



Cannabis and vaping nicotine: An exploration of risk factors using a nationally representative sample of youth and young adults

Elizabeth K. Do^{a,b,*}, Stephanie N. Yoon^a, Tatum McKay^a, Barbara A. Schillo^a, Elizabeth C. Hair^{a,c,d}

^a Schroeder Institute, Truth Initiative, Washington, DC, USA

^b Milken Institute School of Public Health, George Washington University, Washington, DC, USA

^c Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA

^d School of Global Public Health, New York University, New York, NY, USA

ARTICLE INFO

Keywords:

Nicotine

Risk factors

ABSTRACT

Background: Given that cannabis and e-cigarettes are among the most commonly used substances among young people, there is a need to identify risk factors for concurrent cannabis consumption and nicotine vaping among youth and young adults.

Methods: Data were obtained from the Truth Longitudinal Cohort, collected from September 2020 to March 2021, among a cohort aged 15–24 years (N = 6379). Chi-square tests were conducted to detect differences in sample characteristics by dual use status (never e-cigarette and never cannabis users, never cannabis and former/noncurrent e-cigarette users, never e-cigarette and former/noncurrent cannabis users, former/noncurrent e-cigarette and cannabis users, current e-cigarette only users, current cannabis only users, and concurrent cannabis and e-cigarette dual users). Multinomial logistic regression was used to determine key demographic variables predicting dual use status.

Results: Household tobacco use (Relative Risk Ratio, RRR = 4.93), higher sensation seeking (RRR = 3.98), and mental health score (RRR = 2.58) were associated with higher risk of dual use. Being 15–17 years (RRR = 0.22), being female (RRR = 0.59) and having parents with an education level of some college or more (RRR = 0.64) were associated with lower risk of dual use.

Conclusion: Findings suggest the need to carefully monitor cannabis and vaping nicotine among young people. The identification of risk factors provides additional guidance for prevention and treatment efforts, suggesting the need to address use of both substances and target those most at risk.

1. Introduction

Although cannabis is currently classified as a Schedule I controlled substance (i.e., has a high potential for abuse and no acceptable medicinal use) in the United States (US) (Drug Enforcement Administration, 2023), there is a growing trend across the nation towards more permissive cannabis policies (Hammond et al., 2021) – inclusive of policies that decriminalize cannabis or allow for the legalization of medicinal and/or recreational cannabis for adults (O'Grady et al., 2022). As of February 2024, 24 states and the District of Columbia (DC) have legalized the recreational use of cannabis for those aged 21 and older. Another 14 states have legalized cannabis use for medicinal purposes (Shah, 2024).

Although there has been some concern that legalization of cannabis use for adults may increase youth and young adult access and use of cannabis products (O'Grady et al., 2022), cannabis use rates have remained steady over the past few years. In 2021, 17.3 % of 10th graders (generally aged 14–15 years) and 30.5 % of 12th graders (generally aged 17–18 years) reported past year cannabis use. By 2023, 17.8 % of 10th graders and 29.0 % of 12th graders reported past year cannabis use. Past year, past month, and daily cannabis use rates have increased over the past few decades, according to data obtained from a nationally representative sample of US high school students participating in Monitoring the Future (Monitoring the Future, 2023). Cannabis use among young adults (aged 18–35 years) has also been relatively stable, as 24.6 % of 18–25 year olds reported past month cannabis use in 2021 and 25.9 % of

* Corresponding author at: 900 G St NW, 4th Floor, Washington, DC, 20001, USA.

E-mail address: edo@truthinitiative.org (E.K. Do).

<https://doi.org/10.1016/j.addbeh.2024.108094>

Received 1 February 2024; Received in revised form 12 June 2024; Accepted 17 June 2024

Available online 22 June 2024

0306-4603/© 2024 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

18–25 year olds reported past month cannabis use in 2022, according to the National Survey of Drug Use and Health (Substance Abuse and Mental Health Services Administration, 2023).

Currently, cannabis is one of the most commonly used illicit substances among US youth and young adults (Hammond et al., 2021; Substance Abuse and Mental Health Services Administration, 2021). Although inhalation of combusted cannabis remains the most popular method for cannabis consumption, the emergence and growing popularity of electronic cigarettes (e-cigarettes) have provided users of cannabis another method for inhaling cannabinoids using vaping devices (Giroud et al., 2015). Vaping is defined by the Drug Enforcement Administration (DEA) as the “act of inhaling and exhaling an aerosol or vapor made from a liquid or dry material that is heated in an electronic powered device, called an electronic cigarette, or e-cigarette” (Drug Enforcement Administration, 2019). The prevalence of lifetime (6.1 % to 13.6 %), past year (7.2 % to 13.2 %), and past month (1.6 % to 8.4 %) cannabis vaping has increased from 2013 to 2020, according to a recent systematic review and meta-analysis of data from the US and Canada, obtained from participants aged 18 years or younger (Lim et al., 2022).

Adolescent cannabis vaping has been associated with negative health outcomes, such as respiratory symptoms and poorer cognitive development (Lim et al., 2022). There is evidence to suggest that electronic nicotine delivery system (ENDS, including e-cigarettes) use is associated with an increased risk of cannabis use in both longitudinal (adjusted odds ratio, aOR = 2.43; 95 % CI: 1.51, 3.90) and cross-sectional studies (aOR = 3.70, 95 % CI: 2.76, 4.96) (Chadi et al., 2019) and youth (aged 12–17 years) who use cannabis are more likely to report e-cigarette (OR = 4.5; 95 % CI: 2.9, 6.9) use over one year (Weinberger et al., 2020).

Given the links between cannabis and e-cigarette use among youth and young adults, there is a need to continue monitoring the reported concurrent use of cannabis and e-cigarettes among young people. This is especially true as more states legalize adult use of cannabis, and the cannabis market expands. The current study expands upon existing work, focused on characterizing prevalence of past 30-day cannabis vaping among youth and young adults. Specifically, whereas the systematic review and meta-analysis conducted by Lim et al. (2022) only includes participants aged 18 years or younger, our study provides information on concurrent cannabis and e-cigarette use among a nationally representative sample of youth and young adults (aged 15–24 years). Conducting this work allows for the identification of risk factors for concurrent dual use of cannabis and vaping nicotine among this population, while also determining whether any risk factors across different cannabis and e-cigarette user groups are overlapping.

2. Methods

2.1. Data source

Data were obtained from participants of the Truth Longitudinal Cohort (TLC), a nationally representative sample of youth and young adults that was originally started to evaluate the national truth® campaign in April 2014. Participants are recruited primarily via probability-based sampling of addresses in the United States (US) Postal Service’s Delivery Sequence File, drawn from an estimated 97 % of all US households, regardless of telephone status. Additional participants were recruited via an existing national online panel (Ipsos’ KnowledgePanel). Individuals aged 15–24 years were randomly selected to participate from within eligible households. All participants are asked to complete online follow-up surveys, at least annually. Survey measures include questions regarding participant’s attitudes, beliefs, and behaviors regarding tobacco and other substances – including experimentation with products, frequency of use, and multiple product use. All participants provided informed consent and/or assent via electronic form prior to study participation. The analytic sample was comprised of participants who had provided data collected from September 2020 to March 2021. As stated elsewhere (Kreslake et al., 2023), a large

refreshment sample was recruited in 2020 to address attrition and aging of the original cohort. Additional details regarding the methodology have been previously published (Cantrell et al., 2018). All study protocols were approved by Advarra Institutional Review Board (Pro00009087).

2.2. Measures

Participants were asked if they had ever used e-cigarettes, and if so, on how many days in the past 30 days. Participants were also asked if they had ever used cannabis and if so, how many days in the past 30 days. Responses to these questions were used to construct a seven-level outcome variable, indicating dual use status: 1) never e-cigarette and never cannabis users, 2) former/noncurrent e-cigarette and never cannabis users, 3) former/noncurrent cannabis and never e-cigarette users, 4) former/noncurrent user of e-cigarettes and cannabis, 5) current e-cigarette only users, 6) current cannabis only users, 7) concurrent e-cigarette and cannabis dual users (“dual user”). Former/noncurrent use was defined as reporting ever use of a given product, but not within the past 30 days. Current use was defined as reporting use on of a given product on at least one day of the past 30 days. Concurrent use was defined as reporting use of both products on at least one day of the past 30 days.

Covariates included biological sex (male, female), age (15–17, 18–20, 21–24), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic or Latino, another race/ethnicity), lesbian, gay, bisexual, transgender, queer or questioning (LGBTQ) identity (heterosexual/straight, gay/lesbian, bisexual, another identity/not sure), perceived financial situation (don’t meet basic expenses/just meets basic expenses, meets needs with a little left/lives comfortably), household tobacco products (no tobacco products, at least one product), parental education (less than college, some college or more), sensation seeking (dichotomized as low vs. high, based on score of 4 or greater), and mental health status (calculated as a combined mean score, ranging from 1 to 4, based on how true participants felt that the following items were: “you have trouble sleeping”, “you are unhappy, sad or depressed”, and “you have trouble concentrating or paying attention”, with higher mean scores indicative of more mental health challenges).

2.3. Statistical analyses

Frequencies and weighted percentages are presented for sample characteristics. Chi-square tests were conducted to detect statistically significant differences in sample characteristics by dual use status. Multinomial logistic regression was used to evaluate key demographic variables that predict dual use status, indicative of e-cigarette and cannabis use behaviors. Specifically, multinomial logit (mlogit) models were estimated. The resulting exponentiated coefficients represent ratios of relative risks, rather than ratios of odds and are reflective of the ratio of the probabilities for the outcome between the reference group and other groups (StataCorp, 2023). Survey responses are weighted to US census quotas, according to age, race, and gender so that it is nationally representative and account for the complex sampling design of the TLC and nonresponse. Stata 18.0 (StatCorp, LLC: College Station, TX) was used in all analyses.

3. Results

Table 1 shows the sample characteristics and tobacco/cannabis use behaviors by dual use status (N = 6379). More than half of the sample (54.0 %) were never cannabis and never e-cigarette users, followed by former/noncurrent e-cigarette and cannabis users (10.0 %), current cannabis only users (9.0 %), never cannabis and former/noncurrent e-cigarette users (8.5 %), concurrent cannabis and e-cigarette dual users (6.8 %), current e-cigarette only users (6.1 %), and never e-cigarette and former/noncurrent cannabis users (5.7 %).

Table 1
Sociodemographic Characteristics by Dual Use Status (N = 6379).

	Total (Full Sample)		Never cannabis and never e-cigarette users (N = 3321, Weighted % = 54.0%)		Never cannabis and former/ noncurrent e-cigarette users (N = 552, Weighted % = 8.5%)		Never e-cigarette and former/ noncurrent cannabis users (N = 391, Weighted % = 5.7%)		Former/ noncurrent e-cigarette and cannabis users (N = 667, Weighted % = 10.0%)		Current e-cigarettes only users (N = 384, Weighted % = 6.1%)		Current cannabis only users (N = 591, Weighted % = 9.0%)		Concurrent cannabis and e-cigarette dual users (N = 468, Weighted % = 6.8%)		Missing	Chi2 (p-value)
	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	Wt %	Unwt N	
Age																		477.58 (<0.01)
15-17 years	1,576	31.2	1,128	42.3	143	31.6	43	14.1	81	15.6	67	20.2	53	11.1	61	16.3	1	
18-20 years	2,347	27.8	1,207	26.5	224	31.6	142	31.3	223	23.5	142	27.8	211	29.0	198	35.6	3	
21-24 years	2,451	41.0	986	31.2	185	36.8	206	54.6	363	60.9	175	52.1	327	59.9	209	48.1	1	
Biological Sex (missing=1)																		37.32 (<0.01)
Male	2,847	51.0	1,540	51.5	252	51.4	158	49.9	249	45.9	170	51.1	235	48.9	243	57.9	4	
Female	3,526	49.0	1,780	48.5	300	48.6	233	50.1	418	54.1	214	48.9	356	51.1	225	42.1	1	
Race and Ethnicity (missing=11)																		48.95 (<0.01)
Non-Hispanic White	3,669	51.8	1,885	51.6	327	49.9	221	50.3	398	55.3	239	56.9	317	46.6	282	53.5	1	
Non-Hispanic Black	601	13.4	329	13.7	39	12.7	43	14.1	45	7.9	26	11.3	89	22.2	30	9.5	0	
Hispanic	1,348	23.5	685	22.0	124	26.5	83	24.4	153	27.8	78	19.2	120	22.6	105	29.0	3	
Another race	745	11.4	415	12.7	62	10.9	43	11.3	70	9.0	41	12.6	65	8.6	49	8.0	1	
Lesbian, Gay, Bisexual, Transgender, Questioning and Queer (LGBTQ) Identity (missing=3)																		175.87 (<0.01)
Heterosexual/straight	5,198	82.6	2,795	84.3	484	87.4	318	84.8	519	77.4	325	85.7	417	74.8	340	75.8	5	
Gay/lesbian	200	3.2	77	2.5	16	3.2	14	3.3	22	3.8	12	3.3	31	4.0	28	6.1	0	
Bisexual	570	7.7	208	5.6	32	4.8	37	7.5	88	12.8	32	6.9	100	14.6	73	12.7	0	
Another identity/not sure	403	6.5	239	7.6	20	4.6	22	4.5	38	5.9	15	4.1	43	6.6	26	5.4	0	
Perceived Financial Situation (missing=3)																		66.23 (<0.01)
Does not meet basic needs/Just meets basic expenses	1,387	19.4	614	16.3	118	18.2	96	22.2	144	21.0	108	28.0	181	26.3	126	24.1	3	
Meets need with little left over/lives comfortably	4,984	80.6	2,704	83.7	434	81.8	295	77.9	523	79.0	276	72.1	410	73.7	342	75.9	2	
Household Smoking (missing=22)																		485.40 (<0.01)
No tobacco products are used	4,863	77.7	2,830	85.6	401	72.1	292	76.1	514	77.3	200	54.6	394	69.3	232	54.5	2	
At least one tobacco product is used	1,489	22.3	484	14.4	150	27.9	99	23.9	149	22.8	178	45.4	194	30.7	235	45.5	3	
Sensation seeking (dichotomized mean)																		175.89 (<0.01)
Low (score below 4)	5,839	91.7	3,161	95.1	511	92.8	363	90.7	584	87.6	331	86.3	510	85.9	379	82.8	4	
High (score of 4 or greater)	535	8.3	160	4.9	41	7.2	28	9.3	83	12.4	53	13.7	81	14.1	89	17.2	1	
Parental Education (missing=239)																		51.86 (<0.01)
High school or less	1,401	23.6	638	19.9	121	21.7	78	23.8	153	27.6	124	34.5	160	28.1	127	33.3	1	
Some college or more	4,734	76.4	2539	80.1	413	78.3	296	76.2	492	72.4	251	65.5	416	71.9	327	66.7	4	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.		
Mental Health (mean) (missing=2; range: 1 to 4)	2.52	0.01	2.37	0.02	2.56	0.04	2.59	0.05	2.75	0.04	2.62	0.05	2.75	0.04	2.90	0.04	6	422.74 (<0.01)

Note. Unwt = unweighted. Wt = weighted.

The sample was split almost evenly among those who identified as male (51.0 %) and non-Hispanic White (51.8 %). Approximately 41.0 % of the sample was aged 21–24 years, and majority identified as heterosexual/straight (82.6 %), met financial needs with a little left over or lived comfortably (80.6 %), reported no household tobacco use (77.7 %), had a low sensation seeking scores (91.7 %), and have parents with some college education or higher (76.4 %). On average, the mental health score of the sample is 2.52 (SE = 0.01).

Chi-square tests of differences were statistically significant for dual user status across all covariates (also shown on Table 1). For example, a greater proportion of never cannabis and never e-cigarette users identified as: between the age of 15–17 years (42.3 % vs. 16.3 %), female (48.5 % vs. 42.1 %), non-Hispanic Black (13.7 % vs. 9.5 %) or another race (12.7 % vs. 8.0 %), heterosexual/straight (84.3 % vs. 75.8 %); met financial needs with a little left over or lives comfortably (83.7 % vs. 75.9 %); had parents with some college education or higher (80.1 % vs. 66.7 %); reported no tobacco products used in the household (85.6 % vs. 54.5 %); and had low sensation seeking scores (95.1 % vs. 82.8 %), compared to dual users.

Similarly, a greater proportion of never cannabis and former/noncurrent e-cigarette users identified as between the age of 15–17 years (31.6 % vs. 16.3 %), female (48.6 % vs. 42.1 %), non-Hispanic Black (12.7 % vs. 9.5 %) or another race (10.9 % vs. 8.0 %), heterosexual/straight (87.4 % vs. 75.8 %); met financial needs with a little left over or lives comfortably (81.8 % vs. 75.9 %); have parents with some college education or higher (78.3 % vs. 66.7 %); reported no tobacco products used in the household (72.1 % vs. 54.5 %); and, had low sensation seeking scores (92.8 % vs. 82.8 %), when compared to dual users.

Meanwhile, a greater proportion of never e-cigarette and former/noncurrent cannabis users were between the age of 21–24 years (54.6 % vs. 48.1 %); identified as female (50.1 % vs. 42.1 %); identified as non-Hispanic Black (14.1 % vs. 9.5 %) or another race (11.3 % vs. 8.0 %); identified as heterosexual/straight (84.8 % vs. 75.8 %); met financial needs with a little left over or lives comfortably (77.9 % vs. 75.9 %); have parents with some college education or higher (76.2 % vs. 66.7 %); reported no tobacco products used in the household (76.1 % vs. 54.5 %); and had low sensation seeking scores (90.7 % vs. 82.8 %), when compared to dual users.

Relative to dual users, a greater proportion of former/noncurrent e-cigarette and cannabis users identified as: between the age of 21–24 years (60.9 % vs. 48.1 %); female (54.1 % vs. 42.1 %); non-Hispanic White (55.3 % vs. 53.5 %) or another race (9.0 % vs. 8.0 %); heterosexual/straight (77.4 % vs. 75.8 %), bisexual (12.8 % vs. 12.7 %), or another identity (5.9 % vs. 5.4 %); met financial needs with a little left over or lives comfortably (79.0 % vs. 75.9 %); have parents with some college education or higher (72.4 % vs. 66.7 %); reported no tobacco products used in the household (77.3 % vs. 54.5 %), and had low sensation seeking scores (87.6 % vs. 82.8 %).

Compared to dual users, a greater proportion of current e-cigarette only users were between the age of 15–17 years (20.2 % vs. 16.3 %) or 21–24 years (52.1 % vs. 48.1 %), identified as female (48.9 % vs. 42.1 %), identified as non-Hispanic White (56.9 % vs. 53.5 %), non-Hispanic Black (11.3 % vs. 9.5 %) or another race (12.6 % vs. 8.0 %), identified as heterosexual/straight (85.7 % vs. 75.8 %), did not meet basic needs or just met basic expenses (28.0 % vs. 24.1 %), have parents with high school education or less (34.5 % vs. 33.3 %), reported no tobacco products used in the household (54.6 % vs. 54.5 %), and had low sensation seeking scores (86.3 % vs. 82.8 %).

Finally, when compared to dual users, a greater proportion of current cannabis only users were between the age of 21–24 years (59.9 % vs. 48.1 %), identified as female (51.1 % vs. 42.1 %), identified as non-Hispanic Black (22.2 % vs. 9.5 %) or another race (8.6 % vs. 8.0 %), identified as bisexual (14.6 % vs. 12.7 %) or another identity/not sure (6.6 % vs. 5.4 %), did not meet basic needs or just met basic expenses (26.3 % vs. 24.1 %), have parents with some college education or higher

(71.9 % vs. 66.7 %), reported no tobacco products used in the household (69.3 % vs. 54.5 %), and had low sensation seeking scores (85.9 % vs. 82.8 %).

Table 2 presents results from the multinomial logistic regression model (reference: never cannabis and never e-cigarette users). Household tobacco use (Relative Risk Ratio, RRR = 4.93), high sensation seeking (RRR = 3.98), identifying as bisexual (RRR = 1.76), and higher mental health scores (RRR = 2.58) were associated with an increased risk of dual use, while being 15–17 years (RRR = 0.22), being female (RRR = 0.59), and having parents with an education level of some college or more (RRR = 0.64) were associated with a decreased risk of dual use.

Younger age (e.g., being aged 15–17 years) was also associated with a decreased risk of being a never cannabis and noncurrent e-cigarette user (RRR = 0.58), never e-cigarette and former/noncurrent cannabis user (RRR = 0.15), noncurrent e-cigarette and cannabis user (RRR = 0.15), current e-cigarette only user (RRR = 0.28), and current cannabis only user (RRR = 0.13). Compared to those who identified as non-Hispanic White, those who identified as non-Hispanic Black or as another race/ethnicity were more likely to be former/noncurrent e-cigarette and cannabis users (RRR = 0.58 and 0.63, respectively). Meanwhile, compared to those who identify as non-Hispanic White, those identify as non-Hispanic Black were more likely to be a current cannabis only user (RRR = 1.98). Compared to those who identified as heterosexual/straight, those who identified as bisexual were more likely to be a former/noncurrent e-cigarette and cannabis user (RRR = 1.76). Compared to those that did not have tobacco products used in the household, at least one tobacco product being used in the home was associated with higher likelihood of being a part of all use groups, relative to never cannabis and never e-cigarette users (RRR range: 1.98–4.93). Similarly, compared to those with lower mental health averages, increased mental health average was associated with higher likelihood of being a part of all use groups, relative to never cannabis and never e-cigarette users (RRR range: 1.40–2.58).

4. Discussion

Results are consistent with other reported estimates from 2022 (Monitoring the Future, 2023) and demonstrate that a sizable proportion of young people report concurrent dual use of cannabis and e-cigarettes (6.8 %). This is concerning as the dual use of cannabis and e-cigarette products can lead to negative health effects, which can be serious for young people whose brains and bodies are still developing (Roberts et al., 2022). Additionally, the concurrent use of cannabis and vaping nicotine has been found to increase the severity of withdrawal symptoms and hinder cessation efforts (Lemyre et al., 2019). Risk factors for dual use (of cannabis and vaping nicotine) included older age, male gender, identifying as bisexual, household tobacco use, higher sensation seeking, lower parental education, and higher mental health score. These findings are consistent with prior studies examining risk factors for concurrent dual use of cannabis and tobacco in ninth to twelfth graders (Wills et al., 2021) and young adults aged 21–30 years (Seaman et al., 2019).

While the focus of this study was to identify key predictors of dual use of cannabis and nicotine vaping, results also demonstrated overlapping risk factors with current cannabis only and current e-cigarette only use – specifically, household tobacco use, high sensation seeking, and mental health scores. Prior literature supports these findings. For example, household tobacco use has been associated with adolescent e-cigarette and cannabis use in a longitudinal cohort sample (Coleman et al., 2021). Sensation seeking has also been associated with several types of e-cigarette use, inclusive of nicotine only, marijuana only, flavoring only, or nicotine and marijuana (Hoffmann, 2021). Poor mental health (Guxensa et al., 2007) and mental health symptoms or illness, such as depression (Do et al., 2023; Obisesan et al., 2019) have been identified as risk factors for nicotine vaping and cannabis among

Table 2

Multinomial Regression Model Results Predicting Dual Use Status (Reference = Never e-cigarette and never cannabis user).

	Never cannabis and former/ noncurrent e- cigarette users RRR (95% CI)	Never e-cigarette and former/noncurrent cannabis users RRR (95% CI)	Former/noncurrent e- cigarette and cannabis users RRR (95% CI)	Current e- cigarette only users RRR (95% CI)	Current cannabis only users RRR (95% CI)	Current e-cigarette and cannabis dual users RRR (95% CI)
Age						
15–17 years	0.58* (0.44, 0.78)	0.15* (0.10, 0.22)	0.15* (0.11, 0.21)	0.28* (0.20, 0.41)	0.13* (0.09, 0.19)	0.22* (0.15, 0.32)
18–20 years	1.01 (0.77, 1.33)	0.67* (0.50, 0.90)	0.45* (0.36, 0.58)	0.67* (0.50, 0.92)	0.57* (0.44, 0.74)	0.94 (0.70, 1.25)
21–24 years	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Biological Sex						
Male	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Female	0.99 (0.78, 1.25)	1.04 (0.78, 1.38)	1.02 (0.81, 1.28)	0.93 (0.70, 1.24)	0.88 (0.69, 1.12)	0.59* (0.45, 0.77)
Race						
Non-Hispanic White	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Non-Hispanic Black	1.04 (0.68, 1.58)	1.16 (0.76, 1.76)	0.58* (0.38, 0.89)	0.66 (0.38, 1.12)	1.98* (1.38, 2.85)	0.71 (0.43, 1.17)
Hispanic	1.30 (0.97, 1.74)	1.11 (0.78, 1.59)	1.17 (0.88, 1.55)	0.69* (0.48, 0.98)	1.18 (0.87, 1.60)	1.26 (0.89, 1.77)
Another race	0.88 (0.60, 1.29)	0.82 (0.49, 1.36)	0.63* (0.43, 0.93)	0.86 (0.53, 1.39)	0.69 (0.46, 1.02)	0.58* (0.38, 0.90)
LGBTQ						
Heterosexual/straight	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Gay/lesbian	1.03 (0.52, 2.08)	1.01 (0.48, 2.11)	1.10 (0.57, 2.10)	0.97 (0.45, 2.06)	1.20 (0.70, 2.07)	1.67 (0.91, 3.07)
Bisexual	0.65 (0.40, 1.05)	1.16 (0.72, 1.85)	1.76* (1.21, 2.56)	0.84 (0.50, 1.42)	2.19* (1.51, 3.17)	1.76* (1.17, 2.64)
Another identity/not sure	0.58 (0.33, 1.02)	0.52* (0.28, 0.95)	0.77 (0.48, 1.23)	0.47 (0.22, 1.00)	0.71 (0.45, 1.12)	0.67 (0.38, 1.19)
Perceived Financial Situation						
Does not meet basic needs/Just meets basic expenses	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Meets needs with little left over/lives comfortably	1.08 (0.80, 1.46)	0.91 (0.66, 1.25)	1.06 (0.80, 1.39)	0.74 (0.52, 1.03)	0.91 (0.68, 1.21)	1.05 (0.76, 1.46)
Household Smoking						
No tobacco products are used	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
At least one tobacco product is used	2.43* (1.84, 3.21)	1.98* (1.45, 2.72)	1.80* (1.36, 2.37)	4.69* (3.48, 6.31)	2.48* (1.89, 3.27)	4.93* (3.73, 6.53)
Sensation seeking (dichotomized mean)						
Low (score < 4)	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
High (score ≥ 4)	1.47 (0.95, 2.26)	2.25* (1.33, 3.82)	2.95* (2.03, 4.27)	3.27* (2.14, 4.99)	3.43* (2.37, 4.95)	3.98* (2.71, 5.87)
Parental Education						
High school or less	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE	REFERENCE
Some college or more	1.03 (0.77, 1.37)	0.95 (0.66, 1.37)	0.77 (0.59, 1.02)	0.56* (0.41, 0.76)	0.83 (0.62, 1.11)	0.64* (0.47, 0.87)
Mental Health (mean; range = 1 to 4)	1.40* (1.20, 1.62)	1.50* (1.23, 1.82)	1.79* (1.53, 2.10)	1.53* (1.26, 1.86)	1.89* (1.60, 2.24)	2.58* (2.11, 3.18)

Note. *p < 0.05. REFERENCE = reference group; RRR = Relative Risk Ratio.

youth and young adults.

In efforts to prevent and reduce cannabis and e-cigarette use among young people, a better understanding of the relationships between these substances is needed (Lemyre et al., 2019). In support of this public health goal – especially as cannabis legalization expands across the United States – results from the current study suggest the need for continued surveillance of cannabis and nicotine vaping behaviors among young people. Specifically, longitudinal studies including measures of cannabis and nicotine vaping behaviors are needed to characterize patterns of use of these products over time. Given how common concurrent cannabis and e-cigarette use is among young people, and how poor cessation outcomes for adults who use both products are,

results suggest that prevention efforts may be more efficacious if both substances are addressed (Moustafa et al., 2022). The high rates of dual use of cannabis and e-cigarettes also suggest that healthcare providers should screen for cannabis and vaping nicotine behaviors among young people (Chadi et al., 2019). Results from the current study also provide potential intervention targets for public health messaging campaigns aimed at reducing use of cannabis and/or nicotine vaping among young people by identifying groups that are at increased risk of using these products – specifically those who reside tobacco product users, are sensation seekers, and are potentially experiencing mental health challenges.

As with all studies, there are limitations to consider. First, the legality

of cannabis is not uniform in the United States. Thus, there may be some underreporting of cannabis use due to the sensitive and political nature of cannabis and the illegal status of cannabis at the federal level (Congressional Research Service, 2023). There could also potentially be differences in risk factors between states that have legalized adult use of cannabis, states that have only legalized medical use of cannabis, and states that have not legalized cannabis at all that are not accounted for in the current study. Due to the varying levels of legal status, the generalizability of the results may be limited. Additionally, this study does not consider the mode of cannabis consumption. This is an important factor to consider, given that the prevalence of using e-cigarettes to vape cannabis oil among past 30 day users of cannabis in the US has increased from 24.2 % in 2017 to 33.0 % in 2019, according to data obtained from the International Tobacco Control Policy Evaluation Project (ITC) Youth Tobacco and Vaping Survey (Waves 1–3) (Hammond et al., 2021). This is concerning as cannabis oil and concentrates typically contain a higher proportion of tetrahydrocannabinol (THC) – the psychoactive component in marijuana – relative to herbal cannabis (e.g., 70.3 % vs. 21.4 % for products sold in licensed retail stores) (Pacula & Smart, 2017). Finally, reporting biases may be present, as data was derived from self-reported measures of sensitive information (e.g., illicit substance use), among a youth and young adult sample.

Despite these limitations, this study is one of the few nationally representative studies (Jacobs et al., 2021; Mattingly et al., 2020) that examines cannabis and nicotine vaping and uses the most recent data available to examine risk factors for concurrent cannabis and e-cigarette use among youth and young adults. This study also demonstrates that those aged 21–24 years are at an even higher risk of concurrent, dual use of cannabis and vaping nicotine, relative to 15–17-year-olds. Prior studies, focused on those aged 18 years and younger, have demonstrated a similar pattern, whereby the 30-day prevalence of cannabis vaping was higher in older adolescents (in grade 12), when compared to younger adolescents (Lim et al., 2022).

Future research will need to utilize a longitudinal approach to examine how the effect of risk factors for cannabis and vaping nicotine change over time. Additional research will also explore differences in risk factors for dual use across states with various cannabis policies. More research is needed to determine how these associations might change over time and how these risk factors might influence pattern use trajectories of these products over time. Furthermore, since the analysis conducted is cross-sectional in nature, more longitudinal research is needed to characterize trajectories of use for current cannabis only users, current e-cigarette only users, and dual users of cannabis and e-cigarettes. Conducting these analyses will allow for better characterization of product use patterns over time.

5. Conclusions

Dual use of cannabis and vaping nicotine among young people is concerning and warrants further research. Older age, male gender, bisexual identity, presence of household tobacco use, high sensation seeking, lower parental education, and more mental health challenges are risk factors for cannabis and nicotine vaping co-use. These risk factors provide guidance for prevention and treatment efforts, by emphasizing the need to address use of both substances and target those most at risk. Results also suggest the need to carefully monitor reported concurrent dual use of cannabis and e-cigarettes among young people, who may be exposing themselves to the negative health effects of both substances – especially as cannabis legalization grows in the US. Going further, results suggest the need to develop public health messaging campaigns that incorporate intersections between cannabis use and nicotine vaping.

Funding sources

None.

CRedit authorship contribution statement

Elizabeth K. Do: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Stephanie N. Yoon:** Writing – review & editing, Writing – original draft, Project administration. **Tatum McKay:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Barbara A. Schillo:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Elizabeth C. Hair:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgements

The authors would like to thank the participants for contributing their data to this work.

References

- Cantrell, J., Hair, E. C., Smith, A., Bennett, M., Rath, J. M., Thomas, R. K., Fahimi, M., Dennis, J. M., & Vallone, D. (2018). Recruiting and retaining youth and young adults: Challenges and opportunities in survey research for tobacco control. *Tobacco Control*, 27(2), 147–154. <https://doi.org/10.1136/tobaccocontrol-2016-053504>
- Chadi, N., Schroeder, R., Jensen, J. W., & Levy, S. (2019). Association between electronic cigarette use and marijuana use among adolescents and young adults: A systematic review and meta-analysis. *JAMA Pediatrics*, 173(10), e192574.
- Coleman, M., Donaldson, C. D., Crano, W. D., Pike, J. R., & Stacy, A. W. (2021). Associations between family and peer e-cigarette use with adolescent tobacco and marijuana usage: A longitudinal path analytic approach. *Nicotine & Tobacco Research*, 23(5), 849–855. <https://doi.org/10.1093/ntr/ntaa204>
- Congressional Research Service. (2023). The Federal Status of Marijuana and the Expanding Policy Gap with States. *Congressional Research Service*. <https://crsreports.congress.gov/product/pdf/IF/IF12270>.
- Do, E., Aarvig, K., Panigrahi, G., & Hair, E. (2023). Past-year mental illness diagnosis and E-cigarette use status among a college-aged sample: Findings from the national college health assessment (2017–2019). *American Journal of Health Promotion*, 1–10.
- Drug Enforcement Administration. (2019). Vaping & Marijuana Concentrates. *Drug Enforcement Administration*. https://www.dea.gov/sites/default/files/2019-10/VapingMarijuana_Brochure_2019_508.pdf.
- Drug Enforcement Administration. (2023). *Drug Scheduling*. <https://www.dea.gov/drug-information/drug-scheduling>.
- Giroud, C., De Cesare, M., Berthet, A., Varlet, V., Concha-Lozano, N., & Favrat, B. (2015). E-Cigarettes: A review of new trends in cannabis use. *International Journal of Environmental Research and Public Health*, 12(8). <https://doi.org/10.3390/ijerph120809988>
- Guxensa, M., Nebot, M., Ariza, C., & Ochoa, D. (2007). Factors associated with the onset of cannabis use: A systematic review of cohort studies. *Gaceta Sanitaria*, 21(3), 252–260. <https://doi.org/10.1157/13106811>
- Hammond, D., Wadsworth, E., Reid, J. L., & Burkhalter, R. (2021). Prevalence and modes of cannabis use among youth in Canada, England, and the US, 2017 to 2019. *Drug and Alcohol Dependence*, 219, Article 108505. <https://doi.org/10.1016/j.drugalcdep.2020.108505>
- Hoffmann, J. P. (2021). Sensation seeking and adolescent e-cigarette use. *Journal of Substance Use*, 26(5), 542–548. <https://doi.org/10.1080/14659891.2020.1856209>
- Jacobs, W., Idoko, E., Montgomery, L., Smith, M. L., & Merianos, A. L. (2021). Concurrent E-cigarette and marijuana use and health-risk behaviors among U.S. high school students. *Preventive Medicine*, 145, Article 106429. <https://doi.org/10.1016/j.ypmed.2021.106429>
- Kreslake, J. M., Aarvig, K., Liu, M. (Shiyang), Vallone, D. M., & Hair, E. C. (2023). Pathways to Quitting E-cigarettes Among Youth and Young Adults: Evidence From the truth® Campaign. *American Journal of Health Promotion*, 08901171231218492. Doi: 10.1177/08901171231218492.
- Lemyre, A., Poliakova, N., & Bélanger, R. E. (2019). The Relationship Between Tobacco and Cannabis Use: A Review. *Substance Use & Misuse*, 54(1), 130–145. <https://doi.org/10.1080/10826084.2018.1512623>

- Lim, C. C. W., Sun, T., Leung, J., Chung, J. Y. C., Gartner, C., Connor, J., Hall, W., Chiu, V., Stjepanović, D., & Chan, G. C. K. (2022). Prevalence of adolescent cannabis vaping: A systematic review and meta-analysis of US and Canadian Studies. *JAMA Pediatrics*, 176(1), 42–51. <https://doi.org/10.1001/jamapediatrics.2021.4102>
- Mattingly, D. T., Hirschtick, J. L., Meza, R., & Fleischer, N. L. (2020). Trends in prevalence and sociodemographic and geographic patterns of current menthol cigarette use among U.S. adults, 2005–2015. *Preventive Medicine Reports*, 20, 101227. Doi: 10.1016/j.pmedr.2020.101227.
- Monitoring the Future. (2023). *Trends in Annual Prevalence of Use of Various Drugs in Grades 8, 10, and 12*. University of Michigan. <https://monitoringthefuture.org/wp-content/uploads/2022/12/mtf2022table02.pdf>.
- Moustafa, A. F., Rodriguez, D., Pianin, S. H., Testa, S. M., & Audrain-McGovern, J. E. (2022). Dual use of nicotine and cannabis through vaping among adolescents. *American Journal of Preventive Medicine*, 63(1), 60–67. <https://doi.org/10.1016/j.amepre.2021.11.022>
- Obisesan, O. H., Mirbolouk, M., Osei, A. D., Orimoloye, O. A., Uddin, S. M. I., Dzaye, O., El Shahawy, O., Al Rifai, M., Bhatnagar, A., Stokes, A., Benjamin, E. J., DeFilippis, A. P., & Blaha, M. J. (2019). Association between e-cigarette use and depression in the behavioral risk factor surveillance system, 2016–2017. *JAMA Network Open*, 2(12). <https://doi.org/10.1001/jamanetworkopen.2019.16800>
- O'Grady, M. A., Iverson, M. G., Suleiman, A. O., & Rhee, T. G. (2022). Is legalization of recreational cannabis associated with levels of use and cannabis use disorder among youth in the United States? A rapid systematic review. *European Child & Adolescent Psychiatry*, 1–23. <https://doi.org/10.1007/s00787-022-01994-9>
- Pacula, R. L., & