimates that 12.6% of US adults have experimented with e-cigarettes.³ Additionally, half of people who identify as current cigarette smokers have experimented with ENDS, and 22% of former cigarette smokers also reported experimenting with ENDS.³ Although ENDS may be perceived as safer alternatives to traditional cigarettes, the evidence is mixed, and significant concerns have been raised.⁴ For example, experimental studies have found that the liquid in ENDS promotes pro-inflammatory responses in animal and human airway cells.^{5,6} ENDS also often contain nicotine, and prolonged use could increase nicotine dependence.⁷ In addition to suggested harms of ENDS use, there is no current standard or regulation of the range of ingredients included in ENDS.⁸

Given the potential dangers and growing interest in e-cigarettes, it is important to examine the social patterning of ENDS use in order to understand the extent to which social determinants of health impact ENDS use. Social patterning of cigarette smoking has been evident in the U.S. population for decades.^{9–11} Higher rates of tobacco smoking typically are found among those who are less educated and those with lower income.^{12–13} The mechanisms likely associated with these disparities are varied, including social context (e.g. friends and family who smoke),¹⁴ limited accessibility to cessation resources¹⁵ and exposure to stressors, which may promote the maintenance of smoking as a coping mechanism.¹⁶ Studies have not specifically examined the social patterning of ENDS use; however, there are reports of demographic characteristics of ENDS users. For instance, Adkisson et al.¹⁷ found ENDS use to be more common among those who were white, younger, and had higher-incomes. Other studies have found ENDS use to be more prevalent among men and former cigarette smokers^{18–19} and non-minorities.

The association between socioeconomic status (SES) and ENDS use is unclear. Therefore, we investigated the association between SES (education, income, and employment status) and ENDS use status (current, former, never) among participants from the American Heart Association Tobacco Regulatory and Addiction Center (A-TRAC) adult vaping survey, which included a racially diverse sample of U.S. adults 18–64 years old. We hypothesized there would be an inverse association between SES and ENDS use, similar to that of cigarette smoking.

Methods

Participants of the A-TRAC adult vaping survey were selected randomly through a marketing research vendor, who screened for participants who were willing to answer questions about knowledge, perception, and behaviors regarding ENDS during the period of

June – August 2016. The vendor estimated a 20% response rate, so they sent the survey to approximately 13,000 in order to achieve the 2,561 respondents.

The initial screening criteria for participants included being 18 years and older, meeting criteria for one of the tobacco use categories, and willing to report socio-demographics (e.g. sex, race, education, income, and sexual orientation). Recruitment techniques (i.e., randomization, exclusion, sampling) assured there was sufficient representation from key subgroups based on age, race, ethnicity, sex, and smoking status. Survey weights were not applied, as this was not designed to be a nationally representative sample.

Tobacco product use categories were: (a) Current ENDS User: individuals who have vaped within the past week, have vaped for 6 months or longer, have vaped at least 20 times, may use other tobacco products currently and / or historically; (b) Current Cigarette Smoker: individuals who have smoked within the past week, have smoked for 6 months or longer, have smoked at least 100 cigarettes, may have vaped historically but not within the past 6 months; and (c) Experimenter: have smoked or vaped in the past; have not vaped or smoked within the past 6 months, have vaped less than 20 times and / or smoked fewer than 100 cigarettes. Identifying information (i.e., name, place of residence) was neither required nor obtained. Individuals meeting initial screening criteria completed the full ENDS survey. Quality control checks were performed to ensure data reliability and quality. Ultimately, 2561 participants completed the A-TRAC online survey. This study was approved by the IRB of the following institutions: the University of Mississippi Medical Center, Northwestern University, University of Louisville and the American Heart Association (Chesapeake IRB).

Data Variables

Electronic Nicotine Delivery Systems—The outcome of interest for this study was e-cigarette or vaping device use (i.e. ENDS). Participants were asked “How recently have you used an e-cigarette or another device to vape?” If participants had used an ENDS device within the past 30 days, they were considered “Current ENDS users.” If participants had ever used an ENDS device but not in the past 30 days, they were considered “Former ENDS users.” Participants who had never tried an ENDS device or had minimally experimented with ENDS (i.e. never engaged in regular use and have been abstinent for at least 1 year) were classified as “Never ENDS users.”

SES measures—SES measures included self-reported responses from the online questionnaire. Education categories were restricted to: less than high school diploma, general equivalency diploma (GED), high school diploma, some college and college degree or higher. Income categories were based on self-reported total annual household income, which included all members of the participant’s home. Income was categorized as: 1) less than \$20,000; 2) \$20K–\$49,999; 3) \$50K–\$64,999; 4) \$65K–\$89,999; and 5) \$90K and above. Employment status was categorized as “not employed” and “employed” (full and part time). The referent groups were the lowest categories for each SES measure (e.g. less than high school diploma, less than \$20,000, and not employed).

Covariates—Demographic variables for this study included age, sex, marital status (single, married, divorced/separated, or widowed), race-ethnicity (Non-Hispanic White, Hispanic White, Non-Hispanic Black, Hispanic Black, and Other), and sexual orientation (heterosexual, lesbian/gay, bisexual, transgendered, or questioning/other). In addition to demographic variables, we added reasons for ENDS use as covariates because these could be potential confounders. Participants were asked to select up to three responses to, “What was the primary reason you started using your vaping device?” The most common reasons for ENDS use were categorized as: alternative to smoking cigarettes, liked the flavors used in the e-cigarette device, and healthier or less harmful than other tobacco products.

Statistical analyses—Sample characteristics by ENDS use were examined via percentages within the ENDS categories.

Because the prevalence of ENDS use was greater than 10%, Poisson regression was used to estimate prevalence ratios (PRs, 95% confidence interval-CI) of current (vs. never) and former (vs. never) ENDS use by SES.²⁰ Model 1 was unadjusted. Model 2 adjusted for age, sex, sexual orientation, race-ethnicity, and marital status. Model 3 adjusted for Model 2, and reasons for vaping. Analyses were conducted using SAS 9.2 (SAS Institute, Cary, NC).

Results

Table 1 presents the distribution of sample characteristics by ENDS use. Most were current ENDS users (58.3%), between 25 and 34 years of age (34.8%), female (57.9%), identified as “Other” race-ethnicity, single (53.3%), and heterosexual (80.9%). Approximately 70.1% reported that they had at least some college education or higher, 50% reported household incomes greater than \$50,000, and most participants were employed (70.6%). The highest percentage of current and former ENDS users were between 25 and 34 years of age (39% and 32%, respectively), whereas never ENDS users were predominantly between 45 and 64 years of age (53.4%). A greater percentage of current and former ENDS users identified as ‘other’ race followed by non-Hispanic Blacks and then non-Hispanic Whites. Participants with higher (vs. lower) education levels reported greater current, former and never ENDS use. Participants who earned between \$20,000 and \$49,999 were more likely to be current, former, and never ENDS users than the other income classes. Participants who were employed were also more likely to be current, former, and never ENDS users.

Table 2 presents the associations of SES with current (vs. never) and former (vs. never) ENDS use status. In the unadjusted model, having a GED was not significantly associated with current or former ENDS use. The PR of current ENDS use was 1.18 (95% CI 1.03–1.37) for those who had a HS diploma (vs. no HS diploma) in the unadjusted model; the PR increased to 1.21 (95% CI 1.06–1.37) in the fully- adjusted model. Similar results were found for participants with some college and with a college degree or more who reported current ENDS use. Persons with a college degree or more had a 37% greater prevalence of current ENDS use (PR 1.37, 95% CI 1.20–1.55) and a 16% greater prevalence of former ENDS use (PR 1.16, 95% CI 1.06–1.28) in the fully-adjusted model. There was a significant positive trend between levels of education and ENDS use (p value for trend = <0.001). Persons with total income above \$90K (versus <\$20,000) had a 30% greater prevalence of

