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Cross-sectional analysis of e-cigarettes, combustible tobacco and their dual use with binge drinking among college students in the USA

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ABSTRACT

Background Tobacco use is a long-standing epidemic that has caused millions of premature deaths. Electronic cigarette use is rising among young adults, yet few studies have included combustible tobacco, e-cigarettes and their dual use in an analysis of binge drinking among college students. This study aims to calculate the associations between these three forms of tobacco use and binge drinking among college students.

Methods This cross-sectional study used data from 332 721 college students from the American College Health Association-National College Health Assessment survey. Tobacco use was organised into four groups: no tobacco use, e-cigarette use only, combustible tobacco use only and dual use of e-cigarettes and combustible tobacco. Binge drinking was a binary indication of whether students had engaged in binge drinking in the last 2 weeks. Multiple logistic regression was employed to examine the relationship between tobacco use and binge drinking, adjusting for demographic factors and constructs of the integrated behavioural model.

Results Each tobacco use group had significantly higher odds of binge drinking compared with students who did not use tobacco. Students who engaged in dual tobacco use had significantly higher odds of binge drinking compared with exclusive combustible tobacco use (adjusted OR, aOR=2.41, 95% CI: 2.29, 2.53) and exclusive e-cigarette use (aOR=1.79, 95% CI: 1.71, 1.86).

Conclusion The strong relationship between dual tobacco use and binge drinking among college students warrants further investigation into the aetiology and clinical manifestations of this emerging coupled substance use behaviour among the next generation of adults.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Tobacco use, including combustible products and e-cigarettes, and binge drinking are particularly prevalent and associated public health concerns among college students.

WHAT THIS STUDY ADDS

⇒ This study fills a gap in the knowledge between dual use of e-cigarettes and combustible tobacco with binge drinking among college students.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study reveals the importance of focusing efforts on combatting dual tobacco use among college students, including targeted interventions, future research and policy change aimed at drivers of dual tobacco use.

among US adults,[2] with its use being highest among young adults aged 18–24 years old.[3] Overall, 5%–18% of young adults use e-cigarettes[4–7] compared with less than 5% of adults,[2] making young adults a crucial focus for tobacco product research. Tobacco use is the primary cause of preventable death in the USA, and binge drinking is just one of its many health risks.[1] Binge drinking is defined by the Centers for Disease Control and Prevention (CDC) as 'the consumption of five or more drinks for men, or four or more drinks for women, in the span of 2 hours.'[8] This behaviour is most common among young adults, with one in four young adults engaging in binge drinking compared with one in six adults.[9] It is important to understand the mechanisms behind binge drinking as it is associated with thousands of premature deaths among college students every year.[10]

In 2015, when e-cigarettes began growing in popularity, Littlefield *et al* found that e-cigarettes were also linked to binge drinking among college students.[5] Multiple studies

INTRODUCTION

Tobacco use, including combustible products like cigarettes and cigars, is a century-long epidemic that has caused tens of millions of premature deaths.[1] Despite numerous successful programmes and policies to reduce the health burden of tobacco, tobacco use continues to be a prevalent health issue.[1] A relatively new form of tobacco use, electronic cigarettes, has increased in recent years

have advanced tobacco research by studying the individual association of combustible and electronic tobacco use with binge drinking among college students.[4 5 7 11] However, these studies were conducted at a single college or university among less than 2000 students, limiting external validity. Furthermore, only Littlefield *et al* examined the effects of their dual use (ie, both e-cigarettes and combustible tobacco) on binge drinking among college students, finding that the strength of association between exclusive combustible tobacco use and binge drinking was stronger than exclusive e-cigarette use or the dual use of combustible tobacco and e-cigarettes.[5] Given the changing landscape of tobacco products in recent years and the limited studies exploring dual use and its association with binge drinking among college students, further investigation is needed to clarify the potential risks associated with this behaviour among a recent and large sample of college students.

Therefore, the objective of the current study is to fill this gap in the association between the dual use of e-cigarettes and combustible tobacco and binge drinking among college students. The American College Health Association-National College Health Assessment (ACHA-NCHA) survey will assess the association between tobacco use and binge drinking among a recent national sample of college students from 2019 to 2022. Using these data, this study aims to calculate the associations between tobacco use and binge drinking across four distinct categories of college students (ie, non-tobacco-users, exclusive e-cigarette users, exclusive combustible tobacco users, and dual users of e-cigarettes and combustible tobacco). Due to the known association between tobacco products and binge drinking,[4 5 7 11–16] we hypothesise that exclusive e-cigarette use, exclusive combustible tobacco use or dual use of e-cigarettes and combustible tobacco will have a significant and positive association with binge drinking. Due to the known risks of both combustible and electronic tobacco use, we further hypothesise that their dual use will be associated with higher odds of binge drinking compared with their exclusive uses.

METHODS
Data source and sample
Data for this study were acquired from the ACHA-NCHA survey constructed for Fall 2019 to present, referred to as the ACHA-NCHA III.[17] The ACHA-NCHA III is a national, biannual survey administered to millions of students across 973 institutions. The survey is filled out physically or electronically by students. The survey consists of questions on various health behaviours and attitudes, including alcohol, tobacco and other drug use, mental health, physical health, academic characteristics and demographic characteristics. Therefore, this study is cross-sectional. For this study, data were aggregated from Fall 2019 to Fall 2022, including 334 957 responses. Students who responded to survey questions on alcohol

use and/or tobacco use were included in the study, totalling 332 721 students.

Measures
Dependent variable
The primary outcome of interest was a dichotomised indication (Y/N) on whether the student engaged in binge drinking in the past 2 weeks. Students were asked, 'When, if ever, was the last time you drank alcohol?' Students who answered 'never' or an option of more than 2 weeks ago were assigned an indication of 'no' for binge drinking. All remaining students were then asked, 'Over the last 2 weeks, how many times have you had five or more drinks (males) or four or more drinks (females) containing any kind of alcohol at a sitting?' Students who answered 'none' were also assigned 'no' for binge drinking, but students who answered one time or more were assigned an indication of 'yes' for binge drinking. This procedure aligns with the CDC's definition of binge drinking.[8]

Independent variables
The primary predictor of interest was organised into four groups: (1) no tobacco use, (2) e-cigarette use only, (3) combustible tobacco use only and (4) dual use of e-cigarettes and combustible tobacco. Students were asked, 'In your life, which of the following substances have you ever used?' Students who answered 'no' to 'tobacco or nicotine delivery products' were assigned to the non-user group. Students who answered 'yes' were further asked, 'Within the last 3 months, which tobacco products have you used?' Students who answered 'yes' to e-cigarettes and 'no' to cigarettes, cigars and hookahs were assigned to the exclusive e-cigarette user group. Students who answered 'yes' to cigarettes or cigars or hookahs and 'no' to e-cigarettes were assigned to the exclusive combustible tobacco group. Students who answered 'yes' to cigarettes, cigars and/or hookahs and e-cigarettes were assigned to the dual user group. This variable was constructed following previous studies.[11 18]

The selection of demographic characteristics was based on a previous application of the integrated behavioural model (IBM) to model binge drinking among a sample of college students.[19] Sociodemographic characteristics of interest were age (ie, 18–20 years, 21–24 years, 25–19 years, 30+ years), gender identity (ie, cisgender female, cisgender male, gender diverse, transgender), race/ethnicity (ie, American Indian/Alaskan Native, Hispanic or Latino/a/x, Non-Hispanic Asian or Asian American, non-Hispanic biracial or multiracial, non-Hispanic black, non-Hispanic other, non-Hispanic white and Native Hawaiian or Pacific Islander), relationship status (ie, single, partnered), year of study (ie, freshman, sophomore, junior, senior, post-grad, other), housing (ie, on-campus, off-campus, unhoused, other), the highest level of parental education (ie, no high school diploma, high school diploma or equivalent, some college of

associate's degree, bachelor's degree, graduate or professional degree) and campus locale (ie, urban, rural).

Proxies of constructs of IBM, including injunctive norm, descriptive norm, self-efficacy, experiential attitude, instrumental attitude and perceived control, were also incorporated to predict binge drinking. Injunctive norm (ie, perceived social approval of alcohol use, perceived social disapproval of alcohol use) was constructed based on whether students had ever received concern from anyone about their alcohol use. Descriptive norm was represented by a student's level of agreement (ie, 1: strongly disagree to 6: strongly agree) to the statement, 'At my college/university, we are a campus where we look out for each other.' Self-efficacy was a dichotomous Y/N variable for whether students had ever attempted and failed to control their alcohol use. Experiential attitude was represented by the UCLA Loneliness Scale Score, a scale of 3–9 that measures feelings of loneliness.[20] Instrumental attitude was represented by the Diener Flourishing Scale which measures mental well-being on a scale of 8–56 with higher scores representing greater mental well-being.[21] Perceived control was represented by the Connor-Davison Resilience Scale Score (0–8),[22] a resilience measure acting as an indicator of perceived control, with greater scores indicating greater perceived control.

Statistical analysis

Descriptive statistics were used to describe the sociodemographic characteristics of the sample overall and stratified by tobacco use groups. The significance of predictors was tested with either χ^2 tests or one-way analysis of variance. To visually describe the sample, the tobacco groups were presented in a proportional Venn diagram.

Binge drinking was presented across six comparisons of tobacco use groups (ie, exclusive e-cigarette use vs non-use, exclusive combustible tobacco use vs non-use, exclusive combustible tobacco use vs exclusive e-cigarette use, dual-use vs exclusive e-cigarette use, dual-use vs combustible tobacco use and dual-use vs non-use). Associations between tobacco groups and binge drinking were assessed through multivariable logistic regression. These associations were represented by unadjusted and adjusted ORs (aORs) with 95% CIs. The predictive ability of the model was assessed with the area under the receiver operating characteristic curve.

Missing data ranged from 0% to 1.39%, including 1106 (0.33%) missing for the outcome of interest (ie, binge drinking), across all included variables. Only available data were used in all analyses. Goodness-of-fit for logistic regression was assessed visually with Pearson and Deviance residuals and tested formally with Hosmer and Lemeshow's test, Stukel's test, and Osius and Rojek's test. Influential observations were assessed with DFBETAS. Multicollinearity was examined using variance inflation factor (VIF) analysis with VIFs of 10 or higher indicating multicollinearity. All hypothesis tests were two sided with

a significance level of 5%. SAS V.9.4 (SAS Institute) was used for all analyses.

RESULTS
Descriptive statistics

Table 1 provides the characteristics of participants by tobacco use group. Of the total sample, 81.9% (268 825) reported no tobacco use, 8.1% (26,583) reported e-cigarette use only, 3.8% (12,484) reported combustible tobacco use only and 6.2% (20 208) reported the dual use of e-cigarettes and combustible tobacco. These results are visualised in figure 1. While 44.4% of the total sample were 18–20 years, a higher percentage of 18–20 years was observed among students who only use e-cigarettes than among those with only use combustible tobacco (56.4% vs 21.4%). A majority of the sample was cisgender female (56.5%) and non-Hispanic white (52.0%), with a higher percentage of cisgender females and non-Hispanic white students using only e-cigarettes compared with only combustible tobacco (71.2% vs 51.6% and 70.4% vs 58.4%, respectively). Nearly a quarter of students had engaged in binge drinking in the last 2 weeks (24.8%), with the highest proportion in the dual tobacco use group (68.0%).

