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Obesity and Cigarette Smoking: Extending the Link to E cigarette/Vaping Use

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Abstract

Objectives—In recent years, electronic tobacco (e-cigarette/vaping) use among young adults has grown exponentially. Given past research linking obesity and cigarette smoking, assessing whether this relationship extends to electronic tobacco use is warranted. The current study examined weight status as a correlate of substance use patterns reflecting electronic tobacco use.

Methods—Survey data were collected from a convenience sample of 452 (59% female) undergraduates attending a large, public university during the 2015–2016 academic year. Latent class analysis (LCA) was conducted to identify substance use classes and examine weight status as a covariate of class membership.

Results—LCA analyses identified 4 classes: High Substance Use (19%), Risky Alcohol Use (14%), Cigarette/Electronic Tobacco Use (17%), and Low Substance Use (50%). Both obesity status and greater deviation from one's group body mass index (BMI) norm were associated with a higher likelihood of belonging to the Cigarette/Electronic Tobacco Use class.

Conclusions—Findings suggest that electronic tobacco use may fit well into previously established relationships between higher weight status and tobacco use. Future research should examine the longitudinal processes and pathways underlying the relationship between weight status and electronic tobacco use.

Keywords

body mass index; e-cigarette; electronic tobacco; obesity; vaping; weight status

Electronic tobacco (also known as electronic nicotine delivery systems) use among young adults in the United States (US) has grown exponentially in recent years.^{1,2} Prevalence rates indicate that between 22% and 30% of US young adults report lifetime electronic tobacco use and 5% to 9% are current electronic tobacco users.^{3,4} Although studies have reported a robust relationship between cigarette smoking and electronic tobacco use among younger populations,^{5–9} it is unclear whether co-occurring health risks of traditional tobacco use can

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Human Subjects Statement

The study was approved by the California State University, Long Beach Institutional Review Board (IRB# 15-288).

Conflict of Interest Statement

The authors report no conflict of interest.

be extended to electronic tobacco use. For instance, the link between higher weight status (obesity) and cigarette smoking among adolescents and young adults has gained significant have shown that indicators of higher weight status co-occur with and predict cigarette smoking;^{10–14} however, no study to date has assessed whether this relationship extends to electronic tobacco use. As electronic tobacco use grows in popularity and becomes more socially normative in younger populations,^{15–18} it is critical to address whether high-impact health risks, like obesity, are significantly linked to its use. In the current study, we sought to expand the work on weight status and tobacco use among young adults by examining weight status as a correlate of substance use patterns reflecting electronic tobacco use.

Since their introduction into the US market toward the end of the first decade of the 21st century, electronic tobacco products (eg, e-cigarettes, vaporizers, e-hookahs) have surged in popularity.^{1,2} Electronic tobacco use is most prevalent and growing at a faster rate among younger populations. attention in the past decade. Studies^{15–18} Unlike older adults that generally use electronic tobacco as a smoking cessation method,^{19,20} younger adults' motivations for use are linked to recreation/enjoyment and socializing with peers.^{7,8,21,22} These motivations for use may explain why electronic tobacco use has surged in popularity among young adults like college students, with rates of ever electronic tobacco use in college students estimated to be between 28% and 44%.^{5,8,17,23} Given the public health concern over electronic tobacco use among younger populations, identifying co-occurring health-risk behaviors of electronic tobacco use has become an important research objective.

Although electronic tobacco research is in a burgeoning period, there is already large agreement across studies that electronic tobacco use co-occurs significantly with cigarette smoking among young adults.^{5–9} In fact, some studies have reported that electronic tobacco use contributes to continued cigarette smoking among young adults.^{8,23} In contrast, fewer studies have examined the link between electronic tobacco use and alcohol use among young adults, and available studies on young adults are inconclusive. Littlefield et al¹⁷ reported that e-cigarette use was related to increased risk of binge drinking compared to non-nicotine use; however, Sutfin et al⁷ did not find e-cigarette users had higher rates of binge drinking. Hershberger et al²⁴ found that e-cigarette use was predictive of problematic alcohol use, but their sample did not differentiate young adults from other adults. To expand on previous research aimed at understanding co-occurring health risks of electronic tobacco use, the current study utilized person-centered analyses to identify patterns of alcohol use, cigarette smoking, and electronic tobacco use among young adults.

