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Dual Use of Nicotine and Cannabis Through Vaping Among Adolescents

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Abstract

Introduction: This study seeks to identify adolescent nicotine and cannabis vaping patterns and the characteristics of those adolescents who comprised each pattern.

Methods: This prospective longitudinal survey study measured the relationship between nicotine and cannabis vaping among 1,835 adolescents from 4 public high schools outside of Philadelphia, Pennsylvania. Adolescents completed in-classroom surveys, including questions of lifetime and past 30–day nicotine and cannabis vaping, at Wave 1 (fall 2016, ninth grade) and 6-month intervals for the following 36 months (fall 2019, 12th grade). Data were analyzed in 2021.

Results: A sequential processes growth mixture model revealed 4 latent conjoint classes of nicotine and cannabis vaping: Early, Declining Dual Use (Class 1: n=259), Rapidly Increasing Dual Use (Class 2: n=128), Later, Slower Dual Use (Class 3: n=313), and No Use (Class 4: n=1,136). Increased odds of belonging to Class 1 and Class 2 versus Class 4 were significantly associated with cigarette smoking (OR=3.71, OR=2.21), alcohol use (OR=2.55, OR=4.39),

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The authors report no potential conflicts of interest.

The corresponding author (JAM) had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Credit Author Statement

JAM lead the conceptualization and design of the study, wrote and significant portions of the manuscript text, and provided input on the analyses and the interpretation of the data. AFM conducted the literature search, and drafted portions of the introduction and discussion. DR conducted the analyses, drafted the interpretation of the analysis, and provided feedback on drafts of the manuscript. ST and SP edited and provided feedback on manuscript drafts.

peer vaping (OR=1.24, OR=1.20), sensation seeking (OR=1.03, OR=1.11), positive e-cigarette expectations (OR=1.21, OR=1.17), and cigar smoking (OR=2.39 Class 2 only). Increased odds of belonging to Class 3 versus Class 4 were significantly associated with alcohol use (OR=1.66), perceived benefits of e-cigarette use (OR=1.03), positive e-cigarette expectations (OR=1.08), depressive symptoms (OR=1.02), and sensation seeking (OR=1.03).

Conclusions: From middle to late adolescence, vaping of nicotine and cannabis develop in close parallel. Regulatory policy and prevention interventions should consider the interplay between these 2 substances during this period of adolescence.

INTRODUCTION

Nicotine and cannabis vaping have become increasingly popular among adolescents.[1,2] The percentage of adolescents who reported current e-cigarette use (past 30–day) to vape nicotine increased from 1.5% in 2011 to 22% in 2020.[2,3] Similarly, 4.3% of 10th grade students and 4.9% of 12th grade students reported vaping cannabis in the past month in 2017, increasing to 11.3% and 12.2%, respectively, in 2020.[3,4]

Cross-sectional studies have documented associations between nicotine vaping and cannabis vaping.[5–13] Adolescents who currently vape nicotine prefer to vape cannabis over other combustible methods than adolescents who smoke combustible cigarettes.[9] Indeed, adolescents who have ever used an e-cigarette have a 2-fold higher odds of ever and current cannabis vaping 24 months later than youth who had never used e-cigarettes.[7,14] Recent research observed that specific patterns of nicotine vaping were associated with a higher probability of cannabis vaping, whereas never vaping nicotine was associated with a lower likelihood of cannabis vaping among older adolescents transitioning to young adulthood.[6] Whether these relationships emerge across middle to late adolescence is unknown.

There are no studies that have identified adolescents most at risk of vaping both nicotine and cannabis. Such information is critical to optimize the target, timing, and content of prevention messaging. Adolescents who use combustible forms of nicotine and cannabis are more likely to become dependent on both substances.[15] Although the health effects of vaping are not fully understood, negative cognitive consequences of nicotine and cannabis exposure have been identified,[16] and e-cigarette or vaping use–associated lung injury has been linked to impurities in e-liquids such as vitamin E acetate.[17]

This prospective longitudinal cohort study assesses the relationship between nicotine vaping and cannabis vaping from middle to late adolescence. The study seeks to identify developmental patterns of nicotine and cannabis vaping and the characteristics of adolescents who comprised each pattern. The findings provide novel and timely information for public health prevention campaigns as electronic nicotine delivery systems evolve and cannabis use laws become more liberalized.