Inferential statistics

Table 2 presents the adjusted associations between tobacco use groups and binge drinking among college students. Students who only use combustible tobacco had significantly higher odds of binge drinking compared with students reporting no tobacco use (aOR=3.41, 95% CI: 3.27, 3.55). Students who only use e-cigarettes also had significantly higher odds of binge drinking compared with those reporting no tobacco use (aOR=4.59, 95% CI: 4.47, 4.73). Students who reported dual-use e-cigarettes and combustible tobacco had significantly higher odds of binge drinking compared with those who reported no tobacco use (aOR=8.21, 95% CI: 7.93, 8.49).

Table 2 also shows the adjusted associations between tobacco use groups and binge drinking among college students, comparing tobacco use groups to each other. Compared with students who only use combustible tobacco products, students who only use e-cigarettes had significantly higher odds of binge drinking (aOR=1.35, 95% CI: 1.29, 1.41). Compared with students who only use e-cigarettes, students who use both e-cigarettes and combustible tobacco had significantly higher odds of binge drinking (aOR=1.79, 95% CI: 1.71, 1.86). Students who use both e-cigarettes and combustible tobacco also had significantly higher odds of binge drinking compared with exclusive combustible tobacco users (aOR=2.41, 95% CI: 2.29, 2.53).

Covariate/factor associations

Figure 2 shows the adjusted associations between demographic characteristics and binge drinking in the last 2 weeks among college students. With binge drinking as a response, 21–24 years and 25–29 years experienced

Table 1 Characteristics of college students in the USA by tobacco use group

| | Total, n* (%†) | Tobacco use group | | | | P value‡ |
		Non-user, n (%†)	E-cigarettes only, n (%†)	Combustibles only, n (%†)	Dual-use, n (%†)	
Total	332 721 (100)	268 825 (81.9§)	26 583 (8.1§)	12 484 (3.8§)	20 208 (6.2§)	
Age						<0.001
18–20 years	146 151 (44.4)	117 182 (44.1)	14 919 (56.4)	2649 (21.4)	9662 (48.2)	
21–24 years	104 979 (31.9)	82 359 (31.0)	9171 (34.7)	4185 (33.8)	7821 (39.0)	
25–29 years	41 443 (12.6)	35 035 (13.2)	1472 (5.6)	2665 (21.5)	1668 (8.3)	
30+years	36 306 (11.0)	31 057 (11.7)	902 (3.4)	2885 (23.3)	913 (4.6)	
Gender identity						<0.001
Cisgender female	215 254 (65.0)	176 821 (66.1)	18 894 (71.2)	6415 (51.6)	10 715 (53.2)	
Cisgender male	103 340 (31.2)	80 777 (30.2)	6836 (25.8)	5422 (43.6)	8422 (41.8)	
Gender diverse	11 143 (3.4)	8855 (3.3)	723 (2.7)	542 (4.4)	896 (4.5)	
Transgender	1381 (0.4)	1123 (0.4)	88 (0.3)	56 (0.5)	101 (0.5)	
Race						<0.001
AI/AN¶	6974 (2.1)	5388 (2.0)	644 (2.4)	328 (2.6)	510 (2.5)	
NH** Asian or Asian American	46 191 (13.9)	40 965 (15.2)	1792 (6.7)	1231 (9.9)	1675 (8.3)	
NH** Black	16 536 (5.0)	14 716 (5.5)	540 (2.0)	635 (5.1)	434 (2.2)	
Hispanic or Latino/a/x	48 027 (14.4)	40 207 (15.0)	3059 (11.5)	1669 (13.4)	2562 (12.7)	
Native Hawaiian or Pacific Islander	538 (0.2)	423 (0.2)	57 (0.2)	25 (0.2)	25 (0.1)	
NH** other	8999 (2.7)	7151 (2.7)	350 (1.3)	540 (4.3)	572 (2.8)	
NH** white	187 840 (56.5)	145 916 (54.3)	18 722 (70.4)	7292 (58.4)	13 279 (65.7)	
NH** biracial or multiracial	17 616 (5.3)	14 059 (5.2)	1419 (5.3)	764 (6.1)	1151 (5.7)	
Relationship status						<0.001
Singe	172 066 (52.0)	140 110 (52.4)	12 996 (49.0)	5600 (45.1)	11 173 (55.5)	
Partnered	158 911 (48.0)	127 363 (47.6)	13 532 (51.0)	6820 (54.9)	8944 (44.5)	
Housing						<0.001
On-campus	113 963 (34.4)	91 882 (34.3)	10 289 (38.8)	2800 (22.5)	7584 (37.7)	
Off-campus	211 836 (64.0)	171 292 (64.0)	15 994 (60.3)	9303 (74.8)	12 277 (61.0)	
Unhoused	1620 (0.5)	1241 (0.5)	107 (0.4)	110 (0.9)	129 (0.6)	
Highest level of parental degree						<0.001
Less than high school	13 773 (4.2)	12 248 (4.6)	536 (2.0)	448 (3.6)	409 (2.0)	
High school diploma or GED	45 647 (13.8)	37 004 (13.9)	3808 (14.4)	1682 (13.5)	2509 (12.5)	