Beyond examining co-occurrence with alcohol use and cigarette smoking, the robust relationship between electronic tobacco use and cigarette smoking suggests that other health risks associated with cigarette smoking may also extend to electronic tobacco use. Numerous cross-sectional^{25,26} and longitudinal^{10–14} studies have shown that higher weight status or obesity is linked to problematic cigarette smoking. In contrast, these studies have shown that associations between higher weight status and alcohol use are weak. Although the processes and pathways underlying the co-occurrence between higher weight status and tobacco use is not yet clear, it is hypothesized that both socio-contextual and physiological factors play a role. For instance, higher weight status may increase vulnerability to tobacco and electronic tobacco use through stress and depressive symptoms brought on by weight

stigma and poor peer relationships.^{27,28} Moreover, researchers have reported that young adults perceive electronic tobacco use as a useful socialization tool.^{7,8,10} Furthermore, physiological links between obesity and tobacco use, specifically the shared dopaminergic neurological response activated by food and nicotine ‘rewards’^{29–31} may explain behaviors like using tobacco as a weight loss strategy. Due to the rising popularity of electronic tobacco use and its significant co-occurrence with cigarette smoking, examining whether the relationship between weight status and tobacco use extends to electronic tobacco use is warranted.

The key aim of the current study was to determine whether weight status is linked to substance use patterns that include electronic tobacco use. Two different weight status indicators were used to assess whether the conceptualization of ‘higher’ weight status may impact the association between weight status and electronic tobacco use. In addition to using a dichotomous measure of obesity status, we also included a more nuanced measure of weight status, deviation from one’s ethnic and gender body mass index (BMI) norm. The primary purpose of including both obesity status and a BMI deviation score was to examine whether weight status conceptualizations outside of simple clinical cut-off criteria could be useful in explaining the relationship between weight status and co-occurring tobacco use. Social norms frameworks have posited that group norms may have potentially significant impacts on health behavior.³² Given that ethnic and gender disparities in obesity and BMI are prevalent across childhood into adulthood,^{33,34} and the fact that ethnicity and gender are salient markers of one’s identity,³⁵ how persons deviate from their ethnic and gender group’s BMI norm may have a greater impact on their health-risk behavior than just meeting or not meeting obesity status.³⁶ The BMI deviation score could potentially identify social processes underlying co-occurring health-risk behaviors.

Using an ethnically-diverse sample of US young adults attending a large, public university, our study had 2 aims. First, the study incorporated electronic tobacco use into a person-centered approach to identify patterns of alcohol use, cigarette smoking, and electronic tobacco use. Second, the study assessed whether higher weight status indicators would be associated with membership in classes reflecting cigarette smoking and electronic tobacco use. Considering previous research, it was expected that electronic tobacco use and cigarette smoking would co-occur in substance use classes, and that higher weight status indicators would be associated with a class reflecting cigarette smoking and electronic tobacco use, but not alcohol use.

METHODS

Design Overview

The study utilized cross-sectional survey data collected during the 2015–2016 academic year from a convenience sample of undergraduates attending California State University, Long Beach, a large, public university.

Participants

The study included data from 452 young adults enrolled as undergraduates at California State University, Long Beach, a large, public university in an urban region of the US. Participants were eligible for the study if they were 18 years or older and an enrolled undergraduate at the university. The sample closely reflected the gender and ethnic composition of the university's undergraduate population. Participants in the study included (university Fall 2015 statistics in parentheses): 59.1% (56.2%) female; 36.9% (39.0%) Hispanic/Latino, 26.3% (23.4%) Asian/Pacific Islander, 17.9% (18.7%) Caucasian/White, 4.9% (3.8%) African American/Black, 5.1% (4.8%) Multiracial; 2.1% (3.6%) other, 0.2% (0.2%) Native American, and 6.6% declined to respond. At the time the survey was implemented, US Census Bureau estimates indicated that California's population was 50.3% female; 38.8% Hispanic/Latino, 38.0% Caucasian/White, 12.3% Asian/Pacific Islander, 6.5% African American/Black, 3.8% Multiracial, and 1.7% Native American.³⁷ The average age of participants was 21.3 years $\pm$ 2.6 (median = 21.0 years). In terms of residence, just over half (52.7%) of participants were living with their parents, 32.5% with roommates, 3.8% with a significant other, and 2.8% alone. Just over a third (36.3%) of participants were transfer students from community colleges. The average time in college was 3.44 years $\pm$ 1.79, and the average time at California State University, Long Beach was 2.44 years $\pm$ 1.53. Participants represented a wide range of majors, including: 11.1% Engineering; 10.5% Psychology; 8.2% Human Development; 7.7% Biological/Life Sciences; 7.7% Communications; 6.4% Business; 5.1% Health Science; 4.4% Kinesiology; 4.0% Nursing; and 3.3% Sociology.