current ENDS use and 17% greater prevalence of former ENDS use after full adjustment (PR 1.30, 95% CI 1.19–1.41; PR 1.17, 95% CI 1.05–1.30, respectively). For current ENDS use, there was a positive gradient for increasing levels of income (p value for trend = <0.001). After full adjustment, employed (vs. not employed) persons had a 13% greater prevalence of current ENDS use (PR 1.13, 95% CI 1.07–1.19). In the unadjusted model, the prevalence of former ENDS use was 10% greater for those who were employed (PR 1.10, 95% CI 1.03–1.18). This association attenuated and became non-significant after adjustment for demographics and reasons for vaping.

Discussion

This study examined the associations of education, income, and employment status with current and former ENDS use among participants from a multi-racial sample. Overall, contrary to our hypothesis, we found that the prevalence of current ENDS use increased with higher educational attainment, higher household income, and among those employed. Generally, former ENDS use was more associated with household income. Our adjusted findings show that ENDS use is patterned socioeconomic status.

A recent systematic review published in 2016 found that (among seven studies)²¹ there were no clear patterns of e-cigarette use by SES reported among US adults. One study published in the same year examined data from the 2012 National Survey on Drug Use and Health (n=55,268) found that the odds of smokeless tobacco (snus, dissolvable tobacco products, and ENDS) was greater for least educated, low-income, and unemployed persons.²² In contrast, in a nationally representative sample of US adults (n = 34,356), Wilson and Wang (2017)²³ found a greater odds of ever ENDS use among those with higher income. There was also a positive association of ever ENDS use and having a high school diploma and some college, but no association was found among those with a college degree. Similarly, the current study reported greater prevalence of current ENDS use among higher-income persons and a significant positive association between higher education and being employed with current and former ENDS use. Although our findings are similar to Wilson & Wang (2017), we found significant associations between having a college degree and greater ENDS use. Other studies have found no associations or that ENDS use was more common for those with lower socioeconomic status. The difference in findings may be due to the high prevalence of ENDS use in our sample, which presents a potential ceiling effect for all SES groups.

Mechanisms that link high SES to ENDS use may include increased marketing and perceptions of safety. Higher SES groups may be targeted more than lower SES groups because high SES persons are more likely to adopt new technologies.^{24,25} High-status groups' may also perceive that ENDS are safer than other tobacco products. Palazzolo⁴ reported that the marketing of e-cigarettes has convinced many that vaping is safe and is less harmful than traditional cigarettes. Case et al.²⁶ similarly reported that ENDS users and non-users believed that e-cigarettes were less harmful than conventional cigarettes, which may be displayed in the upper SES groups relative to their lower-status counterparts in our study.

Interestingly, those who were employed had a greater prevalence ratio of current and former ENDS use, which may be due to the greater prevalence of former/ current cigarette smoking among employed persons in this sample. Employed persons may use ENDS to cope with job-related stress, similar to how conventional cigarettes are used.²⁷ In addition to coping with stress, marketing may also affect ENDS use among employed persons. Syamlal et al. (2016)²⁸ reported that higher e-cigarettes use among working adults may be due to marketing e-cigarettes as acceptable in prohibited traditional cigarette smoking areas. Age could also affect ENDS use among employed persons, as more ENDS users are younger and more represented in the labor force.