METHODS

Study Sample

Participants were adolescents in the ninth grade taking part in a longitudinal cohort study of tobacco use. Participants were enrolled in 1 of 4 public high schools in suburban Philadelphia, Pennsylvania. The schools were selected such that the sample would be demographically representative of adolescents nationwide (sex, race, ethnicity, annual household income). The cohort participants were drawn from 2,198 students identified through complete class rosters at the beginning of ninth grade. Adolescents were ineligible to participate if they had a severe learning disability or did not speak fluent English. Based on the selection criteria, 2,017 of 2,198 (92%) students were eligible to participate.

Parents were mailed a study information letter (active information) with a telephone number to call to answer any questions and decline consent for their adolescent to participate (passive consent). Of the 2,017 eligible adolescents, 17 (1%) had a parent who actively declined their adolescent's participation. Adolescents with parental consent were approached to provide their written assent for study participation. Adolescents who were absent on the assent/baseline survey days (n=124, 6%) and adolescents who did not provide assent (n=41, 2%) owing to lack of interest were not enrolled in the cohort. Thus, 1,835 of the 2,000 adolescents with consent (92%) provided their assent to participate and completed a 40-minute paper-and-pencil survey. This baseline, or Wave 1, survey was completed on-site during compulsory classes in the fall of 2016.

Adolescents completed 6 paper-and-pencil follow-up surveys at 6-month intervals with 92% completing a survey at Wave 2 (n=1,687, spring 2017), 90% completing a survey at Wave 3 (n=1,658, fall 2017), 89% completing a survey at Wave 4 (n=1,643, spring 2018), 87% completing a survey at Wave 5 (n=1,601, fall 2018), 84% completing a survey at Wave 6 (n=1,538, spring 2019), and 83% completing a survey at Wave 7 (n=1,530, fall 2019). The participants included in this study are adolescents who completed the baseline survey (n=1,835). There were no differences in e-cigarette or cannabis use among adolescents retained compared to adolescents lost to follow-up. The IRB of the University of Pennsylvania and the administration of each of the 4 high schools approved the study. Data analyses were conducted in May 2021.

Measures

The survey included an introduction explaining what e-cigarettes are and the types of products or devices that are labeled as e-cigarettes. Images of different e-cigarette devices were provided to facilitate clarity.[18,19] From baseline (Wave 1) to Wave 3, these images included e-cigarettes, e-hookah, vape pens, and mods. Images of USB-style pod vaporizers were added at Wave 4. Excluding using an e-cigarette device for vaping marijuana, adolescents were asked: *Have you ever used an e-cigarette like the ones pictured above, even 1 or 2 times?* Adolescents who reported ever use of an e-cigarette were prompted to answer questions assessing lifetime frequency of e-cigarette use and time since last e-cigarette use. A subsequent question assessed whether the adolescent typically vaped e-cigarettes with nicotine, which the majority endorsed. An ordered categorical variable defined progression

in e-cigarette use: 0=never used; 1=used, but not in the past 6 months; 2=used in the past 6 months; and 3=used in the past 30 days. Current use was defined as using an e-cigarette on ≥1 day in the past 30 days.[14,20] E-cigarette use was measured in all 7 waves.

Adolescents who reported ever using an e-cigarette device to vape marijuana were prompted to answer a series of epidemiological questions assessing current use (i.e., use on ≥1 day in the past 30 days). Adolescents were asked: *Have you ever used an e-cigarette device like the ones pictured above to vape marijuana (plant, wax, oil, or THC), even 1 or 2 times?*[14,20] Adolescents who reported ever use were prompted to answer questions assessing use in the past 30 days. The following ordered categorical variable was created to define progression in cannabis vaping: 0=never used, 1=ever used, 2=used in the past 30 days. Cannabis vaping was measured in all 7 waves.

Demographic characteristics such as sex, race, and ethnicity were assessed at baseline using self-report items. These demographic variables were included in the model to characterize the sample.