Procedure

During the 2015–2016 academic year, participants were recruited across public space on campus to complete a 15-minute survey on health-risk behaviors. The survey was comprised of 118 questions pertaining to electronic tobacco use, alcohol use, cigarette smoking, nutrition and physical activity, and psychosocial adjustment. Twenty-four data collections were conducted across 6 designated public spaces on campus from September 2015 to March 2016. Individuals that either showed interest in the study banner (advertisement) or greeted research assistants were recruited to participate. Interested and eligible participants completed a written informed consent form and then were administered a survey on an electronic tablet. Participants sat at a table with partitions for privacy, and survey responses were anonymous. A \$10 gift card (choice of Amazon, iTunes, Starbucks, Target) was given for participation in the study. Although 469 participants completed the survey, 17 were excluded from analyses due to technical errors with the electronic tablets or the high likelihood of being a duplicate response.

Measures

Demographic characteristics—Participants reported their age in years, sex (1 = female, 0 = male), and race/ethnicity. Race/ethnicity variables for African American/Black, Asian/Pacific Islander, Caucasian/White, and Hispanic/Latino, were dummy coded (eg, 1 = African-American/Black, 0 = non-African-American/Black).

Obesity status—Participants self-reported height and weight, which was used to calculate body mass index (BMI; $\text{weight}(\text{lbs})/[\text{height}(\text{in})^2 \times 703]$). Those with a BMI score ≥ 30 were identified as obese (1 = obese, 0 = non-obese) as recommended by the US Centers for Disease Control and Prevention (https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/).

Deviation from group BMI norm—A deviation, or difference, score was calculated to determine the degree to which each participant deviated from his/her ethnic and gender group's BMI norm. The BMI deviation score was calculated by subtracting a participant's ethnic and gender group mean BMI score from the participant's BMI score. Positive scores indicated greater deviation from the BMI group norm in the direction of obesity status, and negative scores indicated greater deviation from the BMI group norm in the direction of underweight status.

Substance use—Several items on alcohol use, cigarette smoking, and electronic tobacco use were selected to identify latent classes of substance use. Alcohol and cigarette smoking items were based on interview questions from The National Longitudinal Study of Adolescent to Adult Health (Add Health), a well-established and validated study on a nationally representative sample of US adolescents followed into adulthood.³⁸ Participants were asked questions related to binge drinking and being drunk: (1) "Have you ever drank more than 5 drinks in one sitting?" (more than 4 drinks for females; 1 = yes, 0 = no); (2) "In the past 30 days, how many times have you consumed 5 or more drinks in one sitting?" (4 or more drinks for females) and (3) "In the past 30 days, how many times have you been drunk?" Response choices for the last 2 questions ranged from 1 = never to 5 = often (more than 7 times), and were recoded to 1 = engaging in behavior and 0 = not engaging in behavior because less than 5% of responses were above 'a couple of times'.

Participants were then asked questions related to cigarette smoking and electronic tobacco use: (1) "Have you ever smoked a cigarette?" (1 = yes, 0 = no); (2) "In the past month, have you smoked cigarettes regularly (at least 5 times in the last 30-day period)?" (1 = yes, 0 = no); and (3) "Have you ever smoked cigarettes regularly (at least 5 times in a 30-day period)?" which was used to create a former cigarette smoker variable (1 = yes, 0 = no) by comparing responses from question 3 to question 2. Because there was no available validated questionnaire on young adult electronic tobacco use at the time of survey development and implementation, questions on electronic tobacco use were developed for this specific study. Two questions on prevalence included: (1) "Have you ever tried an electronic tobacco product (like e-cigarettes, vaporizers, e-hookahs)?" (1 = yes, 0 = no); and (2) "Would you consider yourself a regular user of any electronic tobacco product, like e-cigarettes, vaporizers, or e-hookahs?" (1 = yes, 0 = no).