Although there is limited evidence of the adverse effects of ENDS use, some studies have reported the potential risks of ENDS use. For example, studies have found that ENDS use was associated with poor oral health²⁹, greater risk for subsequent cigarette smoking among adolescents,³⁰ and change in bronchial gene expression and other related respiratory conditions.³¹

Limitations

Despite the contributions of this study, there were limitations. First, the study design was cross-sectional, which precludes us from determining the directionality of the association. Second, the online survey methodology used for selecting participants may have excluded individuals who do not use the Internet, or who do not know about ENDS, which may bias our results due to residual confounding. The education and employment composition likely contributes to selection bias of higher status and ENDS use. Third, it is unclear whether the responses of those who chose to participate in this study specifically about tobacco product use are generalizable to the larger population of tobacco product users. Fourth, we must remain mindful that the characteristics that define tobacco users, particularly ENDS users, may be changing over time, given the rapid evolution of this market. On the other hand, a major strength of this work is that it is among the first study to evaluate the social patterning of ENDS use in a multi-racial sample, which is also inclusive of a broad range of men and women across SES, age, and sexual orientation characteristics. This diversity strengthens the likely generalizability of the association between economic resources and non-traditional tobacco product use.

Conclusion

In conclusion, highly educated and high-income persons were more likely to be current and former ENDS users in this study. Unlike other studies, high-SES was significantly associated with ENDS use in this sample. A growing proportion of adult smokers have tried ENDS, as they have become widely available. Although the impact of ENDS on long-term health outcomes needs further study, research suggests that the numerous toxic substances found in e-cigarette aerosol can have negative health effects. This paper indicates higher SES individuals may be at greater risk than others.

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Table 1.

Select Characteristics by Electronic Nicotine Delivery Systems (ENDS) Use (N=2561)*

	Total	ENDS		
		Never (9.3)	Current (58.3)	Former (32.4)
Age				
18–24	532 (20.8)	11 (4.62)	261 (17.5)	260 (31.4)
25–34	892 (34.8)	50 (21.0)	577 (38.6)	265 (32.0)
35–44	569 (22.2)	50 (21.0)	349 (23.4)	170 (20.5)
45–64	568 (22.2)	127 (53.4)	307 (20.6)	134 (16.2)
Sex				
Male	1079 (42.1)	99 (41.6)	722 (48.3)	258 (31.1)
Female	1482 (57.9)	139 (58.4)	722 (51.7)	571 (68.9)
Race-ethnicity				
Non-Hispanic White	560 (21.9)	77 (32.3)	341 (22.8)	142 (17.1)
Hispanic White	243 (9.5)	11 (4.6)	99 (6.6)	133 (16.0)
Non-Hispanic Black	621 (24.3)	91 (38.2)	343 (23.0)	187 (22.6)
Hispanic Black	135 (5.3)	3 (1.3)	80 (5.3)	52 (6.3)
Other	1002 (39.1)	56 (23.5)	631 (42.2)	315 (98.0)
Marital Status				
Single, never married	1366 (53.3)	103 (43.3)	770 (51.5)	493 (59.5)
Married	911 (35.6)	82 (34.5)	578 (38.7)	251 (30.3)
Divorced/Separated	249 (9.7)	11 (4.6)	131 (8.8)	76 (9.2)
Widowed	35 (1.4)	11 (4.6)	15 (1.0)	9 (1.1)
Sexual Orientation				
Heterosexual	2071 (80.9)	216 (90.8)	1233 (82.5)	622 (75.0)
Lesbian/Gay	147 (5.7)	9 (3.8)	77 (5.2)	61 (7.4)
Bisexual	247 (9.6)	12 (5.0)	141 (9.4)	94 (11.3)
Transgendered	14 (0.6)	0 (0.0)	8 (0.5)	6 (0.7)
Questioning/Other	82(3.2)	1 (0.4)	35 (2.3)	46 (05.6)
Education				
<High School Diploma	190 (7.4)	26 (10.9)	63 (4.2)	101 (12.2)
GED	133 (5.2)	20 (8.4)	64 (4.3)	49 (5.9)
High School Diploma	443 (17.3)	46 (19.3)	238 (15.9)	159 (19.2)
Some college	1005 (39.2)	104 (43.7)	611 (40.9)	290 (35.0)
College degree +	790 (30.9)	42 (17.7)	518 (34.7)	230 (27.7)
Income				
<\$20,000	435 (17.0)	75 (31.5)	177 (11.9)	183 (22.1)
\$20k – \$49,999	805 (31.4)	79 (33.2)	440 (29.5)	286 (34.5)
\$50k – \$64,999	461 (18.0)	29 (12.2)	287 (19.2)	145 (17.5)
\$65k – \$89,999	401 (15.7)	21 (8.8)	279 (18.7)	101 (12.2)
\$90k & up	459 (17.9)	34 (14.3)	311 (20.8)	114 (13.8)
Employment Status				

