



The association between alcohol, marijuana use, and new and emerging tobacco products in a young adult population



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HIGHLIGHTS

- Examine correlates of emerging tobacco product use in young adults
- Alcohol use was related to e-cigarette, hookah, and little cigar/cigarillo use.
- Marijuana use was related to e-cigarette, hookah, and little cigar/cigarillo use.
- Sensation seeking moderated alcohol use associations to tobacco product use.

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ABSTRACT

Background: Young adults have the highest rates of alcohol, tobacco, and other drug use relative to any other age group. Few studies have examined the co-occurrence of substance use with new and emerging tobacco products in this vulnerable group, or the underlying personality factors that may explain these associations. To address this gap, this study examined the association of current alcohol and marijuana use with the use of cigarettes and emerging tobacco products in a nationally representative sample of young adults.

Methods: Data were drawn from 18 to 24 year olds in Wave 4 (January 2013; $n = 1609$) of the Legacy Young Adult Cohort, a nationally-representative sample of men and women. Never, ever (lifetime), and past 30-day use of little cigars/cigarillos (LCCs), hookah, e-cigarettes, and cigarettes were assessed separately in current (everyday or some days) alcohol and marijuana users.

Results: Using weighted estimates, multivariable multinomial logistic regression models showed that current alcohol and marijuana use were associated with lifetime and past 30-day use of cigarettes, LCCs, e-cigarettes, and hookah, with different magnitudes of association found across each product. Post-hoc exploratory analyses showed that sensation-seeking traits moderated the relationship of alcohol (but not marijuana) use to current use of select tobacco products.

Discussion: Marijuana and alcohol use may enhance risk for emerging tobacco products use in young adulthood. Prevention and intervention programs may need to target poly-use of alcohol, marijuana, and tobacco rather than focusing on a single risk behavior during these critical years.

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1. Introduction

The transition into young adulthood (18–24) from adolescence is an important developmental period during which young adults are

confronted with a variety of life changes (i.e., fertility, residential mobility, marriage, educational shifts, and employment) and a diversity of roles (i.e., student, worker, other), often for the first time. These significant life transitions mark an increased susceptibility to engaging in a variety of health-risk behaviors, most notably alcohol, tobacco, and other drug use. As a result, young adults have some of the highest rates of substance use relative to any other age group (Dawson, Grant, Stinson, & Chou, 2004; Grant, 1996, 1997; Grant et al., 2004; Pearson,

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Richardson, Niaura, Vallone, & Abrams, 2012; Rath, Villanti, Abrams, & Vallone, 2012).

In recent years, the use of new and emerging tobacco products, like e-cigarettes, little cigars/cigarillos (LCCs), and hookah has been on the rise among young adults (Barnett et al., 2013; Cobb, Ward, Maziak, Shihadeh, & Eissenberg, 2010; Richardson, Williams, Rath, Villanti, & Vallone, 2014; Smith et al., 2011), despite a modest decline in cigarette use (Agaku, King, & Dube, 2014). Eighteen percent of individuals aged 18 to 24 report using a new and emerging tobacco product at least once in their lifetime (King, Dube, & Tynan, 2012; McMillen, Maduka, & Winickoff, 2012). Recent data suggest that 2%–8% of young adults have ever used e-cigarettes, 10%–25% have ever used hookah (McMillen et al., 2012; Rath et al., 2012; Smith et al., 2011) and 26% have ever used LCCs (Rath et al., 2012). Using the National Adult Tobacco Survey, King et al. (2012) examined current tobacco use among US adults 18 years of age or older and found that nearly 16% of young adults were current LCC users and almost 8% were current hookah users. These rates were much higher than older adult-age groups that were examined. Further, there is some data to suggest that hookah use is surpassing cigarette smoking, particularly among young adult college students (Barnett et al., 2013). Rising trends in the use of new and emerging tobacco products are of concern, as evidence suggests that some of these products portend similar negative health consequences as regular cigarette smoking (Akl et al., 2010; American Lung Association, 2007; Nonnemaker, Rostron, Hall, MacMonegle, & Apelberg, 2014).

Similarly, epidemiological evidence indicates rates of alcohol and other substance use disorders are higher in young adults than any other age group; where past year DSM-IV alcohol use disorder diagnoses are 6.6% for dependence and 8.5% for abuse (Dawson et al., 2004; Grant et al., 2004; National Institute on Alcohol Abuse and Alcoholism, 2008), and past-year substance use disorders are 1.6% for dependence and 3.6% for abuse (Compton, Thomas, Stinson, & Grant, 2007). Tobacco use, including use of new and emerging tobacco products, also frequently co-occurs with alcohol and drug use (Falk, Yi, & Hiller-Sturmhöfel, 2006; Fix et al., 2014; Grant, Hasin, Chou, Stinson, & Dawson, 2004; Smith-Simone, Maziak, Ward, & Eissenberg, 2008; Soule, Barnett, & Curbow, 2012; Weitzman & Chen, 2005). LCC and large cigar use have been found to be significantly related to alcohol use, as well as lifetime and current daily marijuana use (Richardson, Rath, Ganz, Xiao, & Vallone, 2013; Schuster, Hertel, & Mermelstein, 2013). Quantity of alcohol use and frequency of marijuana use prior to college entry have been shown to predict hookah initiation and frequency of hookah use, respectively, during the first year of college (Fielder, Carey, & Carey, 2013). Current and sustained use of hookah (over the course of several years) in young adult samples have also been linked to past 30-day alcohol and marijuana use (Dugas, O'Loughlin, Low, Wellman, & O'Loughlin, 2014; Sutfin et al., 2011). Alcohol and marijuana use in this age group enhance the risk of tobacco use (Patton, Coffey, Carlin, Sawyer, & Lynskey, 2005), and could lead to greater nicotine dependence and worse smoking cessation outcomes in later adulthood (Anthony & Echeagaray-Wagner, 2000; Falk et al., 2006; Kahler, Spillane, & Metrik, 2010; Kahler et al., 2008; Richter, Ahluwalia, Mosier, Nazir, & Ahluwalia, 2002).

Given the high prevalence of substance use in young adults, and the negative impact of alcohol and drug use on later adult tobacco use trajectories, additional research is needed to understand their association with new and emerging tobacco products. Evidence shows that alcohol use, one's first experience of drunkenness, and marijuana use in junior high and high school may be gateways to tobacco initiation and nicotine dependence in young adulthood (Collins, 2002; Ellickson, Hays, & Bell, 1992; Graham, Collins, Wugalter, Chung, & Hansen, 1991; Patton et al., 2005; Tarter, Vanyukov, Kirisci, Reynolds, & Clark, 2006; Vaughn, Wallace, Perron, Copeland, & Howard, 2008). The role of marijuana as a gateway to tobacco initiation and use is particularly noteworthy given recent state-level changes in the legalization of marijuana (Office of National Drug Control Policy & The White House, 2014). It is unclear how alcohol

and marijuana use are differentially related to the spectrum of new and emerging tobacco products (LCCs, hookah, e-cigarettes) and, to our knowledge, no data on this association has been collected from a population-based sample of young adults both in and out of college.

Substance use in young adults may be conditioned upon a personality trait that is commonly associated with high-risk behaviors. Sensation-seeking traits have been consistently linked to a variety of health risk behaviors, are frequently reported in individuals who use or abuse alcohol or other substances (Carlson, Johnson, & Jacobs, 2010; Charnigo et al., 2013; Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010; Ersche et al., 2012, 2013; Fix et al., 2014; Hampson, Tildesley, Andrews, Barckley, & Peterson, 2013; Weiland et al., 2013), and have recently been linked to the use of new and emerging tobacco products in college students (Enofe, Berg, & Nehl, 2014). Predominant theories suggest that a desire to seek out novel experiences, having a preference to engage in pleasurable activities with high reward output, and being low on harm avoidance, which are all facets of sensation-seeking, may link substance use behavior to the use of new and emerging tobacco products (Cloninger, 1987; Finn, Sharkansky, Brandt, & Turcotte, 2000; Wills, Vaccaro, & McNamara, 1994). Understanding the intricacies of the relationship between alcohol/marijuana use and the spectrum of new and emerging products, including potential moderating factors, will enhance our ability to develop targeted interventions and refine tobacco use policies that may help deter the uptake of certain products associated with heightened risk for other negative health behaviors.

The primary aim of this study was to examine the association of alcohol and marijuana use with use of cigarettes and several new and emerging tobacco products (LCCs, e-cigarettes, and hookah) in a nationally representative sample of young adults. As a secondary aim, we examined whether a link between alcohol/marijuana use and emerging tobacco product use would be moderated by sensation-seeking. We proposed that alcohol and marijuana use would be associated with the greatest odds of emerging tobacco product use among those with higher, rather than lower levels of sensation-seeking.

2. Method

2.1. Participants and procedure

Data were taken from the subgroup of 18–24 year olds ($n = 1609$) participating in Wave 4 of the Legacy Young Adult Cohort, a nationally-representative sample of men and women aged 18 to 34 ($n = 4288$) drawn from the GfK KnowledgePanel®. Wave 4 was fielded in January 2013. The cohort was recruited via address-based sampling, which accounted for US-based representations by race/ethnicity and cell-phone only households. GfK provided households without internet access with a free netbook computer and internet service to reduce response bias in typical online survey samples. African-American and Hispanic individuals were oversampled to ensure sufficient sample sizes for subgroup analyses. Additional details on the survey methodology are published elsewhere (Rath et al., 2012). The household recruitment rate for the Wave 4 survey was 14.7% and in 65.5% of these households, one member completed a core profile survey in which the key demographic information was collected. For this particular study, only one panel member per household was selected at random to be part of the study sample and no members outside the panel were recruited. The study completion rate was 65.7% and thus, the cumulative response rate for this wave was 6.3%. This study was approved by the Independent Investigational Review Board, Inc., and online consent was collected from participants before survey self-administration.

2.2. Measures

2.2.1. Tobacco use outcomes

The separate use of four different tobacco products was explored as the outcome in the current study: use of cigarettes, little cigars/

cigarillos/bidis (LCCs), electronic cigarettes (e-cigarettes) and hookah. For ever (lifetime) use of a product, participants were asked “which, if any of the following tobacco or nicotine products have you ever used or tried? (for cigarettes, cigars, cigarillos, and e-cigarettes “even 1 puff”).” For current use of a product, participants were asked the following: “Which of the following products have you used in the past 30 days (select all that apply).” Following established methods to increase validity of reporting (Terchek, Larkin, Male, & Frank, 2009; Trapl et al., 2011), examples of usual brands of LCCs (i.e., Black and Milds, Swisher Sweets, and Phillies) and e-cigarettes (blu, NJOY) were included in the question to further assist with the query.

Outcomes were defined separately for each product (i.e., cigarettes, LCCs, e-cigarettes, and hookah) as a categorical variables with three mutually exclusive levels: 1) never use; 2) ever use (but not in the past 30 days); and 3) past 30-day use. Unlike adult surveys of tobacco use, participants did not have to meet a threshold (e.g., 100 cigarettes) to be considered a “current user.”

2.2.2. Current alcohol and marijuana use

Current alcohol and marijuana use were assessed using a single question stem: “how often, if ever, do you currently use the following products?” with separate queries for alcohol and marijuana. Response options for each item were “everyday”, “some days” and “not at all.” Current alcohol or current marijuana use in the present study were defined as using “everyday” or “some days”. We had originally included other drug use as a category of interest (cocaine, heroin, ecstasy, meth), but the number of respondents indicating other drug use was deemed too small (<1%) for analyses. Sixteen cases had missing data on alcohol use and 19 cases had missing data on marijuana use; these were excluded from analysis.