Continued

Table 1 Continued

	Total, n* (%†)	Tobacco use group				P value‡
		Non-user, n (%†)	E-cigarettes only, n (%†)	Combustibles only, n (%†)	Dual-use, n (%†)	
Some college or associate's degree	54863 (16.6)	43605 (16.3)	5086 (19.2)	2181 (17.6)	3240 (16.1)	
Bachelor's degree	96053 (29.1)	76585 (28.7)	8364 (31.5)	3515 (28.3)	6245 (31.1)	
Professional degree	116396 (35.2)	94359 (35.3)	8529 (32.2)	4509 (36.3)	7553 (37.6)	
Campus locale						<0.001
City	246900 (74.2)	201751 (75.0)	18193 (68.4)	9518 (76.2)	14092 (69.7)	
Town or rural	85821 (25.8)	67074 (25.0)	8390 (31.6)	2966 (23.8)	6116 (30.3)	
Injunctive norm						<0.001
Perceived social approval of alcohol	303674 (92.0)	252260 (94.4)	22864 (86.7)	9858 (79.5)	15271 (76.1)	
Perceived social disapproval of alcohol	26474 (8.0)	14987 (5.6)	3512 (13.3)	2550 (20.5)	4798 (23.9)	
Descriptive norm†† mean (SD)‡‡	4.39 (1.15)	4.4 (1.1)	4.4 (1.1)	4.3 (1.2)	4.2 (1.2)	<0.001§§
Self-efficacy						<0.001
Yes	311862 (94.4)	257061 (96.1)	23949 (90.6)	10515 (84.6)	16765 (83.4)	
No	18593 (5.6)	10375 (3.9)	2485 (9.4)	1914 (15.4)	3339 (16.6)	
Experiential attitude¶¶ mean (SD)	5.52 (1.88)	5.5 (1.9)	5.6 (1.9)	5.5 (1.9)	5.7 (1.9)	<0.001§§
Instrumental attitude*** mean (SD)	44.91 (8.66)	45.0 (8.6)	44.9 (8.4)	45.0 (8.8)	44.0 (9.0)	<0.001§§
Perceived control††† mean (SD)	6.01 (1.55)	6.0 (1.6)	6.0 (1.5)	6.2 (1.5)	6.0 (1.6)	<0.001§§
Binge drink last 2 weeks						<0.001
Yes	82073 (24.8)	46939 (17.5)	13990 (52.8)	5628 (45.2)	13707 (68.0)	
No	249542 (75.2)	221126 (82.5)	12522 (47.2)	6829 (54.8)	6436 (32.0)	

*n=Sample size; not all counts add up to total because of missing values.
†Column percentage.
‡χ2 test for independence
§Row percentage.
¶American Indian/Alaskan Native.
**Non-Hispanic.
††Level of agreement (1: strongly disagree to 6: strongly agree) that students at campus look out for each other
‡‡SD.
§§One-way analysis of variance.
¶¶ Scale of 3–9 with higher scores indicating increased feelings of loneliness
***Scale of 8–56 with higher scores indicating greater psychological well-being.
†††Scale of 0–8 with higher scores indicated greater perceived control.
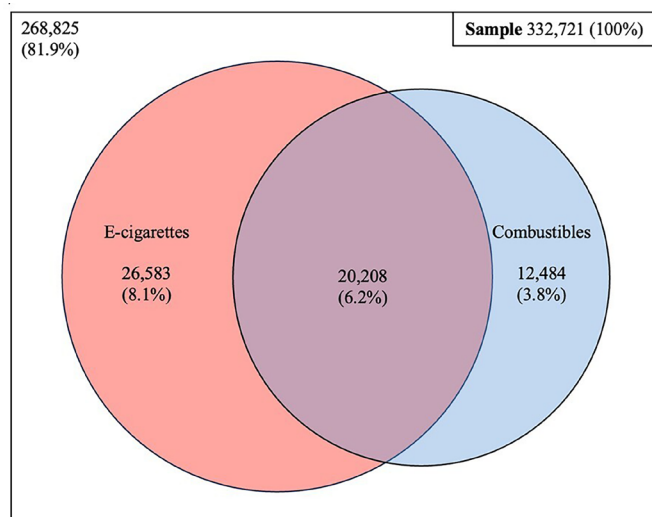AI/AN, American Indian/Alaskan Native; GED, General Educational Development; NH, non-Hispanic.

Figure 1 Proportional Venn Diagram of tobacco use groups among college students in the USA. Each value is presented as n (%). Not all counts add up to total because of missing values.

significantly higher odds of binge drinking compared with 18–20 years, while students 30 years old or older experienced lower odds of binge drinking compared with 18–20 years. Cisgender males had significantly higher odds of binge drinking compared with cisgender females, while gender-diverse and transgender students experienced significantly lower odds of binge drinking compared with cisgender female students. Additionally, every race/ethnicity group had significantly lower odds of binge drinking compared with non-Hispanic white students.

Figure 2 also presents the adjusted associations between the IBM constructs and binge drinking. Students who had a perceived social disapproval of their alcohol consumption had significantly higher odds of binge drinking compared with students who had perceived social approval. A one-unit increase in students' descriptive norm score was associated with lower odds of binge drinking. A student with self-efficacy concerning their alcohol consumption had lower odds of binge drinking

compared with students without self-efficacy concerning their alcohol consumption. A one-unit increase in a student's experimental attitude score was associated with lower odds of binge drinking, while a one-unit increase in a student's perceived control score was associated with higher odds of binge drinking. Online supplemental table 1 further presents these findings numerically.

