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Longitudinal trajectories of marijuana use in tobacco products among Texas young adult college students from 2015-2019

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Abstract

Aims—To explore longitudinal trajectories of marijuana use in four tobacco/nicotine products (hand-rolled cigarettes/spliffs, cigars/blunts, hookah, e-cigarettes) among young adult Texas college students from 2015 to 2019.

Design—This study used six consecutive waves of data from the Marketing and Promotions across Colleges in Texas project (Project M-PACT), a longitudinal study of the tobacco behaviors of young adult college students. The first four waves were collected every six months (fall 2015-spring 2017), and the final two waves were conducted yearly (spring 2018 and 2019). Growth curve models explored trajectories of marijuana use in tobacco products across the 3.5-year period. All models included socio-demographic covariates of sex, race/ethnicity, age, 2-year/4-year college attendance, and sexual and gender minority (SGM) identity.

Setting and Participants—A total of 4,857 young adults from 24 colleges in the largest metropolitan areas of Texas (Austin, Dallas, Houston, and San Antonio): mean age=21.0, SD=2.3; 64.2% assigned female; 36.1% non-Hispanic white, 31.0% Hispanic, and 33.0% other or combination race/ethnicity.

Measurements—Participants completed online surveys assessing their past six-month use of marijuana in four tobacco products of interest (spliffs, blunts, hookah, and e-cigarettes) and socio-demographic variables

Findings—Observed vaping marijuana in e-cigarettes approximately doubled between the spring of 2015 and the spring of 2019, from 11.8% to 23.9% following a quadratic time trend (linear

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OR=0.84, CI=0.73–0.97, quadratic OR=1.18, CI=1.13 – 1.22). This same time period saw a quadratic decline in using marijuana in hookah ($p<.001$) and no changes in using hand-rolled cigarettes/spliffs or cigars/blunts for marijuana delivery.

Conclusions—E-cigarettes, which are typically marketed for nicotine delivery and have risen rapidly in popularity, provide novel avenues for the delivery of marijuana. Understanding which tobacco products may influence co-use and co-administration is a priority for health professionals, particularly as tobacco products continue to evolve and more states legalize marijuana use.

Keywords

e-cigarettes; young adults; marijuana; cannabis; co-administration; co-use; tobacco use

INTRODUCTION

Marijuana (i.e., cannabis) use reached an all-time high in 2019, with 27% of young adults ages 19-28 reporting use in the past 30 days.¹ This rise is often attributed to increasingly permissive attitudes about marijuana,^{2,3} decreased harm perceptions surrounding its use,⁴ and the potential increase in willingness to report marijuana use post-legalization.⁵ Marijuana use is associated with negative health effects including cognitive impairment, decreased brain development, and pulmonary health effects.^{6,7} Perhaps more concerning is the fact that most marijuana users also use tobacco,⁸ a behavior termed “co-use.” One form of co-use is “concurrent use,” frequently operationalized as using both products within a specific period of time, such as the past 30 days.⁸ Compounded effects of co-using marijuana with cigarettes or other combustible tobacco products include an increased risk for chronic obstructive pulmonary disease (COPD), decreased lung function, poorer mental health, and less successful cessation outcomes.^{9,10} Young adults in particular have a heightened risk for co-use relative to other age groups.⁸

Another form of co-use is the co-administration of marijuana and tobacco/nicotine, where the products are used simultaneously in the same product or device,¹¹ and frequently the product used is marketed as a tobacco/nicotine product. Modalities of co-administration include spliffs (hand-rolled cigarettes with loose tobacco and marijuana combined), or blunts (cigar tobacco leaf wrappers rolled with marijuana).¹² Hookah is a traditional water pipe used to smoke shisha tobacco, sometimes combined with loose marijuana.^{11,13} A popular and expanding class of tobacco/nicotine products known as electronic nicotine delivery systems (ENDS, or “e-cigarettes”) deliver aerosolized “e-liquid,” a popular practice known as vaping.¹⁴ In addition to concerns related to e-cigarettes’ addictive potential, some devices can be “hacked,” where marijuana or its derivatives (extracts, concentrates) are added to the factory-sealed cartridges.¹⁶ These derivatives can contain unprecedented levels of tetrahydrocannabinol (THC, the active component of cannabis¹⁷), reaching from 35 to 90% THC¹⁸ (versus an approximately 12% in marijuana flower).¹⁹ High-potency marijuana use is associated with increased rates of psychosis, acute cognitive impairment, and cannabis use disorders.¹⁸ Thus, e-cigarettes allow for the co-administration of non-combusted nicotine alongside marijuana or its derivatives. While delivering marijuana via convection heating (i.e., without combustion) is not new,²⁰ e-cigarettes provide newer, more portable, and more

easily-concealable²¹ avenues for vaporizing both marijuana flower and its derivatives, with or without nicotine.^{17,22,23}