2.2.3. Sensation-seeking

Sensation-seeking was measured with the Brief Sensation Seeking Scale (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002), an 8-item Likert scale that assesses four dimensions of sensation seeking personality traits (experience seeking, boredom susceptibility, thrill and adventure seeking, and disinhibition) measured at baseline. The BSSS has been demonstrated as valid and reliable in previous studies (Hoyle et al., 2002; Stephenson, Hoyle, Palmgreen, & Slater, 2003). Response options range from “1” (strong disagree) to “5” (strongly agree). Cronbach’s alpha in the current study sample was .73. Index scores were created for each participant by summing across the eight items; participants missing responses to three or more items were excluded using listwise deletion.

2.2.4. Other covariates

As part of KnowledgePanel® routine data collection, participants provided information on age (grouped as less than 21 years vs. 21 years or older), gender, race/ethnicity (White, non-Hispanic; Black, non-Hispanic; Other, non-Hispanic; and Hispanic) and educational attainment (less than high school, high school, and some college or greater).

2.3. Analytic plan

2.3.1. Primary analyses

All analyses were performed using Stata IC 13.1 (StataCorp, 2014) and post-stratification weights were used to offset any non-response or non-coverage bias and produce nationally representative estimates. Missing data were handled with listwise deletion per Stata’s survey procedures.

The prevalence of alcohol, marijuana, and tobacco product use was calculated in the sample. Bivariate analyses were then conducted to examine correlates of alcohol and marijuana use, as well as associations between alcohol or marijuana use and the association with each of the four different tobacco products.

Multinomial logistic regression analyses were performed separately to examine the associations of alcohol and marijuana use to the outcomes of ever use, past 30-day use, or never use of each tobacco product (cigarettes, LCCs, hookah, e-cigarettes), after adjusting for relevant covariates.¹ To reduce model over-parameterization, only covariates that were significantly correlated (at the bivariate level) with either the exposure (alcohol or marijuana use) or the outcome variables (tobacco product use) at $p < 0.10$ were included. This resulted in different covariates being included in the models for each tobacco product. Explanatory variables were added to the models as groups sequentially: we first examined an overall unadjusted (baseline) model, which included only the exposure variable (alcohol or marijuana use). Relevant covariates (those correlated with the exposure or the outcome variable at $p < 0.10$ in bivariate analyses) were then added to the model in a simultaneous fashion to examine overall changes in odds ratios after adjustment. Statistical significance of final model estimates was determined using the Benjamini–Hochberg procedure to adjust for multiple comparisons for each model, using a false discovery rate (FDR) of 0.2 (Benjamini & Hochberg, 1995).

2.3.2. Secondary analyses

We examined mean differences between alcohol and marijuana users (versus non-users) on sensation-seeking scores, as well as associations between sensation-seeking and demographic covariates. Then, multinomial logistic regression analyses were performed to examine the main effects of sensation-seeking and interactions of sensation-seeking with alcohol and marijuana use on tobacco product use, after adjusting for relevant covariates. Separate models were conducted for each tobacco product as the outcome. Sensation-seeking and the interaction of alcohol/marijuana use with sensation-seeking were added to the model in the last step. As with the primary analyses, covariates were selected that were significantly related to the exposure or criterion variable at $p < 0.10$.

3. Results

3.1. Socio-demographic characteristics of the sample

The study sample was comprised of 1788 (weighted) young adults aged 18–24 (Mean age = 20.9, SD = 2.0). Fifty four percent were over the age of 21, 55% were White; 48% were college-educated; and there was an equal balance of males and females (Table 1).

3.2. Prevalence and correlates of alcohol, marijuana, and tobacco product use

Overall, 55% of the sample reported any current alcohol use (everyday or some days). Current alcohol users were more likely to be over the age of 21 (65% vs. 40%), White (61% vs. 48%), and more highly

¹ We examined alcohol and marijuana in separate models for several reasons. First, alcohol use and abuse are much more prevalent among young adults than any other form of drug use or abuse (Compton, Grant, Colliver, Glantz, & Stinson, 2004; Compton et al., 2007; Dawson et al., 2004; Grant, 1997; Grant et al., 2004; Stinson, Ruan, Pickering, & Grant, 2006). Second, the majority of individuals who use or abuse alcohol do not abuse other drugs (Stinson et al., 2005). Results of a cross-tabulation of alcohol and marijuana use showed that 41.9% were neither alcohol nor marijuana users, 44.3% were only alcohol users, 3.5% were only marijuana users, and 10.4% were both alcohol and marijuana users. Thus there are likely different risk factors and correlates of alcohol versus marijuana use (Degenhardt & Hall, 2012). We had considered sequentially adding alcohol and marijuana use as predictors in the same models, but given that alcohol and marijuana use were associated with different correlates at the bivariate level (Table 1), one model including both predictors would be over-parameterized and include correlates relevant to one predictor but not the other. For the sake of parsimony and to be statistically and conceptually conservative, we examined them as separate predictors. Lastly, we felt that combining marijuana and alcohol use together into one model, or examining the sequential effects of one after the other, would obfuscate the unique associations that each predictor may have with various different tobacco use products after adjusting for relevant covariates.

Table 1
Correlates of current alcohol use or marijuana use in U.S. young adults aged 18–24.