Variables associated with nicotine and cannabis use were selected as risk factors.[5,21–24] Risk factors were selected to characterize the trajectories on e-cigarette access and support of use, motivation to use e-cigarettes, positive expectancies surrounding use, potential affective and dispositional vulnerability for substance use, and other tobacco and substance use. Peer e-cigarette use was measured by asking adolescents whether their best friend, 4 other best male friends, and 4 other best female friends use e-cigarettes.[25,26] If adolescents responded *yes* to either of these questions, they were prompted to answer how many. Household e-cigarette use was measured with the question: *Does anyone in your house use e-cigarettes?* (0=no household e-cigarette use, 1=at least 1 member).[25]

Perceived benefits of using e-cigarettes were measured with 12 items using a Likert scale (0=*strongly disagree* to 3=*strongly agree*). Items assessed available flavors, smell, affordability, impact on non-tobacco users, and substitution in smoke-free situations.[27–30] Positive expectations of e-cigarette use were measured with a 9-item Likert-style scale.[27,31,32] The items included*: I think vaping e-cigarettes would…give me something to do when I'm bored, …help me deal with problems or stress* (0=*strongly disagree* to 3=*strongly agree*).[27,33] The Centers for Epidemiology Studies of Depression scale (20 items) assessed depression symptoms over the past week (0=*rarely or none of the time* to 3=*most of the time*).[34–36] Sensation seeking was measured with the 8-item Brief Sensation Seeking Scale (0=*strongly disagree* to 4=*strongly agree*).[37]

Combustible cigarette smoking, cigar smoking (large cigar, little cigar, or cigarillo), and alcohol use were assessed by asking adolescents if they ever used these substances. Adolescents who indicated they had were then asked whether they had used them in the past 6 months (0=*no*, 1=*yes*).[14,38] Owing to low frequencies in past 6–month use, lifetime combustible cigarette smoking was modeled (0=never, 1=ever).

Statistical Analysis

First, the number of latent classes of nicotine vaping and cannabis vaping were determined with a sequential processes growth mixture model. This latent variable mixture modeling method identifies the latent (unobserved) classes representing the joint development of 2 behaviors across time through repeated measures.[39] The modeling began with assessing the average growth trajectory of cannabis vaping and the average growth trajectory of nicotine vaping with latent growth curve models. Then, latent variable mixture modeling was used to identify the optimal number of conjoint latent classes based on nicotine and cannabis vaping patterns. Given 2 processes, the total number of latent classes reflects the number of proposed latent classes for each behavior. Two classes for cannabis vaping and 2 latent classes for nicotine vaping were first considered, resulting in 4 possible latent classes. The Bayesian information criterion was used to identify the optimal number of conjoint classes, with lower values indicating a more optimal model.[40]

Second, the latent classes were treated as a dependent variable in a multinomial logistic regression to assess the likelihood of belonging to each specific conjoint class compared to the comparison class for a unit increase in each baseline predictor variable. M*plus*, version 8.3 was used to empirically identify the conjoint trajectories, and SPSS, version 28, was used to characterize class membership through multinomial logistic regression analysis. To account for missing data, M*plus* estimates mean, variance, and covariance parameters using a full information maximum likelihood estimating procedure that employs the expectation-maximization algorithm, when data are missing at random.

RESULTS

Conjoint classes were identified using a sequential processes growth mixture model. Models with 4 (Model 1) and 6 (Models 2 and 3) conjoint latent classes were identified. Two separate models for the 6-class option were run, 1 with 3 latent classes of nicotine vaping and 2 classes of cannabis vaping (3 X 2=6 classes; Model 2), and another with 2 classes of nicotine vaping and 3 classes of cannabis vaping (2 X 3=6; Model 3). The Bayesian information criterion values for Models 1 to 3 were 22356.07, 23073.13, and 23262.78, respectively. These results indicated that the 4-class model (2 nicotine vaping X 2 cannabis vaping=4) better represented the data. Further, the 6-class model included 3 latent classes with class sizes <5% of the sample. Based on the pattern of uptake (Appendix Table 1), the 4 latent classes were labeled based on changes in past 30–day use (Figure 1).

Almost 27% of adolescents in the Early, Declining Dual Use (Class 1: n=259) class were currently vaping nicotine, and 20% were currently vaping cannabis at baseline. Dual use steadily decreased to about 4% across the following 36 months. Almost 20% of adolescents in the Rapidly Increasing Dual Use (Class 2: n=128) class were vaping nicotine, and 8% were vaping cannabis at baseline. Six months later, adolescents in the group evidenced a rapid escalation in dual use, culminating in 66% currently vaping nicotine and 62% vaping cannabis. Adolescents in the Later, Slower Dual Use (Class 3: n=313) class did not vape either nicotine or cannabis at baseline. The percentage of adolescents currently vaping nicotine and currently vaping cannabis began to increase 6 and 12 months later, respectively.