Statistical Analysis

Latent class analysis (LCA) was conducted to identify classes of participants based on alcohol use, cigarette smoking, and electronic tobacco use, and examine indicators of weight status as covariates of substance use classes. In LCA underlying patterns of observed categorical variables are used to classify individuals with similar behaviors, characteristics,

or responses into latent classes.^{39,40} Predictors of class membership (covariates) can also be estimated. LCA utilizes an iterative process using full information maximum likelihood estimation.

The 3-step approach developed by Vermunt⁴¹ and popularized by Asparouhov and Muthén⁴² was utilized to examine covariates of the identified substance use classes. In the first step, the best fitting substance use class model was identified using indicators of alcohol use, cigarette smoking, and electronic tobacco use. The optimal model was selected based of statistical indices, parameter estimates, and practical implications.⁴³

The second step of the LCA involved creating a most likely class variable using the latent class posterior probabilities obtained in step 1. Logits reflecting the classification uncertainty rate were also obtained, which were applied in the third step of the analysis to account for measurement error in the most likely class variable. Covariates were included here as auxiliary variables to be saved in the dataset for use in the final step.

In the third and final step, the most likely class variable was used to assess covariates of the substance use classes while accounting for measurement error in classification.

Demographic variables and weight status indicators were examined as covariates of the substance use classes. Analyses were conducted using Mplus version 7.4.⁴⁴

RESULTS

Descriptives

Table 1 presents descriptive statistics for the sample, and compares obese versus non-obese participants on demographic and substance use variables. Across the sample, 10.8% of participants met obesity status. In comparison, findings from the Behavioral Risk Factor Surveillance System (BRFSS), a population-based health behavior survey, reported the 2015 obesity rate among young adults 18–24 years in California at 13.6%.⁴⁵ Almost 60% of the sample reported ever binge drinking, and around one-third reported binge drinking or being drunk in the past month. Given that 199 (44.0%) of participants were not of legal drinking age (21 years), chi-square tests were performed to determine whether those under 21 years were less likely to report alcohol use, possibly due to under-reporting. Chi-square tests indicated no significant differences between participants under age 21 versus 21 years or older on past month binge drinking or being drunk, but participants under 21 years old were significantly less likely than those 21 years or older to report ever binge drinking (47.5% vs 72.8%, respectively; $\chi^2 = 29.28$, $p < .001$). At the time of data collection, the legal age to purchase and consume tobacco products in California was 18 (it was increased to age 21 in June 2016). About 40% of participants had tried cigarette smoking; 8% reported being a current regular smoker and 8% indicated being a former regular smoker. Almost 40% (39.8%) of the sample had engaged in electronic tobacco use, and 5% self-identified as a regular electronic tobacco user. In comparison, findings from a nationally representative sample of young adults (19–28 years) taken from the Monitoring the Future (MTF) survey reported 30.3% of young adults have tried electronic tobacco use.⁴

Chi-square and t-tests used to assess differences between obese versus non-obese participants revealed no significant cigarette smoking, and electronic tobacco use indicators. Latino/Hispanic participants were significantly more likely to be obese than non-obese, and Asian/Pacific Islanders were significantly less likely to be obese than non-obese. Obese participants were significantly older than non-obese participants.

Latent Class Analysis

Model selection—LCA was conducted to identify latent classes of substance use based on indicators of alcohol use, cigarette smoking, and electronic tobacco use. First, the unconditional model (ie, one-class model) was specified to be used as a comparison for an increasing number of classes. An increasing number of classes were evaluated until the models specified no longer replicated the best maximum log-likelihood value. Commonly used statistical fit indices (presented in Table 2) were assessed for 5 classes (the sixth-class model did not replicate). Statistical indices, including the Bayesian Information Criterion (BIC)⁴⁶ and the Lo-Mendell-Rubin likelihood ratio test (LMR LRT),⁴⁷ as well as interpretability of classes, were used in determining model selection. The fit indices indicated that the 4-class model was likely the optimal model. The BIC and adjusted BIC indices were lowest for the 4-class model, and the LMR LRT indicated that the 4-class model fit better than the 3-class model, and the 5-class model did not fit any better than the 4-class model. A closer analysis of the parameter estimates of the 3-, 4-, and 5-class models corroborated the 4-class model was the best-fitting class model. Participants in the 4-class model had the most homogenous response patterns within classes and classes were distinct from each other. The 4 classes identified were also conceptually meaningful and each represented a significant proportion of the sample. To note, because less than 5% of participants endorsed the item on self-defined regular electronic tobacco use, “Would you consider yourself a regular user of any electronic tobacco product, like e-cigarettes, vaporizers, or e-hookahs?” it was difficult to identify its pattern of response across classes; consequently, it was removed from LCA analyses.