	Alcohol (weighted $n = 1772$)			Marijuana (weighted $n = 1762$)			Full sample
	Not at all	Everyday or some days use	p -Value	Not at all	Everyday or some days use	p -Value	
Overall	0.45	0.55	–	0.86	0.14	–	
Age			<0.0001			0.87	
Less than 21	0.60	0.35		0.46	0.47		0.46
21 +	0.40	0.65		0.54	0.53		0.54
Gender			0.5172			0.0393	
Male	0.48	0.51		0.48	0.59		0.50
Female	0.52	0.49		0.52	0.41		0.50
Race/ethnicity			0.0069			0.3888	
White, non-Hispanic	0.48	0.61		0.55	0.57		0.55
Black, non-Hispanic	0.14	0.13		0.13	0.17		0.14
Other, non-Hispanic	0.13	0.07		0.10	0.05		0.10
Hispanic	0.25	0.19		0.22	0.21		0.22
Education			<0.0001			0.3344	
Less than high school	0.23	0.11		0.16	0.19		0.16
High school	0.42	0.30		0.35	0.40		0.36
Some college or greater	0.35	0.59		0.49	0.41		0.48

Note: Missing observations: alcohol use (16), marijuana (19).

educated (59% with some college vs. 35%) compared to those who did not use alcohol. In terms of marijuana use, 14% of the sample reported any current use (everyday or some days). Marijuana users and non-users were similar across socio-demographic characteristics.

Seventeen percent of the sample reported past 30-day use of cigarettes and 18% reported ever using cigarettes; 4% reported past 30-day use of LCCs and 17% had ever used LCCs; 2% had used e-cigarettes in the past 30 days and 6% had ever used e-cigarettes; and 4% had used hookah in the past 30 days, while 17% had ever used hookah.

In bivariate analyses, age, race, and education were differentially associated with tobacco product use (Table 2). Specifically, being over the age of 21 was significantly associated with ever and past 30-day use of each tobacco product measured. Being White, non-Hispanic was associated with the highest prevalence of ever and past 30-day LCC use, although race was unrelated to current or past 30-day use of cigarettes, e-cigarettes, or hookah. Further, compared to those with less than a high school degree, some high school or college education was related to increased prevalence of ever and past 30-day use of LCCs and hookah. Gender was unrelated to tobacco use. Both alcohol and substance users had tried a greater number of

tobacco products than non-users and these significant differences were found across all products.

3.3. Primary analyses: multinomial logistic regressions

3.3.1. Current alcohol use as a correlate of tobacco product use

In multinomial models, alcohol remained the strongest correlate of ever and past 30-day cigarette use, LCC use, and hookah use after controlling for covariates (Tables 3a and 3b). Alcohol use was associated with a more than three-fold increase in ever use of cigarettes, LCCs and hookah (AOR range: 3.09–3.87; Table 3a) and a more than four-fold increase in past 30-day use of these same products (AOR range: 4.49–9.97; Table 3b). Alcohol use was also highly correlated with past 30-day e-cigarette use (AOR = 9.03, 95% CI: 2.18–37.36), though there was no significant relationship between alcohol use and ever e-cigarette use.

The only socio-demographic characteristic associated with both ever and past 30-day use of a single tobacco product in the alcohol models was older age (21 +), which was correlated with an 80% increase in the odds of ever cigarette use and a more than two-fold increase in

Table 2
Correlates of tobacco product use in U.S. young adults aged 18 to 24.

	Cigarette				p	LCC				p	e-cig				p	hookah				p
	Full	No	Ever	Past 30-day		No	Ever	Past 30-day	No		Ever	Past 30-day	No	Ever		Past 30-day	No	Ever	Past 30-day	
Overall	0.66	0.18	0.16	0.16	***	0.79	0.17	0.04	***	0.91	0.06	0.02	***	0.79	0.17	0.04	***			
Age																				
<21	0.46	0.53	0.33	0.31		0.49	0.34	0.38		0.48	0.25	0.34		0.49	0.34	0.42				
21 +	0.54	0.47	0.67	0.69		0.51	0.66	0.62		0.52	0.75	0.66		0.51	0.66	0.58				
Gender																				
Male	0.50	0.51	0.46	0.50		0.48	0.53	0.69		0.51	0.41	0.52		0.50	0.52	0.48				
Female	0.50	0.49	0.54	0.50		0.52	0.47	0.31		0.49	0.59	0.48		0.50	0.48	0.52				
Race/ethnicity																				
White, non-Hispanic	0.55	0.52	0.58	0.64		0.53	0.65	0.41		0.54	0.63	0.81		0.53	0.64	0.51				
Black, non-Hispanic	0.13	0.14	0.10	0.14		0.13	0.11	0.32		0.14	0.13	0.01		0.15	0.06	0.19				
Other, non-Hispanic	0.10	0.11	0.10	0.04		0.11	0.06	0.00		0.10	0.05	0.08		0.10	0.08	0.09				
Hispanic	0.22	0.23	0.22	0.18		0.22	0.17	0.27		0.22	0.19	0.10		0.22	0.23	0.20				
Education					†				*								***			
<High school	0.16	0.18	0.12	0.15		0.18	0.08	0.19		0.16	0.20	0.07		0.19	0.05	0.13				
High school	0.35	0.37	0.29	0.37		0.36	0.33	0.38		0.36	0.32	0.27		0.38	0.26	0.32				
Some college or greater	0.48	0.45	0.59	0.48		0.46	0.59	0.43		0.48	0.48	0.66		0.44	0.69	0.55				
Any alcohol	0.55	0.43	0.74	0.81	***	0.48	0.81	0.85	***	0.53	0.72	0.94	***	0.47	0.83	0.91	***			
Any marijuana	0.14	0.11	0.13	0.27	***	0.11	0.21	0.57	***	0.12	0.30	0.42	***	0.11	0.26	0.25	***			

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.0001$; missing observations: alcohol use (16), any marijuana use (15). † $p < .10$

Table 3a
Multinomial logistic regression models of alcohol use as a correlate of ever use of emerging tobacco products in young adults aged 18–24.