Approximately 23% of adolescents reported dual use 36 months later. The No Use (Class 4: n=1,135) did not vape nicotine or cannabis.

Descriptive statistics for all model covariates are presented in Table 1 for the total sample and divided by latent class. Table 2 presents class characteristics resulting from the multinomial logistic regression analysis with the odds and 95% CIs of being in each class compared with No Use (Class 4). Appendix Table 2 provides data for Class 3 as the reference group.

The odds of belonging to Early, declining Dual-Use group (Class 1) compared to the No Use group (class 4) were examined. Non-Hispanic ethnicity (OR=0.58, 95% CI=0.41, 0.83) was associated with a 42% decrease in the odds of belonging to Class 1 versus Class 4. By contrast, ever smoking combustible cigarettes was associated with a nearly 4-fold increased odds of belonging to Class 1 versus Class 4 (OR=3.71, 95% CI=1.99, 6.93). Past 6–month use of alcohol was also associated with a >2.5-fold increased odds of belonging to Class 1 versus Class 4 (OR=2.55, 95% CI=1.69, 3.83). Peer vaping (OR=1.24, 95% CI=1.13, 1.35) was associated with a 24%, sensation seeking (OR=1.03, 95% CI=1.01, 1.06) with a 3%, and positive e-cigarette expectations (OR=1.21, 95% CI=1.15, 1.26) with a 21% increased odds of belonging to Class 1 versus Class 4.

The odds of belonging to the Rapidly increasing Dual-Use group (Class 2) compared to the No Use group (Class 4) were examined. Past 6–month use of alcohol was associated with a >4-fold increased odds of belonging to Class 2 versus Class 4 (OR=4.39, 95% CI=2.71, 7.11). Likewise, past 6–month cigar smoking (OR=2.39, 95% CI=1.05, 5.45) and ever smoking combustible cigarettes (OR=2.21, 95% CI=1.01, 4.82) were associated with >2-fold increased odds of belonging to Class 2 versus Class 4. Peer vaping (OR=1.20, 95% CI=1.08, 1.34) was associated with 20%, sensation seeking (OR=1.11, 95% CI=1.07, 1.15) with 11%, and positive e-cigarette expectations (OR=1.17, 95% CI=1.10, 1.24) with 17% increased odds of belonging to Class 2 versus Class 4.

The odds of belonging to the Later, slower Dual-Use group (Class 3) compared to the No Use group (Class 4) were examined. Black race compared with White race was associated with a 54% decrease in the odds of belonging to Class 3 versus Class 4 (OR=0.46, 95% CI=0.30, 0.70). By contrast, odds of belonging to Class 3 versus Class 4 were increased 66% by past 6–month use of alcohol (OR=1.66, 95% CI=1.11, 2.49), 3% by perceived benefits of e-cigarette use (OR=1.03, 95% CI=1.01, 1.06), 8% by positive expectations of e-cigarette use (OR=1.08, 95% CI=1.04, 1.12), 2% by depressive symptoms (OR=1.02, 95% CI=1.01, 1.04), and 3% by sensation seeking (OR=1.03, 95% CI=1.01, 1.06).

DISCUSSION

The present study provides new evidence for the co-development of nicotine and cannabis vaping from middle to late adolescence. Three of the 4 conjoint trajectories were composed of adolescents who vaped both nicotine and cannabis. Despite the paralleled use, onset, rate of progression, level of dual use, and risk factor profile varied across distinct adolescent

subgroups. The findings suggest that prevention efforts should mirror the developmental patterns and target nicotine and cannabis vaping to optimize prevention outcomes.

The fact that single-use trajectories (nicotine vaping only, cannabis vaping only) were not identified indicates that adolescents either vape both substances or neither. Vaping one of these substances may increase the willingness to vape the other, allowing neurobiological reward-related processes associated with using both substances to unfold.[41] Adolescents report similar reasons for preferring vaping as a method for consuming nicotine and cannabis. Vaping is smokeless, odorless, easier to conceal, and is perceived as healthier and less risky than other methods.[1,9,42]

Concerns have been raised that adolescents who might otherwise not use cannabis are more likely to vape cannabis, especially if they already vape nicotine.[43] Although campaigns such as “The Real Cost” have expanded to address the rise in nicotine vaping, cannabis vaping is not addressed.[44] The high rates of dual use suggest that prevention efforts may be more efficacious if both substances are addressed. Preventing escalation to regular dual use would have a significant public health impact as the cessation outcomes for adults who use both tobacco and cannabis are poor.[41]