Identified classes—Item-response probabilities for each class of the 4-class model are presented in Figure 1. Three of the 4 classes reflected more problematic substance use. Students in the High Substance Use class (Class 1; 16.8%) represented the highest endorsement of alcohol, tobacco, and electronic tobacco use. All participants in this class reported binge drinking and being drunk in the past month. All participants had tried cigarette smoking (40% were current or former regular smokers), and almost 80% had tried electronic tobacco products. In Class 2, labeled Risky Alcohol Use (14.1%), most participants reported recent binge drinking and drunk behaviors but virtually none reported cigarette smoking. Ever electronic tobacco use was less than 30%, compared to the 70%–80% observed in the High Substance Use and Cigarette/Electronic Tobacco classes. The Cigarette/Electronic Tobacco class (Class 3; 19.0%) was comprised of participants that endorsed tobacco and electronic tobacco use, but had low endorsement of alcohol use. Almost all students reported cigarette smoking, and the Cigarette/Electronic Tobacco class had the highest proportion of current or former smoking (42%). Over 70% had also tried electronic tobacco products. Compared to the Risky Alcohol and High Substance Use classes, alcohol use was low. Last, about half (50.1%) of participants were classified into a

Low Substance Use class (Class 4) reflecting low endorsement of alcohol, tobacco, and electronic tobacco use. The clear majority of participants had neither engaged in recent binge drinking or drunk behavior (less than 30% reported any past binge drinking) nor tried cigarette smoking. In addition, less than 20% had tried electronic tobacco products.

Predictors of class membership—Using the 3-step approach for examining covariates in latent class models,^{38,39} covariates were included in the 4-class model to determine whether obesity status or deviation from the group BMI norm would be associated with particular substance use classes. Covariates included age, sex, race/ethnicity (Caucasian/white vs non-Caucasian/white), obesity status (obese vs non-obese), and deviation from the group BMI norm. Multinomial logistic regression was first conducted with the Low Substance Use class (Class 4) as the reference class (Table 3), and then repeated with each class as the reference to evaluate all pairwise comparisons (weight status findings for each comparison are presented in Table 3).

Both indicators of weight status, obesity and deviation from the group BMI norm, were generally associated with membership in the Cigarette/Electronic Tobacco class. Obese participants had a higher likelihood of belonging to the Cigarette/Electronic Tobacco class compared to the High Substance Use ($\beta = 1.48$, OR = 4.40, $p < .05$) and Risky Alcohol Use ($\beta = 1.94$, OR = 6.97, $p < .05$) classes; however, higher likelihood of being classified into the Cigarette/Electronic Tobacco class compared to the Low Substance Use class was only marginally significant ($\beta = 1.29$, OR = 3.63, $p = .07$). Greater deviation from the group BMI norm significantly predicted higher likelihood of belonging to the Cigarette/Electronic Tobacco class compared to the Low Substance Use ($\beta = .11$, OR = 1.11, $p < .05$) and High Substance Use ($\beta = .11$, OR = 1.12, $p < .05$) classes; but a higher likelihood of belonging to the Cigarette/Electronic Tobacco class compared to the Risky Alcohol Use class was only marginally significant ($\beta = .11$, OR = 1.11, $p = .06$).

As for the other predictors of class membership (see Table 3 for statistical values using the Low Substance Use class as a reference), older students were more likely to be classified into the High Substance Use and Cigarette/Electronic Tobacco classes than the Low Substance Use and Risky Alcohol use classes. Females were less likely than males to be classified in the High Substance Use compared to any other class. Caucasian/white students were more likely to be classified into the High Substance Use and Cigarette/Electronic Tobacco classes than the Low Substance Use class.

DISCUSSION

Given the rapid growth and popularity of electronic tobacco use among US young adults,^{1,2} it is critical to examine the co-occurrence of electronic tobacco use with other health-risk behaviors, including those that have been associated with traditional forms of tobacco use. The current study is the first to incorporate an indicator of electronic tobacco use into the relationship between weight status and tobacco use. Ever electronic tobacco use was prominently reflected in 2 substance use classes – the Cigarette/Electronic Tobacco class and the High Substance Use class. These findings indicated that ever electronic tobacco use was strongly linked to cigarette smoking, but only some young adults that had tried electronic

tobacco use reported co-occurring risky alcohol use. The study hypothesized that higher weight status would predict a greater likelihood of belonging to substance use classes reflecting cigarette smoking and electronic tobacco use. Indeed, both weight status indicators (obesity and deviation from the group BMI norm) were uniquely associated with membership in the Cigarette/Electronic Tobacco class. It does appear that the relationship between obesity and cigarette smoking may extend to electronic tobacco use among young adults.

Our findings corroborate previous research that has established a strong relationship between cigarette smoking and electronic tobacco use.⁵⁻⁹ Both classes reflecting problematic cigarette smoking (Cigarette/Electronic Tobacco and High Substance Use) were comprised of high rates of ever electronic tobacco use as well. The identified classes also suggest that ever electronic tobacco use co-occurs with risky alcohol use, but only for a subset of those that have tried electronic tobacco use (ie, High Substance Use class). Utilizing a person-centered approach by identifying patterns of substance use behaviors versus conducting variable-centered analyses was a key strength of this study, as results may inform why findings on co-occurring electronic tobacco use and risky alcohol use have been inconsistent. Young adults that have tried electronic tobacco use are not likely to be a homogenous group when it comes to co-occurring substance use. Some appear to be engaging in cigarette smoking without risky alcohol use, whereas others are engaging in both cigarette smoking and risky alcohol use.

In addition, the use of a person-centered approach highlights a unique relationship between weight status and cigarette smoking/electronic tobacco use that is overlooked by variable-centered approaches focused on average group differences. The average group differences shown in Table 1 indicate that substance use behaviors do not vary significantly between obese and non-obese participants, suggesting that weight status is not linked to substance use, including ever electronic tobacco use. However, the utilization of a person-centered approach showed that both weight status indicators, obesity status and deviation from the group BMI norm, were significantly associated with a higher likelihood of membership in the Cigarette/Electronic Tobacco class compared to the other classes. There were small discrepancies between the weight status indicators, but generally both were linked to the substance use class characterized by problematic cigarette smoking and ever electronic tobacco use, but without risky alcohol use. This finding was in line with past research reporting co-occurrence between higher weight status (eg, obesity) and cigarette smoking, but weak associations with alcohol use.¹²⁻¹⁴ Furthermore, finding that although deviation from the group BMI norm was hypothesized to be a more robust correlate of a cigarette smoking/electronic tobacco class than obesity status alone, the fact both weight status indicators were specifically linked to membership in the Cigarette/Electronic Tobacco Use class increases confidence that higher weight status and cigarette smoking/electronic tobacco use are co-occurring health-risk behaviors. The unique association between weight status and the Cigarette/Electronic Tobacco Use class emphasizes the need for further studies examining the relationship between weight status and electronic tobacco use in younger populations.

Several limitations need to be considered. First, the study is cross-sectional; consequently, associations between health risks were assessed but the impact and directionality of health

risks, particularly higher weight status and electronic tobacco use, is not yet known. Second, the study is based on a non-probability sample of young adults in college. Although the sample is ethnically diverse and represents a wide range of majors, participants were not randomly sampled and a college sample lacks generalizability to community samples of young adults. The sample represented state population sex and race/ethnicity demographics, but it is important to note the sample was comprised of a higher percentage of Asian/Pacific Islanders and lower percentage of Caucasians/Whites. Even so, given that college students are known for initiating and developing substance use trends,^{48,49} as well as experiencing major life transitions that leave them vulnerable to risky behavior,^{50,51} there is a benefit to examining questions related to electronic tobacco use among college students. Third, the study relied on self-reported height and weight to obtain BMI. Although there is evidence that obese individuals underestimate their weight more than non-obese counterparts,^{52,53} past research also has reported a strong correlation between self-reported and direct measurement of BMI.^{54,55} Additionally, it is likely that the BMI deviation score was able to capture at least some participants that were excluded from obesity status due to underreporting weight, but different enough from their group BMI norm to be identified as deviating in weight status. Fourth, substance use behaviors were self-reported, which may have resulted in the underreporting of such behaviors due to social desirability or fear of legal consequences (for participants reporting alcohol use under 21 years). Although past-month binge drinking and being drunk did not differ between those under 21 years and 21 years or older, the rate of ever binge drinking was lower in participants under 21 years; thus, respondents not of legal drinking age may have underreported binge drinking behavior. To prevent issues of underreporting, the survey was kept separate from the written informed consent; it was completely anonymous and collected on an electronic tablet through an online service provider. Also, more sensitive questions related to marijuana use or other illicit drug use, including prescription drug abuse, were not asked. Last, the survey was limited in the fact that it did not provide information on specific frequency and duration of electronic tobacco use. However, because no study to date has assessed the relationship between weight status and electronic tobacco use to any degree, the inclusion of ever electronic tobacco use in this study is useful for ascertaining whether this research should be expanded. Although a study with more refined measures of electronic tobacco use clearly is needed, in addition to conducting longitudinal work on a more representative sample of young adults, the present study marks the beginning of a potentially significant weight status and electronic tobacco use.

Identifying the underlying mechanisms linking higher weight status to electronic tobacco use also may inform the relationship between weight status and traditional tobacco use. Examining both socio-contextual motivations (eg, using electronic tobacco as a tool for increasing social acceptance among peers or to decrease depressive symptoms brought on by peer victimization/exclusion) and physiological processes (eg, electronic tobacco use brought on by shared biobehavioral markers like impulsivity or shared neurological reward pathways) linking weight status and tobacco use is critical for understanding the etiology and course of these co-occurring health risks. Our findings provide a guide to understanding the relationship between weight status and electronic tobacco use, which ultimately may

have a beneficial impact on prevention/intervention efforts targeting these 2 significant health concerns for younger populations.

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Figure 1.
Substance Use Classes among Young Adults: Item-response Probabilities

Table 1

Demographic and Substance Use Variables: Obese versus Non-obese Young Adults

Variable N (%) or Mean $\pm$ SD	Overall (N = 452)	Obese (N = 49)	Non-obese (N = 402)
Age (years) *	21.3 $\pm$ 2.6	22.1 $\pm$ 2.6	21.2 $\pm$ 2.5
Sex			
Female	267 (59.1%)	29 (59.2%)	238 (59.2%)
Male	185 (40.9%)	20 (40.8%)	164 (40.8%)
Ethnicity^a			
African-American/Black	22 (4.9%)	5 (10.2%)	16 (4.0%)
Asian/Pacific Islander **	120 (26.5%)	6 (12.2%)	114 (28.4%)
Caucasian/White	84 (18.6%)	8 (16.3%)	76 (18.9%)
Hispanic/Latino *	167 (36.9%)	26 (53.1%)	141 (35.1%)
Multiracial	25 (5.5%)	2 (4.1%)	23 (5.7%)
Alcohol Use	(N = 451)		
Binge drinking	264 (58.5%)	31 (63.3%)	232 (57.7%)
Binge past month	130 (28.8%)	11 (22.4%)	119 (29.6%)
Drunk past month	179 (39.7%)	14 (28.6%)	164 (40.8%)
Cigarette Smoking	(N = 451)		
Ever cigarette	177 (39.2%)	22 (44.9%)	155 (38.6%)
Current smoker	35 (7.8%)	5 (10.2%)	30 (7.5%)
Former smoker	34 (7.5%)	3 (6.1%)	31 (7.7%)
Electronic Tobacco Use	(N = 449)		
Ever electronic tobacco use	180 (40.1%)	16 (32.7%)	163 (40.5%)
Regular user	22 (4.9%)	3 (6.1%)	19 (4.7%)

*
p < .05;**
p < .01

Note.

^a 'other', 'Native American', and 'decline to respond' not included in table.

Table 2

Latent Class Model Fit Indices

Classes	Log Likelihood	Free Parameters	BIC	Adjusted BIC	AIC	LMR LRT	p-value for k-1	Entropy
1	-1716.80	7	3476.35	3454.14	3447.60		N/A	N/A
2	-1452.28	15	2996.17	2948.56	2934.56		.00	.82
3	-1402.55	23	2945.56	2872.57	2851.10		.00	.85
4	-1370.46	31	2930.24	2831.86	2802.93		.00	.89
5	-1360.72	39	2959.62	2835.84	2799.44		.13	.89

Note.

AIC = Akaike information criterion; BIC = Bayesian information criterion; LMR LRT = Lo-Mendell-Rubin likelihood ratio test.

Table 3

Estimated Odds Ratios (OR) of Class Membership based on Sex, Race/Ethnicity, Obesity Status, and Deviation from Group BMI Norm

	Reference class: Low Substance Use (Class 4)					
	vs High Substance Use (Class 1)		vs Risky Alcohol Use (Class 2)		vs Cigarette/Electronic Tobacco Use (Class 3)	
	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)
Age (years)	.24 (.06)***	1.27 (1.12–1.43)	.07 (.07)	1.07 (.94–1.22)	.38 (.08)***	1.47 (1.26–1.71)
Female vs male	–1.17 (.31)***	.31 (.17–.57)	–.04 (.35)	.96 (.49–1.90)	–.13 (.35)	.88 (.44–1.73)
Caucasian/White vs non-White	1.20 (.36)**	3.33 (1.65–6.73)	.75 (.41)	2.11 (.94–4.75)	.91 (.38)*	2.49 (1.19–5.21)
Obese vs non-obese	–.19 (.63)	.82 (.24–2.85)	–.65 (.86)	.52 (.10–2.82)	1.29 (.70)	3.63 (.92–14.35)
Greater vs less deviation from group BMI norm	–.01 (.05)	.99 (.91–1.09)	–.00 (.05)	1.00 (.91–1.09)	.11 (.05)*	1.11 (1.01–1.23)
Reference class: High Substance Use (Class 1)						
	vs Risky Alcohol Use (Class 2)		vs Cigarette/Electronic Tobacco Use (Class 3)		vs Low Substance Use (Class 4)	
	B (SE)	OR (95%CI)	β (SE)	OR (95%CI)	β (SE)	OR (95%CI)
Obese vs non-obese	–.46(.92)	.63 (.53–3.82)	1.48 (.72)*	4.40 (3.78–5.13)	.19 (.63)	1.21 (.32–1.07)
Greater vs less deviation from group BMI norm	.01 (.06)	1.01 (.90–1.12)	.11 (.06)*	1.12 (1.01–1.09)	.01 (.05)	1.01 (.92–1.10)
Reference class: Risky Alcohol Use (Class 2)						
	vs High Substance Use (Class 1)		vs Cigarette/Electronic Tobacco Use (Class 3)		vs Low Substance Use (Class 4)	
	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)
Obese vs non-obese	.46 (.92)	1.58 (.26–2.26)	1.94 (.96)*	6.97 (1.06–45.68)	.65 (.86)	1.92 (.35–10.41)
Greater vs. less deviation from group BMI norm	–.01 (.06)	1.00 (.89–1.11)	.11 (.06)	1.11 (1.00–1.25)	.00(.05)	1.00 (.91–1.10)
Reference class: Cigarette/Electronic Tobacco Use (Class 3)						
	vs. High Substance Use (Class 1)		vs. Risky Alcohol Use (Class 2)		vs. Low Substance Use (Class 4)	
	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)	B (SE)	OR (95%CI)
Obese vs. non-obese	–1.48(.72)*	.23 (.06–.94)	–1.94 (.96)*	.14 (.02–.95)	–1.29 (.70)	.28 (.07–1.09)

Reference class: Low Substance Use (Class 4)					
vs High Substance Use (Class 1)			vs Risky Alcohol Use (Class 2)		
B (SE)	OR (95%CI)		B (SE)	OR (95%CI)	
-.11 (.06)*	1.12 (.80-.99)		-.11 (.06)	.90 (.80-1.00)	
vs Cigarette/Electronic Tobacco Use (Class 3)					
B (SE)	OR (95%CI)		B (SE)	OR (95%CI)	
-.11 (.05)*	.90 (.81-.99)		-.11 (.05)*	.90 (.81-.99)	
Greater vs. less deviation from group BMI norm					

* p < .05;
** p < .01;
*** p < .001