	Model 1 Ever use of cigarettes (vs. never)	Model 2 Ever use of LCCs (vs. never)	Model 3 Ever use of e-cigarettes (vs. never)	Model 4 Ever use of hookah (vs. never)
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Alcohol use (everyday/some days vs. not at all)	3.09 (1.95–4.89)**	3.23 (1.92–5.41)**	1.91 (0.91–4.02)	3.87 (2.25–6.65)**
Age				
Less than 21	Ref.	Ref.	Ref.	Ref.
21 +	1.80 (1.12–2.91)*	1.44 (0.91–2.27)	2.96 (1.42–6.17)*	1.16 (0.75–1.77)
Gender				
Male				
Female		0.80 (0.54–1.19)		
Race/ethnicity				
White, non-Hispanic	Ref.	Ref.	Ref.	Ref.
Black, non-Hispanic	0.64 (0.30–1.38)	0.79 (0.41–1.53)	0.73 (0.24–2.26)	0.34 (0.14–0.83)*
Other, non-Hispanic	1.06 (0.52–2.17)	0.58 (0.25–1.36)	0.51 (0.12–2.19)	0.85 (0.39–1.83)
Hispanic	0.97 (0.59–1.59)	0.72 (0.41–1.29)	0.69 (0.29–1.66)	1.12 (0.64–1.94)
Education				
Less than high school	0.90 (0.43–1.87)	0.53 (0.24–1.16)	2.49 (0.97–6.40)	0.22 (0.11–0.47)**
High school	0.90 (0.56–1.43)	0.93 (0.59–1.45)	1.33 (0.66–2.67)	0.52 (0.34–0.81)*
Some college or greater	Ref.	Ref.	Ref.	Ref.
Constant	0.05 (0.02–0.14)**	0.02 (0.00–0.06)**	0.01 (0.00–0.06)**	0.02 (0.01–0.06)**

Note. FDR-adjusted refers to the Benjamini–Hochberg procedure used to correct for the false discovery rate.

* FDR-adjusted $p < 0.05$.

** FDR-adjusted $p < 0.01$.

Table 3b
Multinomial logistic regression models of alcohol use as a correlate of past 30-day use of emerging tobacco products in young adults aged 18–24.

	Model 1 Past 30-day use of cigarettes (vs. never)	Model 2 Past 30-day use of LCCs (vs. never)	Model 3 Past 30-day use of e-cigarettes (vs. never)	Model 4 Past 30-day use of hookah (vs. never)
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Alcohol use (everyday/some days vs. not at all)	4.49 (2.68–7.53)**	6.66 (2.32–19.11)**	9.03 (2.18–37.36)*	9.97 (2.26–43.98)*
Age				
Less than 21	Ref.	Ref.	Ref.	Ref.
21 +	2.37 (1.49–3.78)**	1.44 (0.68–3.08)	1.21 (0.40–3.62)	0.90 (0.47–1.74)
Gender				
Male		Ref.		
Female		0.42 (0.17–1.03)		
Race/ethnicity				
White, non-Hispanic	Ref.	Ref.	Ref.	Ref.
Black, non-Hispanic	0.82 (0.41–1.63)	3.77 (1.34–10.59)*	0.05 (0.01–0.42)*	1.56 (0.50–4.89)
Other, non-Hispanic	0.39 (0.18–0.86)*	0.02 (0.00–0.19)**	0.76 (0.15–3.95)	1.44 (0.28–7.45)
Hispanic	0.71 (0.40–1.28)	1.59 (0.64–3.99)	0.35 (0.12–1.05)	1.21 (0.47–3.12)
Education				
Less than high school	1.69 (0.85–3.35)	1.79 (0.60–5.38)	0.66 (0.11–3.87)	0.77 (0.27–2.40)
High school	1.55 (0.95–2.54)	1.58 (0.66–3.79)	0.69 (0.21–2.27)	0.80 (0.36–1.79)
Some college or greater	Ref.	Ref.	Ref.	Ref.
Constant	0.01 (0.00–0.04)**	0.00 (0.00–0.01)**	0.00 (0.00–0.01)**	0.00 (0.00–0.01)**

Note. FDR-adjusted refers to the Benjamini–Hochberg procedure used to correct for the false discovery rate.

* FDR-adjusted $p < 0.05$.

** FDR-adjusted $p < 0.01$.

past 30-day cigarette use. Some college education was also associated with significantly higher odds of ever hookah use, but not past 30-day hookah use.²

3.3.2. Current marijuana use as a correlate of tobacco product use

Compared to alcohol use, there were fewer consistent relationships between marijuana use and ever or current use of the four tobacco

use behaviors (Tables 4a and 4b). Marijuana use was correlated with a more than three-fold increase in ever use of e-cigarettes (AOR = 3.30, 95% CI: 1.56–6.43; Table 4a), but the association with past 30-day use of e-cigarettes (AOR = 3.46, 95% CI: 1.15–10.44; Table 4b) was no longer significant after adjustment for multiple comparisons. Marijuana use was also associated with significantly higher past 30-day use of LCCs (AOR = 8.06, 95% CI: 3.17–19.19) and cigarettes (AOR = 2.31, 95% CI: 1.43–4.35). While marijuana use was correlated with greater ever hookah use (AOR = 2.51, 95% CI: 1.44–4.11), it was not significantly related to past 30-day hookah use. Those aged 21 or older reported a more than two-fold higher prevalence of ever and past 30-day cigarette use and, as in the alcohol model, ever use of hookah was significantly higher in those with some college education.

² Since covariates were selected for inclusion in the multivariable models based on potential association with either alcohol use or use of each of the tobacco products examined, the four tobacco outcome models (Models 1–4) control for different socio-demographic correlates and are not directly comparable.

Table 4a
Multinomial logistic regression models of marijuana use as a correlate of ever use of emerging tobacco products in young adults aged 18–24.

	Model 5 Ever use of cigarettes (vs. never) AOR (95% CI)	Model 6 Ever use of LCCs (vs. never) AOR (95% CI)	Model 7 Ever use of e-cigarettes (vs. never) AOR (95% CI)	Model 8 Ever use of hookah (vs. never) AOR (95% CI)
Marijuana use (everyday/some days vs. not at all)	1.15 (0.62–2.13)	1.71 (1.00–2.92)	3.30 (1.62–6.74)*	2.51 (1.47–4.26)*
Age				
Less than 21	Ref.	Ref.	Ref.	Ref.
21+	2.14 (1.34–3.44)*	1.81 (1.15–2.85)*	2.74 (1.39–5.40)*	1.41 (0.92–2.16)
Gender				
Male	Ref.	Ref.	Ref.	Ref.
Female	1.21 (0.82–1.79)	0.82 (0.56–1.21)	1.53 (0.83–2.82)	0.99 (0.67–1.48)
Race/ethnicity				
White, non-Hispanic		Ref.		
Black, non-Hispanic		0.68 (0.35–1.32)		
Other, non-Hispanic		0.52 (0.23–1.18)		
Hispanic		0.67 (0.38–1.18)		
Education				
Less than high school	0.65 (0.31–1.37)	0.39 (0.18–0.85)*		0.15 (0.07–0.32)**
High school	0.70 (0.44–1.09)	0.79 (0.49–1.17)		0.43 (0.28–0.65)**
Some college or greater	Ref.	Ref.		Ref.
Constant	0.05 (0.02–0.16)**	0.03 (0.01–0.09)**	0.01 (0.00–0.07)**	0.03 (0.01–0.11)**

Note. FDR-adjusted refers to the Benjamini–Hochberg procedure used to correct for the false discovery rate.

* FDR-adjusted $p < 0.05$.

** FDR-adjusted $p < 0.01$.

3.4. Secondary analyses: moderating effects of sensation-seeking

3.4.1. Group differences and main effects of sensation-seeking

In terms of group differences, mean sensation-seeking scores were significantly higher among those who reported current alcohol use versus no use ($M = 25.15$, $SD = 0.29$ for alcohol use vs. $M = 23.02$, $SD = 0.33$ for no use, $p < 0.0001$) and among those who reported current marijuana use versus no use ($M = 28.13$, $SD = 0.59$ for marijuana use vs. $M = 23.53$, $SD = 0.22$ for no use, $p < 0.0001$).

Examining the main effects in the multivariable models using alcohol as the explanatory variable, the association between sensation-seeking and tobacco use was strongest for past 30-day LCC use (AOR = 1.12, 95% CI: 1.05–1.18), followed by past 30-day e-cigarette use (AOR = 1.11, 95% CI: 1.00–1.23), past 30-day hookah use (AOR = 1.10, 95% CI:

1.04–1.18) and past 30-day cigarette use (AOR = 1.06, 95% CI: 1.02–1.10). In the models using marijuana as the explanatory variable, effect sizes showed a similar pattern, though the association between sensation-seeking and tobacco product use was strongest for past 30-day hookah use (AOR = 1.12, 95% CI: 1.05–1.19).

There was a significant interaction between alcohol use and sensation-seeking for past 30-day use of LCCs (AOR = 0.81, 95% CI: 0.69–0.95), and for past 30-day use of e-cigarettes (AOR = 0.81, 95% CI: 0.68–0.96). Figs. 1 and 2 depict higher sensation-seeking scores correlated with higher log odds of past 30-day LCC use and e-cigarette use, with a steeper slope among the alcohol nonusers compared to users. There were no significant interactions between marijuana use and sensation-seeking with regards to ever or past 30-day use of any of the tobacco products after adjustment for multiple comparisons.

Table 4b
Multinomial logistic regression models of marijuana use as a correlate of past 30-day use of emerging tobacco products in young adults aged 18–24.

	Model 5 Past 30-day use of cigarettes (vs. never) AOR (95% CI)	Model 6 Past 30-day use of LCCs (vs. never) AOR (95% CI)	Model 7 Past 30-day use of e-cigarettes (vs. never) AOR (95% CI)	Model 8 Past 30-day use of hookah (vs. never) AOR (95% CI)
Marijuana use (everyday/some days vs. not at all)	2.31 (1.32–4.03)*	8.06 (3.23–20.12)**	3.53 (1.16–10.76)*	1.93 (0.80–4.68)
Age				
Less than 21	Ref.	Ref.	Ref.	Ref.
21+	2.78 (1.75–4.42)**	1.58 (0.69–3.63)	1.89 (0.67–5.29)	1.19 (0.60–2.39)
Gender				
Male	Ref.	Ref.	Ref.	Ref.
Female	1.06 (0.70–1.61)	0.43 (0.18–1.05)	1.01 (0.41–2.50)	1.10 (0.50–2.39)
Race/ethnicity				
White, non-Hispanic		Ref.		
Black, non-Hispanic		2.89 (0.97–8.56)		
Other, non-Hispanic		0.02 (0.00–0.19)**		
Hispanic		1.52 (0.60–3.88)		
Education				
Less than high school	1.01 (0.51–2.03)	0.88 (0.30–2.60)		0.46 (0.15–1.47)
High school	1.15 (0.72–1.84)	1.06 (0.43–2.62)		0.62 (0.29–1.34)
Some college or greater	Ref.	Ref.		Ref.
Constant	0.02 (0.01–0.08)**	0.01 (0.00–0.08)**	0.00 (0.00–0.03)**	0.00 (0.00–0.02)**

Note. FDR-adjusted refers to the Benjamini–Hochberg procedure used to correct for the false discovery rate.

* FDR-adjusted $p < 0.05$.

** FDR-adjusted $p < 0.01$.

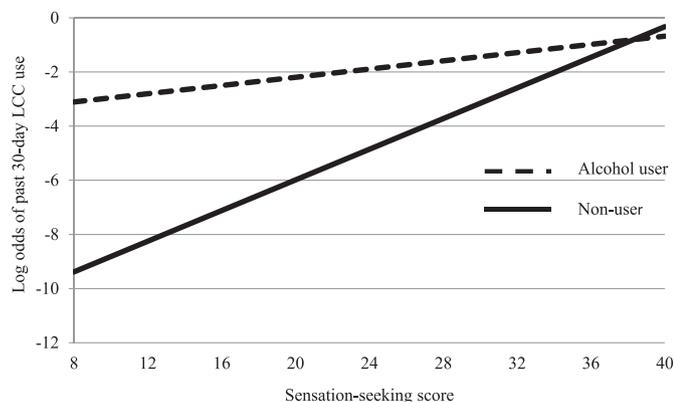


Fig. 1. Interaction between alcohol use and sensation-seeking on past 30-day use of LCCs.

4. Discussion

Substance use in young adults is a significant public health problem that is critical to target as part of tobacco-related prevention and intervention initiatives (Anthony & Echeagaray-Wagner, 2000; Degenhardt & Hall, 2012; White & Hingson, 2014; Windle & Windle, 2005). However, few studies have examined the strength of correlations between current alcohol and marijuana use to the use of a variety of emerging tobacco products using a population-based sample of young adults (18–24). We found that over half of the sample reported being current alcohol users (everyday or some days), while a smaller proportion, 14%, reported being current marijuana users. These numbers are consistent with averages reported for this age group in several large national population-based studies (Anthony & Echeagaray-Wagner, 2000; Falk et al., 2006; Grant, 1997; Slutske, 2005). Both alcohol and marijuana use were associated with being over the age of 21, but alcohol use was uniquely associated with being college-educated and White. Consistent with past reports, alcohol and marijuana use were strongly correlated with cigarette use. Interestingly, but not consistent with the literature, White, non-Hispanic young adults were most likely to report LCC use. Richardson et al. (2013), in a national sample of 18 to 34 year olds, found that LCC-only users and dual users of LCCs and large cigars were most likely to be non-Hispanic Blacks. Finally, ever use of LCCs, hookah, and cigarettes appeared to be equally prevalent (at 17%), matching rates reported in other large community and national samples (King, Dube, & Tyman, 2012; Primack et al., 2013). The prevalence of past 30-day use of each product varied, with cigarettes being the most widely used, followed by LCCs, hookah, and then e-cigarettes. Not surprisingly, e-cigarette

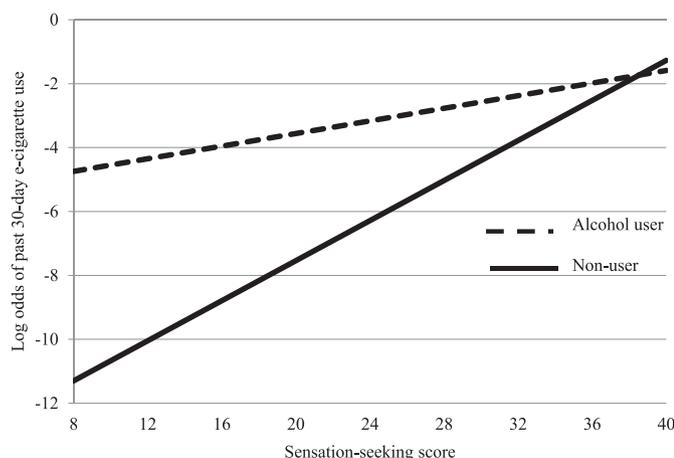


Fig. 2. Interaction between alcohol use and sensation-seeking on past 30-day use of e-cigarettes.

prevalence (ever use and past 30-day use) was the lowest, likely owing to the fact that they are the newest products to have emerged on the market.

Adding to the literature, there was clearly a strong association of alcohol and marijuana use to the use of a variety of emerging tobacco products; however different patterns of association were identified. Alcohol use was most strongly correlated with recent (past 30 days) hookah and e-cigarette use, followed by LCC use. Marijuana use was also significantly associated with ever and current use of each of several of the emerging tobacco products, but the odds ratios were less pronounced relative to the alcohol models; likely owing to the smaller percentage of marijuana use in the sample. Marijuana use was most strongly correlated with recent (past 30 days) LCC use, as might be expected from prior research (Richardson et al., 2013; Schuster et al., 2013), followed by recent use of e-cigarettes. Marijuana use was not associated recent hookah use in this young adult sample. This finding is consistent with another study in adolescents (Sterling & Mermelstein, 2011), but differs from results in a U.S. college sample (Jarrett, Blossnich, Tworek, & Horn, 2012).

Taken together, given the different patterns of associations of current alcohol and marijuana use with emerging tobacco product use, more research is needed to determine “for whom” and “under what circumstances” these factors influence the use of other tobacco products. Further, the finding that current alcohol use was strongly correlated with current hookah and e-cigarette use, and less strongly correlated with current cigarette use, suggests specific targets for future intervention in young adults. There should be an increased focus on diverting young adults from using new and emerging tobacco products.

The relationship of alcohol and marijuana use to recent e-cigarette use is particularly noteworthy, given the heated debate in the tobacco control field about the degree of harm and potential addiction liability associated with e-cigarettes (Chatham-Stephens et al., 2014; Glynn, 2014; King, Smith, McNamara, Matthews, & Fridberg, 2014; Niaura, Glynn, & Abrams, 2014; Siegel, 2014). One recent cross-sectional population-based study has already shown that individuals who use e-cigarettes are high on certain mental health vulnerability factors known to predict smoking persistence and cessation failure (Cummins, Zhu, Tedeschi, Gamst, & Myers, 2014). These findings could suggest two very different reasons for e-cigarette use and thus different intervention targets: individuals who are high on certain risk factors that portend negative health outcomes may self-select to e-cigarette use; conversely, cigarette users who are known to have difficulty quitting (i.e., those with substance abuse and/or other mental health problems) may be using e-cigarettes as a quit method. These different pathways to e-cigarette use should be explored in future work.