The findings also highlight potential content for dual use prevention programming by identifying shared risk factors among the dual use classes. Though the level of risk that these factors carried varied across the dual use classes, sensation seeking, peer use, positive expectations of use, and other substance use (combustible tobacco, alcohol) should be targeted in dual use prevention programming. Indeed, greater sensation seeking, alcohol, and other combustible tobacco use discriminated between the faster and slower uptake classes in supplementary analyses. Although unique to the Later, Slower Dual Use class, depression symptoms and perceived benefits of e-cigarette use may be important variables for preventing later progression to dual use. These unique risk factors characterize a group that is more likely to be White than another race.

Adolescents in the Rapidly Increasing Dual Use class evidenced a rapid escalation in dual use, culminating in 66% currently vaping nicotine and 62% vaping cannabis 36 months later. Although co-administration of cannabis and nicotine was not assessed, it is possible that co-administration facilitated the rapid escalation in dual use. Fourteen percent of adolescents who have used an e-cigarette report simultaneously mixing nicotine and cannabis in their vaporizer devices, likely increasing the reinforcing effects that foster dependence on both substances.[11,15,45]

Despite having similar risk factors, adolescents in the Early, Declining Dual Use class showed a steady decrease in dual use. These risk factors may have lessened over time, or these adolescents may have had factors protective of continued use that were not measured. Future research may seek out these explanations of why some adolescents discontinue nicotine and cannabis vaping while others remain users.

As the first study to examine the unique patterns and predictors of dual nicotine and cannabis vaping, the study has strengths and limitations. Study strengths include a diverse sample of adolescents measured during a vulnerable period for substance use, excellent

participation and retention rates, modeling of nicotine and cannabis vaping across 7 timepoints, and the inclusion of varied risk factors to characterize the adolescent subgroups. Future longitudinal research should examine how adolescents are vaping nicotine and cannabis (e.g., sequential use, concurrent use, co-administration) to further understand dual use trajectories and the associated prevention intervention implication.[51]

Limitations

One potential limitation is that the data were derived from 4 different school districts within a 60-mile radius of Philadelphia. Although Pennsylvania's tobacco control policies do not differ from most states, only cannabis for medicinal purposes has been legalized,[46,47] including vaporizable forms via dispensaries.[48] The results may not generalize to all adolescents across the U.S., especially in states with different cannabis policies. In addition, the measures of nicotine vaping and cannabis vaping were based on self-report. Adolescent self-report of substance use in epidemiological studies is valid and reliable, especially when confidentiality is emphasized, the substances are more socially acceptable, and reporting is not interviewer-based.[49,50]

CONCLUSIONS

From middle to late adolescence, vaping of nicotine and cannabis develop in close parallel. Regulatory policy and prevention interventions should consider the interplay between these 2 substances during this period of adolescence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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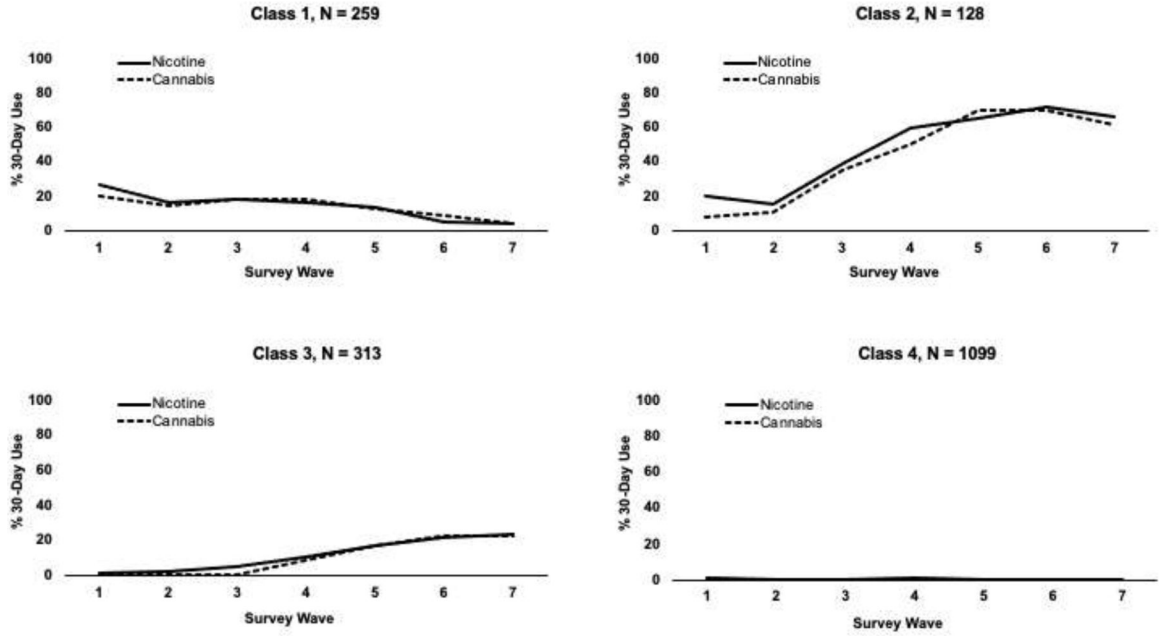

Figure 1.
Conjoint trajectories of nicotine and cannabis vaping.

Table 1.

Descriptive Statistics for the Total Sample and by Class

Variable	Total	Class 1	Class 2	Class 3	Class 4
Sex, n (%)					
Male	923 (50.3)	135 (52.1)	68 (53.1)	138 (44.1)	582 (51.3)
Female	912 (49.7)	124 (47.9)	60 (46.9)	175 (55.9)	553 (48.7)
White, n (%)					
Yes	1,335 (72.8)	172 (66.4)	101 (78.9)	261 (83.4)	801 (70.6)
No	500 (27.2)	87 (33.6)	27 (21.1)	52 (16.6)	334 (29.4)
Black, n (%)					
Yes	265 (14.4)	47 (18.1)	15 (11.7)	29 (9.3)	174 (12.3)
No	1,570 (85.6)	212 (81.9)	113 (88.3)	284 (90.7)	961 (84.7)
Other, n (%)					
Yes	235 (12.8)	31 (12.0)	11 (8.6)	29 (9.3)	164 (14.4)
No	1,600 (87.2)	228 (88.0)	117 (91.4)	284 (90.7)	971 (85.6)
Hispanic, n (%)					
Yes	381 (20.8)	91 (35.1)	19 (14.8)	59 (18.8)	212 (18.7)
No	1,454 (79.2)	168 (49.9)	109 (85.2)	254 (81.2)	923 (81.3)
Household e-cigarette use, n (%)					
Yes	233 (12.7)	59 (22.8)	26 (20.3)	43 (13.7)	105 (9.2)
No	1,602 (87.3)	200 (77.2)	102 (79.7)	270 (86.3)	1,030 (90.8)
Cigars, n (%)					
Yes	97 (5.3)	45 (17.4)	29 (22.7)	9 (2.9)	14 (1.2)
No	1,738 (94.7)	214 (82.6)	99 (77.3)	304 (97.1)	1,121 (98.8)
Combustible cigarettes, n (%)					
No	1,711 (93.2)	195 (75.3)	102 (79.7)	300 (95.8)	1,114 (98.2)
Yes	124 (6.8)	64 (24.7)	25 (20.3)	13 (4.2)	21 (1.8)
Alcohol, n (%)					
No	1,532 (83.4)	160 (61.8)	60 (46.9)	258 (82.4)	1,053 (92.8)
Yes	304 (16.6)	99 (38.2)	68 (53.1)	55 (17.6)	82 (7.2)
Peer e-cigarette use, mean (SD)	0.69 (1.75)	1.93 (2.76)	1.65 (2.36)	0.66 (1.55)	0.31 (1.16)
Perceived benefits of e-cigarette use, mean (SD)	12.79 (5.83)	15.97 (5.47)	15.19 (5.67)	13.61 (5.19)	11.57 (5.70)
Depressive symptoms, mean (SD)	18.29 (9.38)	19.96 (11.65)	21.08 (10.82)	19.90 (8.74)	17.15 (8.59)
E-cigarette positive expectations, mean (SD)	6.57 (4.38)	10.44 (4.20)	9.65 (4.48)	6.88 (4.16)	5.25 (3.71)
Sensation seeking, mean (SD)	13.94 (7.11)	16.67 (7.05)	19.58 (6.00)	15.23 (6.72)	12.34 (6.75)

Notes: Covariate values are as follows: Sex (1=female), Race dummy coded with White as reference group (Black, 0=No 1=Yes; Other, 0=No 1=Yes), Ethnicity (0=Hispanic, 1=Non-Hispanic), Cigarette smoking (0=Never, 1=Ever), Alcohol use (past 6 months, 0=No 1=Yes), Cigar smoking (past 6 months, 0=No 1=Yes). Possible score range for following variable in parentheses: peer e-cigarette use (0−9), perceived benefits of e-cigarette use (0−36), e-cigarette positive expectations (0−27), depressive symptoms (0−60), sensation seeking (0−32).

Table 2.

Multinomial Logistic Regression Analysis Comparing Each Class to Class 4

Covariate	B	OR (95% CI)
Class 1 versus Class 4		
Sex	−0.01	0.99 (0.71, 1.38)
Black race	−0.13	0.88 (0.57, 1.34)
Other race	−0.12	0.89 (0.55, 1.46)
Non-Hispanic	−0.54	**0.58** ** (0.41, 0.83)
Peer e-cigarette use	0.21	**1.24** *** (1.13, 1.35)
Household e-cigarette use	−0.05	0.95 (0.61, 1.51)
Depressive symptoms	0.01	1.01 (0.99, 1.02)
Sensation seeking	0.03	**1.03** * (1.01, 1.06)
Cigarette smoking	1.31	**3.71** *** (1.99, 6.93)
Perceived e-cigarette benefits	0.03	1.03 (0.99, 1.06)
Positive e-cigarette expectations	0.19	**1.21** *** (1.15, 1.26)
Alcohol use	0.93	**2.55** *** (1.69, 3.83)
Cigar use	0.54	1.72 (0.80, 3.69)
Class 2 versus Class 4		
Sex	−0.11	0.90 (0.58, 1.38)
Black race	−0.52	0.60 (0.32, 1.11)
Other race	−0.31	0.73 (0.36, 1.48)
Non-Hispanic	0.55	1.74 (0.99, 3.05)
Peer e-cigarette use	0.18	**1.20** ** (1.08, 1.34)
Household e-cigarette use	−0.14	0.87 (0.49, 1.55)
Depressive symptoms	0.01	1.01 (0.99, 1.03)
Sensation seeking	0.10	**1.11** *** (1.07, 1.15)
Cigarette smoking	0.79	**2.21** * (1.01, 4.82)
Perceived e-cigarette benefits	−0.01	0.99 (0.95, 1.04)
Positive e-cigarette expectations	0.16	**1.17** *** (1.10, 1.24)
Alcohol use	1.48	**4.39** *** (2.71, 7.11)
Cigar use	0.87	**2.39** * (1.05, 5.45)
Class 3 versus Class 4		
Sex	0.21	1.23 (0.94, 1.61)
Black race	−0.78	**0.46** *** (0.30, 0.70)
Other race	−0.49	**0.61** * (0.40, 0.94)
Non-Hispanic	0.09	1.09 (0.78, 1.53)
Peer e-cigarette use	0.08	1.09 (0.99, 1.20)
Household e-cigarette use	−0.02	0.98 (0.65, 1.48)
Depressive symptoms	0.02	**1.02** * (1.01, 1.04)

Covariate	B	OR (95% CI)
Sensation seeking	0.03	**1.03** ** (1.01, 1.06)
Cigarette smoking	0.22	1.25 (0.58, 2.72)
Perceived e-cigarette benefits	0.03	**1.03** * (1.01, 1.06)
Positive e-cigarette expectations	0.07	**1.08** *** (1.04, 1.12)
Alcohol use	0.51	**1.66** * (1.11, 2.49)
Cigar smoking	−0.13	0.88 (0.35, 2.23)

Notes: Covariate values are as follows: Sex (1=female), Race dummy coded with White as reference group (Black, 0=No 1=Yes; Other, 0=No 1=Yes), Ethnicity (0=Hispanic, 1=Non-Hispanic), Cigarette smoking (0=Never, 1=Ever), Alcohol use (past 6 months, 0=No 1=Yes), and Cigar smoking (past 6 months, 0=No 1=Yes). Boldface indicates statistical significance

* $p<0.05$;

** $p<0.01$;

*** $p<0.0001$.