	Total	ENDS		
		Never (9.3)	Current (58.3)	Former (32.4)
Not employed	753 (29.4)	110 (46.2)	346 (23.2)	297 (35.8)
Employed	1808 (70.6)	128 (53.8)	1148 (76.8)	532 (64.2)

* Percentages are calculated within ENDS Use categories

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Table 2. Prevalence Ratios (PRs, 95% CI) of Electronic Nicotine Delivery Systems (ENDS) Use by Socioeconomic Status

SES predictor	Current (vs. Never) ENDS use			Former (vs. Never) ENDS use		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Education						
<High School	Ref	Ref	Ref	Ref	Ref	Ref
GED	1.08 (0.90–1.29)	1.10 (0.93–1.30)	1.10 (0.94–1.29)	0.89 (0.32–1.24)	0.95 (0.81–1.06)	0.96 (0.82–1.11)
High School diploma	1.18 (1.03–1.37)	1.21 (1.06–1.38)	1.21 (1.06–1.37)	0.97 (0.87–1.09)	1.04 (0.94–1.16)	1.06 (0.96–1.17)
Some college	1.21 (1.05–1.38)	1.25 (1.10–1.43)	1.26 (1.11–1.42)	0.93 (0.83–1.03)	1.03 (0.93–1.14)	1.06 (0.96–1.16)
College degree +	1.31 (1.14–1.50)	1.36 (1.19–1.55)	1.37 (1.20–1.55)	1.06 (0.96–1.18)	1.14 (1.04–1.26)	1.16 (1.06–1.28)
P for trend	<0.001	<0.001	<0.001	0.20	0.004	0.0005
Income						
<\$20,000	Ref	Ref	Ref	Ref	Ref	Ref
\$20K – \$49,999	1.21 (1.10–1.32)	1.19 (1.10–1.30)	1.18 (1.09–1.28)	1.10 (1.00–1.21)	1.13 (1.04–1.24)	1.11 (1.03–1.21)
\$50K – \$64,999	1.29 (1.18–1.41)	1.28 (1.18–1.39)	1.26 (1.16–1.37)	1.17 (1.06–1.30)	1.19 (1.08–1.31)	1.20 (1.10–1.32)
\$65K – \$89,999	1.32 (1.21–1.44)	1.31 (1.21–1.43)	1.30 (1.20–1.41)	1.17 (1.04–1.31)	1.22 (1.10–1.35)	1.20 (1.08–1.32)
\$90K & up	1.28 (1.18–1.40)	1.31 (1.20–1.43)	1.30 (1.19–1.41)	1.09 (0.96–1.22)	1.16 (1.04–1.30)	1.17 (1.05–1.30)
P for trend	<0.001	<0.001	<0.001	0.05	0.001	<0.001
Employment status						
Not employed	Ref	Ref	Ref	Ref	Ref	Ref
Employed	1.19 (1.12–1.25)	1.14 (1.08–1.20)	1.13 (1.07–1.19)	1.10 (1.03–1.18)	1.07 (0.99–1.14)	1.06 (0.99–1.12)

Model 1: SES predictor (unadjusted); Model 2: model 1 + age + sex + sexual orientation + race/ethnicity + marital status; Model 3: model 2 + reasons for vaping