Lastly, secondary analyses examined whether sensation-seeking moderates the relationships between alcohol and marijuana use to tobacco product use. Multivariable models showed that sensation-seeking was correlated with ever and current use of cigarettes, LCCs, e-cigarettes and hookah, controlling for alcohol or marijuana use. Further exploration of interactions revealed that the relationship between alcohol use and past 30-day LCC use and e-cigarette use was moderated by sensation-seeking. Specifically, the odds of LCC and e-cigarette use remained unchanged across high and low levels of sensation-seeking among current alcohol users. However, non-alcohol users had increasing odds of LCC and e-cigarette use if they also reported higher levels of sensation-seeking. Thus sensation-seeking may be a significant risk correlate of tobacco use among young adults who are not regular drinkers but plays a less significant role among those who are established drinkers. These findings are somewhat consistent with Cloninger’s theory of substance use (Cloninger, 1987), which suggests that certain sensation-seeking traits like high reward and low harm avoidance increase risk for substance use behavior. However, it does not explain why those low on alcohol use would be more likely to use tobacco products, even if they did have heightened personality risk. We would expect alcohol users and those high in sensation-seeking to

have the greater risk of tobacco use. More research in this area needs to be conducted.

4.1. Limitations

There were several limitations associated with this study. First, because this is a secondary analysis of previously collected data, our models were limited to the measurement questionnaires available in the dataset. For example, while multiple personality traits are related to alcohol and drug use (the Big Five, reward/punishment sensitivity, delayed gratification, UPPS impulsivity traits), sensation-seeking was the closest proxy to these characteristics that was available in the dataset. Additionally, we did not query quantity and frequency of tobacco product so cannot make interpretations about intensity of use and its relation to alcohol and drug use. Second, low response to the survey must be considered when generalizing study findings to the broader population of young adults. Third, due to the cross-sectional nature of the data, causal interpretations cannot be made. We cannot firmly conclude whether sensation-seeking or alcohol and marijuana use cause one to engage in tobacco product use, or whether tobacco use may enhance one's vulnerability toward sensation-seeking traits and alcohol or marijuana use. Finally, this analysis also did not investigate how co-use of alcohol and marijuana may have impacted quantity and frequency of tobacco product use. It could be that co-use of these substances leads to enhanced frequency of tobacco use (daily versus someday use), or escalation of alcohol/marijuana use, which then triggers tobacco experimentation and use. Future analyses should seek to understand the impact of alcohol and other drug use, in addition to marijuana, on tobacco product use across the lifespan, and how early patterns of use, and co-use may impact the co-occurrence of and risk factors associated with alcohol, tobacco, and other drug use in later adulthood.

4.2. Strengths

Major strengths of the current study are use of a national sample of young adults, many of whom were not college students, and assessment of novel tobacco product use in conjunction with alcohol and marijuana use (Cavazos-Rehg, Krauss, Spitznagel, Grucza, & Bierut, 2014). Most studies in this area have relied on college students samples. Furthermore, studies focused on alcohol or marijuana use in young adults often have not included assessment of new and emerging tobacco products such as hookah and e-cigarettes, which are becoming increasingly popular in this age group (Rath et al., 2012; Richardson et al., 2014; Villanti, Cobb, Cohn, & Rath, in press). In our study, those participants who were in college were more likely to report lifetime hookah use, and this highlights the potential need for targeted prevention efforts in the college student population. Lastly, no studies to date have investigated personality risk factors that might explain the connection between alcohol and marijuana use to emerging tobacco product use in young adults using a national sample.

5. Conclusions

Although cigarette use in adult populations has shown some small declines over the years (Agaku et al., 2014; Centers for Disease Control & Prevention, 2011, 2012), our data indicate that emerging tobacco product use is a public health problem among young adults and show similar associations with alcohol/drug use as cigarettes. More research needs to be done to examine the longitudinal use patterns among young adults for these products. Public health professionals should be vigilant about tracking increasing trends of emerging tobacco product use as they relate to alcohol and other drug use, particularly in this age group. To do this, it is important to identify which risk factors are correlated with the changing tobacco product landscape. While decades of work have noted the link between substance use and cigarette consumption, a dearth of published literature has examined this link with

new tobacco products. The robust association between substance use and emerging tobacco product use in young adults in the present investigation (even after controlling for covariates) suggests that new policies need to be developed to deter tobacco use in this age group, as it is associated with other risk behaviors. Additionally, identifying relevant contextual (substance use) and personality (sensation-seeking) risk factors of emerging tobacco product use improves the targets for prevention and intervention programs. Not all substances will be equally correlated with each different product (findings supported in our study). This suggests different “profiles” or “clusters” of individuals who use new and emerging products and thus different prevention and intervention approaches depending on product type.

Lastly, public health campaigns targeted toward reducing tobacco product use in this age group should consider messages to temper the excitement or thrill associated with use of novel tobacco products to reduce appeal to young adults. Our findings suggest important implications with regards to the channels in which we communicate messages about tobacco product use, as those high in sensation-seeking might use different media outlets or respond to different creative strategies than young adults who are lower on sensation-seeking (Palmgreen, Donohew, Lorch, Hoyle, & Stephenson, 2001). Event-based strategies for communication (such as in bars, clubs, and music concerts) may be effective ways to capture the attention of this specific group of young adults, as sensation-seekers may be more likely to frequent these types of venues than watch television or “surf” the internet at home. In conclusion, the findings consistently show a relationship between alcohol and marijuana use across a variety of tobacco products in young adults, as well as different patterns of use. While we cannot determine from the present data whether alcohol and marijuana use lead to tobacco use, or vice versa, our findings suggest that these robust associations need to be considered both in terms of how they affect substance use trajectories, overall health, attempts to quit, and how we think about designing interventions to mitigate use of these substances that target the most “at risk” audience.

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Contributors

Andrea Villanti and Jessica Rath designed the study and wrote the protocol. Amy Cohn and Andrea Villanti conducted literature searches, provided summaries of previous research studies, and assisted with conceptualization and writing of the current study findings. Amy Cohn conducted the statistical analysis. Valerie Williams assisted with data analysis and Cassandra Stanton and Robin Mermelstein assisted with conceptualization and interpretation of study findings. Author Cohn wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

Conflict of interest

The authors have no conflicts of interest to disclose.

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