Over 80% of all ever-marijuana users reported using tobacco products/devices for marijuana delivery in a 2016 nationally representative study.²⁴ Understanding which tobacco products are popular avenues for marijuana delivery is a priority, especially as more states allow recreational marijuana use, and as the avenues for its delivery from products typically advertised as tobacco/nicotine delivery continue to evolve. Thus, the **purpose** of this study was to explore trajectories of marijuana use in tobacco products (hand-rolled cigarettes/spliffs, cigars/blunts, hookah, and e-cigarettes) across a 3.5-year period from 2015-2019 among a cohort of young adult college students.

METHODS

Participants and Procedures

Participants were 4,857 young adults (M age=21.8, SD=2.3; 64.6% assigned female; 35.7% non-Hispanic white) participating in the Marketing and Promotions across Colleges in Texas Project (Project M-PACT). Project M-PACT tracked the tobacco use behaviors of a cohort of 5,482 young adult students, who originally attended college in the largest metropolitan areas of Texas: Austin, Dallas, Houston, and San Antonio. Project M-PACT eligibility required participants to be 18-29 years old at recruitment in 2014, and full- or part-time, degree- or certificate-seeking undergraduate students at one of 24 participating 2- or 4-year colleges. The current study spans six waves across the 3.5-year period from fall 2015 (when questions regarding marijuana use in tobacco/nicotine products were added) to spring 2019. The first four waves (fall 2015-spring 2017) were collected every six months, and the final two waves were conducted yearly (spring 2018 and 2019). To be included in analyses, participants were required to have participated in at least one of the six waves and provided responses to each of the four outcomes, so that all models were based on the same participants. Retention in the six waves ranged from 69% (spring 2019) to 81% (spring 2016). Informed consent was obtained from all participants prior to enrollment, and all study procedures were approved by the university's Institutional Review Board (IRB). Detailed study procedures are published elsewhere.²⁵

Measures

Dependent Variables—At each wave, participants were asked if they had used tobacco/nicotine products for marijuana delivery in the past 6 months in each of the products of interest: spliffs, blunts, hookah, and e-cigarettes. For example, “In the past 6 months, have you smoked marijuana in a hand-rolled cigarette with tobacco (spliff)?” These questions followed dedicated survey sections that inquired about tobacco product use “*as intended*, i.e., with nicotine/tobacco,” to avoid inadvertent overlap with marijuana co-administration/delivery. Each of these four outcomes was dichotomized so that participants who indicated using marijuana in the tobacco product were coded 1, all others were assigned a value of 0.

Covariates—Because male sex,²⁶ non-Hispanic white race/ethnicity,^{26,27} being between 18 and 25 years of age,^{8,27} 4-year college attendance,²⁸ and non-heterosexual/non-cisgender

identities are associated with using marijuana,²⁹ we included five socio-demographic covariates in our analyses. These included sex assigned at birth (female=0, male=1), race/ethnicity (dummy coded for Hispanic/Latino, African American/Black, Asian, or other/multiple relative to non-Hispanic white participants), current age, type of college attended (2-year=0, 4-year=1), and sexual and gender minority (SGM) identity, where participants indicating non-heterosexual and/or non-cisgender identity were coded 1, and those indicating exclusively heterosexual and cisgender identity were coded 0.

Statistical Analysis

Trajectories of marijuana use in tobacco products were fit for growth curve models using six waves of data across the 3.5-year period from 2015-2019, with year centered at the first wave. Models were fit using generalized linear mixed models, with a logit link function for a binary distribution with the R `glmer` function in the `lme4` package, version 1.1.21.9002.^{30,31} All models were multilevel, nesting study waves within individuals and individuals within college, and included a random intercept for participant and baseline school attended. Separate linear and quadratic models were fit for marijuana use in each tobacco product of interest. Linear and quadratic models were compared using the Bayesian Information Criterion (BIC), accounting for both model complexity and sample size in determining the best-fitting model.³² All models included the five socio-demographic covariates described above. Including covariates in the models ameliorated the potential of missing data bias by adjusting for a variety of interpersonal characteristics, making the missing at random assumption more viable.³³

RESULTS

Participants' marijuana use in the four tobacco/nicotine products at each study wave are displayed in Table 1. From fall 2015 to spring 2019, the use of marijuana in spliffs, blunts, and hookah all declined, while marijuana use in e-cigarettes increased from 11.8% to 23.9%. Growth curve models depicting trajectories of use across the 3.5-year study are displayed in Figure 1. Odds ratios (ORs) and 95% confidence intervals (CI) for model parameters are displayed in Table 2.