DISCUSSION

This study aimed to determine the associations between tobacco use and binge drinking across four distinct groups of college students (ie, non-tobacco-users, exclusive e-cigarette users, exclusive combustible tobacco users, and dual users of e-cigarettes and combustible tobacco). Consistent with previous literature,[7 12 14 16] exclusive combustible tobacco use, exclusive e-cigarette use and the dual use of each had a strong and positive association with binge drinking. This study adds to the current literature by identifying that the dual use of combustible tobacco and e-cigarettes was associated with higher odds of binge drinking compared with their exclusive uses. This finding is contrary to previous research by Littlefield *et al* that found dual tobacco use to exhibit a smaller effect on binge drinking than exclusive combustible tobacco use among college students.[5] This contradiction is likely due to the current study having access to a large and national sample, as well as data from recent years. Therefore, dual tobacco use may be a growing problem among college students that requires further investigation.

The transition from dual tobacco use to binge drinking

Dual tobacco use is not only harmful to college students because it is a clustering of two toxic behaviours, but it also may lead to an increased risk of binge drinking, a behaviour associated with various short-term and long-term negative health outcomes.[23] Exclusive combustible tobacco use and exclusive e-cigarette use both have a bidirectional relationship with binge drinking among young adults, such that their individual uses can each be a gateway substance to binge drinking and vice-versa.[24 25] Due to the novelty of dual tobacco use, few longitudinal

Table 2 Odds of binge drinking across tobacco use group comparisons

	Unadjusted	Adjusted*	
	OR (95% CI)	aOR (95% CI)	AUC
Exclusive combustible tobacco use vs non-use	3.88 (3.74, 4.03)	3.41 (3.27, 3.55)	
Exclusive e-cigarette use vs non-use	5.26 (5.13, 5.40)	4.59 (4.47, 4.73)	
Dual-use vs non-use	10.03 (9.72, 10.35)	8.21 (7.93, 8.49)	0.757
Exclusive e-cigarette use vs exclusive combustible tobacco use	1.36 (1.30, 1.42)	1.35 (1.29, 1.41)	
Dual-use vs exclusive e-cigarette use	1.91 (1.83, 1.98)	1.79 (1.71, 1.86)	
Dual-use vs exclusive combustible tobacco use	2.58 (2.47, 2.70)	2.41 (2.29, 2.53)	

*Adjusted for age, gender identity, race, relationship status, housing, highest degree earned by parent/guardian, campus locale and IBM constructs (injunctive norm, descriptive norm, self-efficacy, experiential attitude, instrumental attitude, and perceived control).
aOR, adjusted OR; AUC, area under the curve; IBM, integrated behavioural model.
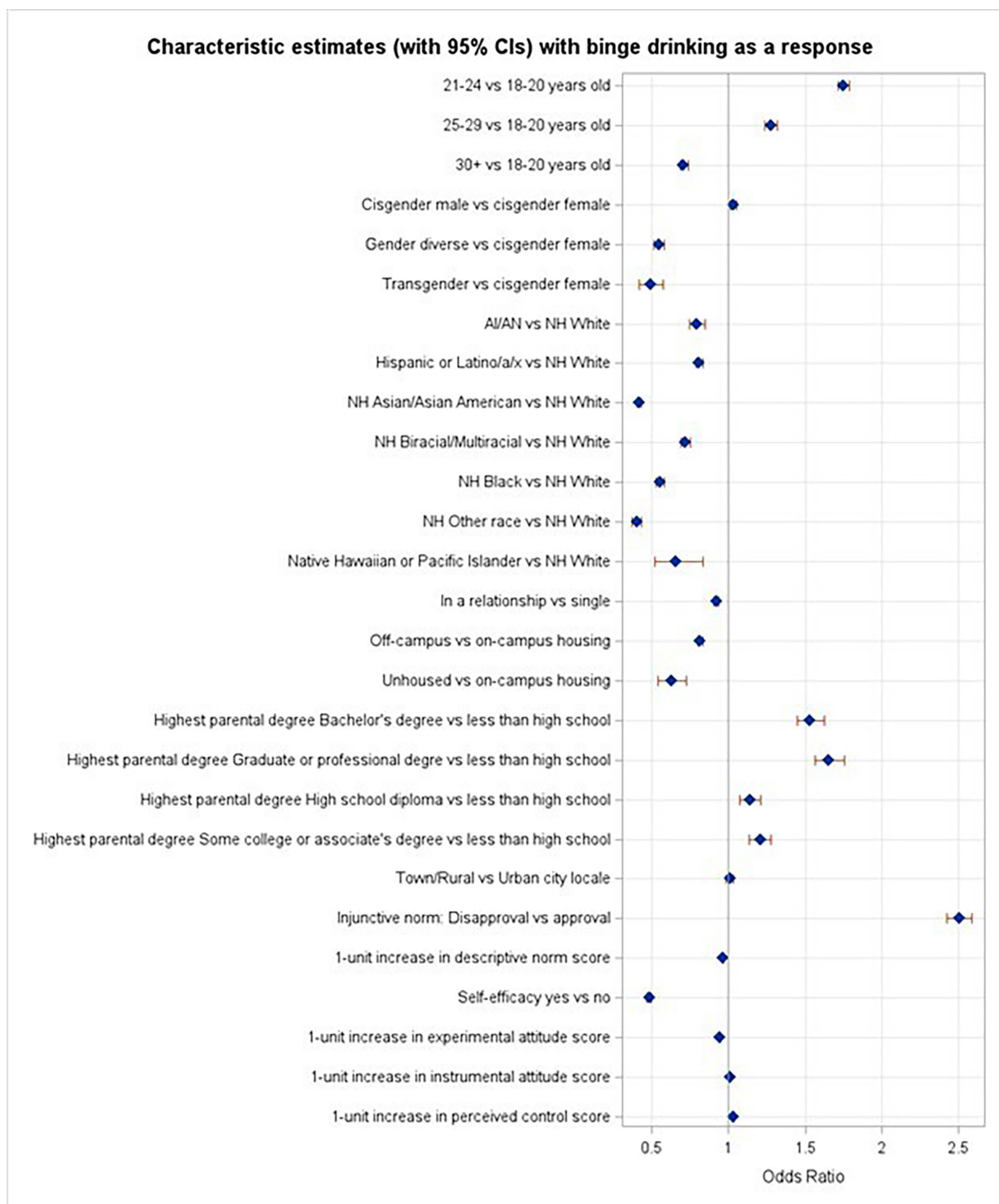
Figure 2 Characteristic estimates (with 95% CIs) from multiple variable logistic regression with binge drinking as a response. NH, non-Hispanic.

studies have investigated the aetiology between dual tobacco use and binge drinking. Future studies are needed to explore whether dual tobacco use is a stronger gateway substance to binge drinking compared with individual tobacco use.

A relationship between risk factors

The present study highlights the intertwined relationships between binge drinking and tobacco use among college students, which are two prevalent risk factors for adverse health outcomes, such as mental health disorders, cancers and cardiovascular diseases.[26–29] As cardiovascular disease is the leading cause of death in the USA,[30] exploring this outcome in relation to tobacco use and binge drinking is integral. Although e-cigarettes are marketed and perceived as less harmful than combustible tobacco,[31] emerging evidence suggests their effects on

cardiovascular health are comparable to those of combustible tobacco, and dual tobacco use has an even greater impact on cardiovascular issues.[32] As the first generation to navigate the combined hazards of e-cigarettes and dual tobacco use alongside high rates of binge drinking, understanding the cardiovascular impacts among current young adults is imperative. For instance, the role of e-cigarettes and their concurrent use with combustible tobacco in the tobacco/alcohol-cardiovascular disease relationships should be further explored.

Relevant demographic characteristics

Consistent with previous literature,[33 34] binge drinking was more prevalent among cisgender white males compared with other gender identities and racial/ethnic groups. College fraternities majorly consist of cisgender white males (due to historical barriers for racial and ethnic minority students[35–37]) and create an environment that promotes binge drinking and tobacco use.[38 39] Binge drinking among fraternity members is associated with multiple consequences, such as long-term alcohol abuse,[40] sexual assault[41] and death.[42] College fraternities, therefore, offer a focal point for tailored binge drinking interventions. These interventions have the potential to not only reduce binge drinking for members but also to address associated consequences. On the other hand, the current analysis found that students who felt support from fellow students and staff at their institutions exhibited a lower likelihood of binge drinking. Colleges and universities should, therefore, create a supportive environment among their students to reduce binge drinking on campuses. One institution, for instance, implemented a successful student-led initiative that promotes alcohol moderation on campus through peer-to-peer engagement.[43] Institutions should focus their efforts on at-risk groups as well as leverage their strengths in efforts to reduce binge drinking.

Strengths and limitations

A strength of the current study is the utilisation of national data from the ACHA-NCHA survey, which includes a large cohort of college students. This study additionally included the dual use of combustible tobacco and e-cigarettes in its analysis of binge drinking, which few studies focused on college students had done.

A limitation of the study was its inability to determine causation due to its cross-sectional nature. Future studies should consider longitudinal designs to explore causal relationships between tobacco use and binge drinking among college students. Additionally, tobacco use and binge drinking were measured by differing time frames (ie, last 3 months vs last 2 weeks, respectively). Future longitudinal studies should ensure temporal alignment to elucidate causal patterns. All data were collected by self-reported surveys which introduce possible response biases, such as recall bias or non-response bias. The study also employed indirect measures of constructs of the IBM. Finally, while the current study controlled for many

relevant factors, unmeasured confounding variables may remain unaccounted for, such as the dosage of tobacco use. Future studies should incorporate the dosage of tobacco use to expound on the relationships between tobacco use and binge drinking.

Implications and conclusion

The present study identified that the dual use of e-cigarettes and combustible tobacco is associated with higher odds of binge drinking compared with their exclusive uses. These findings add to growing research that has recognised dual tobacco use as a harmful behaviour.[32 44–46] Dual tobacco use, therefore, requires additional attention among college students. Young adults have voiced that they would value mobile-based tobacco cessation programmes that educate them on the dangers of dual/poly-tobacco use, provide information on healthy behavioural substitutions and promote social support in quitting,[47] but interventions addressing dual tobacco use among college students remain rare. Additionally, future policies should be made that limit common motivations for young adults to use both combustible tobacco products and e-cigarettes, including appealing e-cigarette flavours, affordability and advertising all e-cigarettes as healthy alternatives.[48 49] It should be noted that, in some situations, transitioning to e-cigarettes can be moderately successful in combustible tobacco cessation,[50–52] but the public must understand how to implement this method without worsening their nicotine addiction and converting to e-cigarette use or dual tobacco use. Education campaigns can promote e-cigarette products with appropriate nicotine content, device type and delivery speed for successful tobacco cessation. These focused efforts could limit the consequences of dual tobacco use among college students, including an increased likelihood of binge drinking.

The strong relationship between dual tobacco use and binge drinking among college students warrants further investigation and intervention. Future longitudinal studies are needed to assess causation between these behaviours, and the clinical manifestations of dual tobacco use coupled with binge drinking should be studied among the next generation of US adults. Interventions tailored for college students who engage in dual tobacco use are needed, and institutions should consider demographic factors in designing interventions, as certain groups, such as cisgender white males, are more prone to binge drinking. By addressing dual tobacco use and its associated risks, public health efforts can work towards mitigating the harmful consequences of combined substance use behaviours among young adults.

REFERENCES

1 National Center for Chronic Disease P, Health Promotion Office on S, Health. Reports of the surgeon general. In: *The health consequences of smoking—50 years of progress: a report of the surgeon general*. Atlanta (GA): Centers for Disease Control and Prevention (US), 2014.
2 Cornelius ME, Loretan CG, Jamal A, *et al*. Tobacco Product Use Among Adults - United States, 2021. *MMWR Morb Mortal Wkly Rep* 2023;72:475–83.
3 Kramarow EA, Elgaddal N. Current Electronic Cigarette Use Among Adults Aged 18 and Over: United States, 2021. *NCHS Data Brief* 2023;2023:1–8.
4 Hefner KR, Sollazzo A, Mullaney S, *et al*. E-cigarettes, alcohol use, and mental health: Use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addict Behav* 2019;91:12–20.
5 Littlefield AK, Gottlieb JC, Cohen LM, *et al*. Electronic Cigarette Use Among College Students: Links to Gender, Race/Ethnicity, Smoking, and Heavy Drinking. *J Am Coll Health* 2015;63:523–9.
6 Oh H, Smith L, Jacob L, *et al*. Food Insecurity and Substance Use Among Young Adult College Students in the United States. *J Addict Med* 2023;17:163–8.
7 Wilson OWA, Bullen C, Duffey M, *et al*. The association between vaping and health behaviors among undergraduate college students in the United States. *J Am Coll Health* 2024;72:1360–4.
8 CDC. Binge drinking: centers for disease control and prevention. 2022. Available: https://www.cdc.gov/alcohol/fact-sheets/binge-drinking.htm
9 Bohm MK, Liu Y, Esser MB, *et al*. Binge Drinking Among Adults, by Select Characteristics and State - United States, 2018. *MMWR Morb Mortal Wkly Rep* 2021;70:1441–6.
10 Hingson R, Zha W, Smyth D. Magnitude and Trends in Heavy Episodic Drinking, Alcohol-Impaired Driving, and Alcohol-Related Mortality and Overdose Hospitalizations Among Emerging Adults of College Ages 18-24 in the United States, 1998-2014. *J Stud Alcohol Drugs* 2017;78:540–8.
11 Saddleson ML, Kozlowski LT, Giovino GA, *et al*. Risky behaviors, e-cigarette use and susceptibility of use among college students. *Drug Alcohol Depend* 2015;149:25–30.
12 Britt JP, Bonci A. Alcohol and tobacco: how smoking may promote excessive drinking. *Neuron* 2013;79:406–7.
13 Frie JA, Nolan CJ, Murray JE, *et al*. Addiction-Related Outcomes of Nicotine and Alcohol Co-use: New Insights Following the Rise in Vaping. *Nicotine Tob Res* 2022;24:1141–9.
14 Gelino BW, Reed DD, Spindle TR, *et al*. Association of electronic nicotine delivery system (ENDS) and cigarette solo and dual use with alcohol-related consequences among US adults. *Addict Behav* 2023;146:107806.
15 Osibogun O, Erinoso O, Gautam P, *et al*. Marijuana use modifies the association between heavy alcohol consumption and tobacco use patterns among US adults: Findings from Behavioral Risk Factor Surveillance System, 2020. *Addict Behav* 2022;135:107435.
16 Walsh BE, Williams CM, Zale EL. Expectancies for and Pleasure from Simultaneous Alcohol and E-Cigarette Use among Young Adults. *Subst Use Misuse* 2022;57:2101–9.
17 Lederer AM, Hoban MT. The development of the American College Health Association-National College Health Assessment III: An improved tool to assess and enhance the health and well-being of college students. *J Am Coll Health* 2022;70:1606–10.
18 Song H, Yang X, Yang W, *et al*. Cigarettes smoking and e-cigarettes using among university students: a cross-section survey in Guangzhou, China, 2021. *BMC Public Health* 2023;23:438.
19 Gutema H, Debela Y, Walle B, *et al*. Predicting binge drinking among university students: Application of integrated behavioral model. *PLoS One* 2021;16:e0254185.
20 Russell D, Peplau LA, Cutrona CE. The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence. *J Pers Soc Psychol* 1980;39:472–80.
21 Diener E, Wirtz D, Tov W, *et al*. New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings. *Soc Indic Res* 2010;97:143–56.
22 Vaishnavi S, Connor K, Davidson JRT. An abbreviated version of the Connor-Davidson Resilience Scale (CD-RISC), the CD-RISC2: psychometric properties and applications in psychopharmacological trials. *Psychiatry Res* 2007;152:293–7.
23 Molina PE, Nelson S. Binge Drinking's Effects on the Body. *Alcohol Res* 2018;39:99–109.
24 Jackson KM, Sher KJ, Cooper ML, *et al*. Adolescent alcohol and tobacco use: onset, persistence and trajectories of use across two samples. *Addiction* 2002;97:517–31.
25 Lozano A, Liu F, Lee TK, *et al*. Bidirectional associations between e-cigarette use and alcohol use across adolescence. *Drug Alcohol Depend* 2021;220:108496.
26 Gallucci G, Tartarone A, Lerose R, *et al*. Cardiovascular risk of smoking and benefits of smoking cessation. *J Thorac Dis* 2020;12:3866–76.
27 Piano MR, Mazzuco A, Kang M, *et al*. Cardiovascular Consequences of Binge Drinking: An Integrative Review with Implications for Advocacy, Policy, and Research. *Alcohol Clin Exp Res* 2017;41:487–96.
28 Huang Y, Loux T. A cross-sectional study: Association between tobacco/alcohol usage and mental health with disabilities. *Ment Health Prev* 2023;32:200302.
29 Pelucchi C, Gallus S, Garavello W, *et al*. Cancer risk associated with alcohol and tobacco use: focus on upper aero-digestive tract and liver. *Alcohol Res Health* 2006;29:193–8.
30 Heron M, Anderson RN. Changes in the Leading Cause of Death: Recent Patterns in Heart Disease and Cancer Mortality. *NCHS Data Brief* 2016;2016:1–8.
31 Brikmanis K, Petersen A, Doran N. E-cigarette use, perceptions, and cigarette smoking intentions in a community sample of young adult nondaily cigarette smokers. *Psychol Addict Behav* 2017;31:336–42.
32 Glantz SA, Nguyen N, Oliveira da Silva AL. Population-Based Disease Odds for E-Cigarettes and Dual Use versus Cigarettes. *NEJM Evid* 2024;3.
33 Kava CM, Hannon PA, Harris JR. Use of Cigarettes and E-Cigarettes and Dual Use Among Adult Employees in the US Workplace. *Prev Chronic Dis* 2020;17:E16.
34 Syamlal G, King BA, Mazurek JM. Tobacco Use Among Working Adults - United States, 2014-2016. *MMWR Morb Mortal Wkly Rep* 2017;66:1130–5.
35 Barone RP. White clauses in two historically white fraternities: Documenting the past & exploring future implications. *Journal of Sorority and Fraternity Life Research and Practice* 2014;9:54–73.

36 Duran A, Garcia CE, Reyes HL. Critically examining the experiences of queer people of color in culturally-based sororities and fraternities. *J Divers High Educ* 2021;16:781–91.

37 Gillon KE, Beatty CC, Salinas C Jr. Race and Racism in Fraternity and Sorority Life: A Historical Overview. *New Drctns for Student Srvcs* 2019;2019:9–16.

38 Cheney MK, Harris LW, Gowin MJ, *et al*. Smoking and membership in a fraternity or sorority: a systematic review of the literature. *J Am Coll Health* 2014;62:264–76.

39 Ranker LR, Lipson SK. Prevalence of heavy episodic drinking and alcohol use disorder diagnosis among US college students: Results from the national Healthy Minds Study. *Addict Behav* 2022;135:107452.

40 McCabe SE, Veliz P, Schulenberg JE. How Collegiate Fraternity and Sorority Involvement Relates to Substance Use During Young Adulthood and Substance Use Disorders in Early Midlife: A National Longitudinal Study. *J Adolesc Health* 2018;62:S35–43.

41 Abbey A. Alcohol-related sexual assault: a common problem among college students. *J Stud Alcohol Suppl* 2002;2002:118–28.

42 Pledge deaths in US colleges. *The Lancet* 2017;390:2326.

43 Robertson-Boersma D, Butt P, Dell CA. Reflections on How a University Binge Drinking Prevention Initiative Supports Alcohol Screening, Brief Intervention, and Referral for Student Alcohol Use. *Yale J Biol Med* 2015;88:339–46.

44 Alzahrani T, Pena I, Temesgen N, *et al*. Association Between Electronic Cigarette Use and Myocardial Infarction. *Am J Prev Med* 2018;55:455–61.

45 Kalkhoran S, Glantz SA. E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med* 2016;4:116–28.

46 Merianos AL, Russell AM, Mahabee-Gittens EM, *et al*. Assessment of Exclusive, Dual, and Polytobacco E-Cigarette Use and COVID-19 Outcomes Among College Students. *Am J Health Promot* 2022;36:421–8.

47 Tran DD, Davis JP, Ring C, *et al*. Informing the development of interventions for e-cigarette use and prevention of transition to cigarette smoking in young adults: A qualitative study. *Prev Med Rep* 2023;35:102332.

48 Rutten LJF, Blake KD, Agunwamba AA, *et al*. Use of E-Cigarettes Among Current Smokers: Associations Among Reasons for Use, Quit Intentions, and Current Tobacco Use. *Nicotine Tob Res* 2015;17:1228–34.

49 Yong HH, Borland R, Cummings KM, *et al*. Reasons for regular vaping and for its discontinuation among smokers and recent ex-smokers: findings from the 2016 ITC Four Country Smoking and Vaping Survey. *Addiction* 2019;114:35–48.

50 Foulds J, Cobb CO, Yen MS, *et al*. Effect of Electronic Nicotine Delivery Systems on Cigarette Abstinence in Smokers With No Plans to Quit: Exploratory Analysis of a Randomized Placebo-Controlled Trial. *Nicotine Tob Res* 2022;24:955–61.

51 Morphett K, Fraser D, Borland R, *et al*. A Pragmatic Randomized Comparative Trial of e-Cigarettes and Other Nicotine Products for Quitting or Long-Term Substitution in Smokers. *Nicotine Tob Res* 2022;24:1079–88.

52 Streck JM, Regan S, Neil J, *et al*. Interest in Electronic Cigarettes for Smoking Cessation Among Adults With Opioid Use Disorder in Buprenorphine Treatment: A Mixed-Methods Investigation. *Nicotine Tob Res* 2022;24:1134–8.