Based on model BIC comparisons, linear growth curve models were the best fit for spliffs and blunts. However, neither linear trend was significant, indicating that marijuana use in spliffs (OR=0.97, CI=0.92–1.03) and blunts (OR=0.97, CI=0.92–1.04) was constant across the 3.5-year period. Quadratic models were the best fit for hookah and e-cigarettes. For hookah, the combination of the linear (OR=0.49, CI=0.41–0.59) and quadratic (OR=1.14, CI=1.08–1.19) trends resulted in a rapid and significant decrease from fall 2015 to spring 2017, at which point the trend stabilized. For vaping marijuana in e-cigarettes, the combination of the linear (OR=0.84, CI=0.73–0.97) and quadratic (OR=1.18, CI=1.13–1.22) trends resulted in stable use for the first 1.5 years of the study, then an approximate doubling between the spring 2017 and the spring of 2019.

Male participants were more likely to use marijuana in spliffs, blunts, and e-cigarettes than female participants (OR=1.48, CI=1.24–1.76, OR=1.29, CI=1.05–1.58, OR=1.51, CI=1.29–1.77, respectively). Asian participants reported a lower likelihood of using marijuana

in spliffs, blunts, and e-cigarettes than their non-Hispanic white counterparts (OR=0.76, CI=0.59–0.99; OR=0.48, CI=0.35–0.66; OR=0.67, CI=0.53–0.84, respectively), but were more likely to use marijuana in hookah (OR=1.42, CI=1.13–2.48). Hispanic/Latino, African American/Black, and other or multiple race/ethnicity respondents each reported a higher likelihood of using hookah for marijuana delivery than non-Hispanic white participants (OR=1.42, CI=1.16–1.74; OR=1.83, CI=1.36–2.48; OR=1.86, CI=1.37–2.52, respectively) as did four-year college attendees (OR=1.56, CI=1.05–2.30). The likelihood of using blunts decreased with age (OR=0.68, CI=0.52–0.88). Finally, SGM participants reported a higher likelihood of using marijuana in spliffs, blunts, hookah, and e-cigarettes relative to cisgender/heterosexual participants (OR=2.34, CI=1.92–2.84; OR=2.28, CI=1.82–2.87; OR=1.44, CI=1.20–1.73; OR=2.18, CI=1.83–2.60, respectively).

DISCUSSION

In this sample of Texas young adult college students, only vaping marijuana in e-cigarettes demonstrated a significant rise from 2015 to 2019 (from 11.8% to 23.9% respectively), while marijuana use in other tobacco/nicotine products was stable or declined across time. This time period also saw a concurrent rise nationally in the number of adolescents and young adults vaping marijuana,^{1,34} and a drastic increase in the number of adolescents and young adults using JUUL and similar pod vape devices for the inhalation of nicotine.³⁵ The popularity of these pod vape devices may be of particular importance to co-use and co-administration behaviors, as they were the most popular e-cigarette device type of this time period,³⁶ and they are easily modified for use with marijuana derivatives.²⁶ Indeed, using e-cigarettes for nicotine delivery and having peers who vape nicotine is associated with an increased likelihood of vaping marijuana.^{26,37}

There was either no significant change or declining use of marijuana in the other products that are typically marketed as tobacco/nicotine products, including spliffs, blunts, and hookah. The decline in using hookah for marijuana delivery coincides with the decline in hookah use nationally among adolescents that peaked in 2014, a time period that also saw a decline in combustible tobacco use,³⁸ possibly as young people switched to e-cigarette devices.

Limitations

This is among the first studies to longitudinally explore the changing behaviors of young adults using tobacco/nicotine products for marijuana delivery, yet it has limitations. First, our survey did not specifically ask about the addition of tobacco/nicotine used concurrently with marijuana in hookah or e-cigarettes, nor did it specifically ask about “hacking” e-cigarettes to include marijuana or its derivatives. Thus, findings related to hookah and e-cigarettes do not definitively include co-administration behaviors. Rather, they describe marijuana use in products that are typically advertised for tobacco/nicotine delivery.²³ Second, we used a convenience sample of Texas college students; findings may not be generalizable to other larger and more diverse young adult samples. However, few studies can demonstrate the changing behaviors of young adults using the most popular and

prevalent tobacco/nicotine products for marijuana delivery, particularly in a state with continued prohibition of recreational cannabis.

Conclusions

The diverse array of products in the contemporary tobacco landscape provides new and popular devices capable of delivering marijuana/marijuana extracts in unprecedented concentrations,¹⁸ in portable and easily concealable ways,³⁹ with or without the addition of nicotine. Co-administration of tobacco/nicotine with marijuana is associated with health concerns such as increased dependence⁴⁰ and other substance use problems.⁴¹ Health professionals should pay specific attention to the potential unique harms related to vaping marijuana, including an increased risk of driving under the influence,⁴² respiratory problems,⁴³ and the presence of harmful trace volatile compounds, particularly from unregulated markets.³⁹ This study's findings coincide with changes in the commercial tobacco and marijuana markets of the time period, where some terminology and products became synonymous and identical between nicotine-delivery practices and those of marijuana.^{44,45} For example, "vaping" now regularly also refers to exclusive marijuana delivery, and new terms such as "JUULing" relate to the device used, regardless of the device's ingredients.^{44,46} Our findings suggest that the popularity of nicotine e-cigarettes may be expanding the avenues for marijuana delivery among young adults, particularly as the modalities of marijuana delivery continue to diversify. Specific, in-depth research is needed on the nicotine and marijuana co-administration behaviors of young adults,⁴⁷ as increasingly available legal recreational marijuana may increase use of marijuana in tobacco products.⁸

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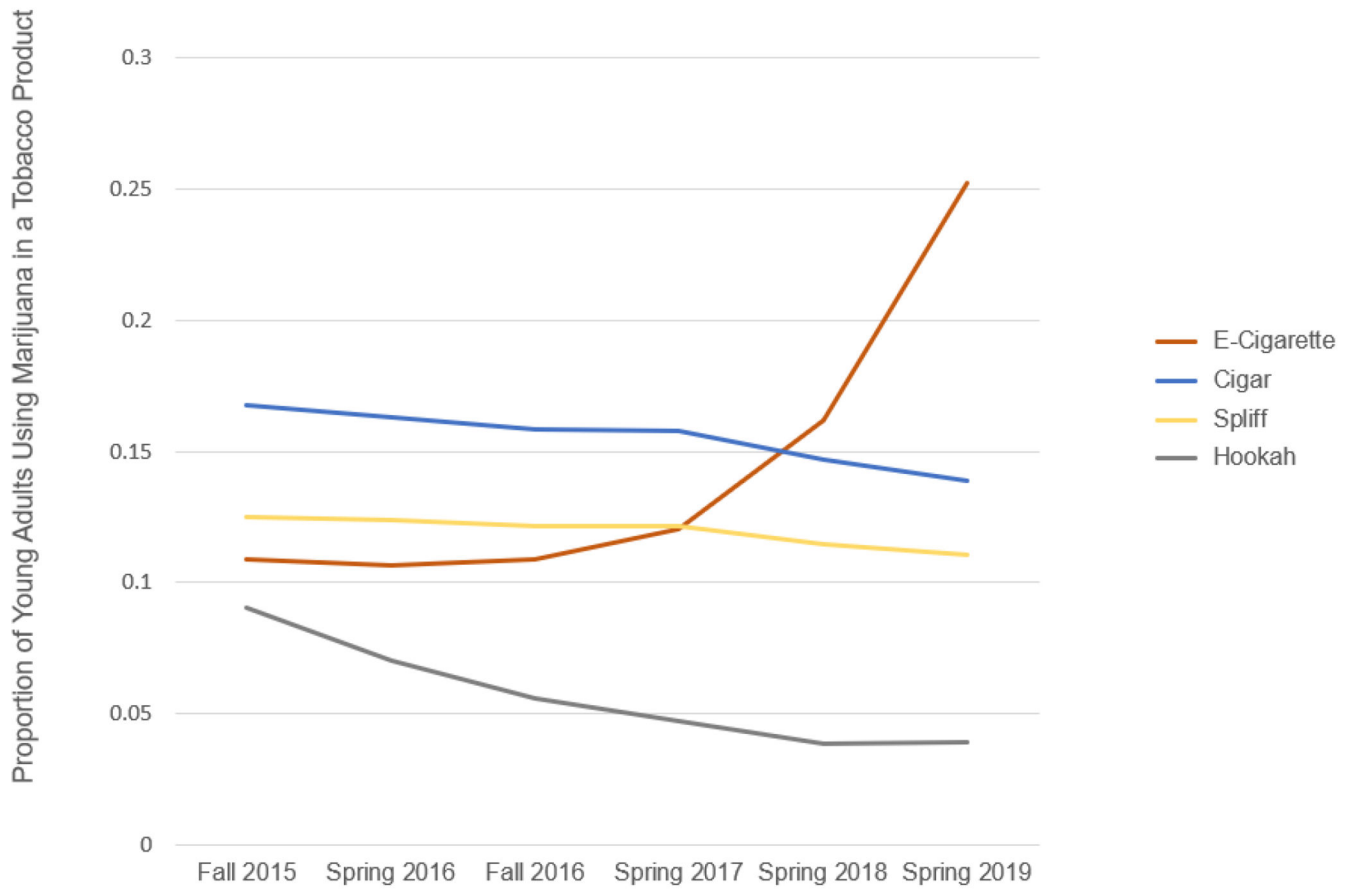


Figure 1: Growth Curve Models of Proportion of Participants Reporting of Past 6-Month Use of Marijuana in Four Tobacco Products across 3.5 Years from Fall 2015 to Spring 2019 (N=4857)

Marijuana Use in Tobacco Products, 2015–2019 (N = 4857)

Table 1:

Past 6-Month Marijuana Use	Wave 3 Fall 2015 n = 4270	Wave 4 Spring 2016 n = 4363	Wave 5 Fall 2016 n = 4204	Wave 6 Spring 2017 n = 4316	Wave 8 Spring 2018 n = 4075	Wave 9 Spring 2019 n = 3746
In a spliff (hand rolled cigarette with tobacco)	12.5% (535)	12.7% (555)	11.6% (489)	12.0% (519)	11.7% (478)	11.0% (411)
In a cigar/blunt	16.6% (708)	16.1% (704)	16.3% (686)	15.7% (676)	15.1% (615)	13.6% (508)
In hookah	9.1% (387)	7.3% (320)	4.7% (199)	5.1% (220)	4.1% (166)	3.8% (143)
In any e-cigarette device	11.8% (505)	10.5% (458)	9.6% (402)	10.9% (468)	19.2% (782)	23.9% (897)

Table 2:

Odds Ratios and 95% Confidence Intervals for Model Parameters (N=4857)

	Spiffs	Blunts	Hookah	E-Cigarettes
Male sex (vs. female)	1.48 [1.24 - 1.76]	1.29 [1.05 - 1.58]	1.02 [0.86 - 1.20]	1.51 [1.29 - 1.77]
Race/Ethnicity (vs. non-Hispanic white)	-	-	-	-
- Hispanic/Latino	1.21 [0.98 - 1.49]	1.09 [0.86 - 1.40]	1.42 [1.16 - 1.74]	0.97 [0.80 - 1.17]
- African American/Black	1.00 [0.71 - 1.42]	2.30 [1.59 - 3.35]	1.83 [1.36 - 2.48]	0.80 [0.59 - 1.10]
- Asian	0.76 [0.59 - 0.99]	0.48 [0.35 - 0.66]	1.42 [1.13 - 2.48]	0.67 [0.53 - 0.84]
- Other/multiple	1.06 [0.75 - 1.49]	1.09 [0.74 - 1.61]	1.86 [1.37 - 2.52]	1.20 [0.90 - 1.62]
Age	0.87 [0.69 - 1.10]	0.68 [0.52 - 0.88]	0.86 [0.69 - 1.07]	1.09 [0.87 - 1.35]
4-Year College (vs. 2-year)	1.32 [0.84 - 2.07]	0.93 [0.58 - 1.49]	1.56 [1.05 - 2.30]	1.06 [0.72 - 1.56]
SGM Identity (vs. heterosexual/cisgender)	2.34 [1.92 - 2.84]	2.28 [1.82 - 2.87]	1.44 [1.20 - 1.73]	2.18 [1.83 - 2.60]
Time	0.97 [0.92 - 1.03]	0.97 [0.92 - 1.04]	0.49 [0.41 - 0.59]	0.84 [0.73 - 0.97]
Time (quadratic)	-	-	1.14 [1.08 - 1.19]	1.18 [1.13 - 1.22]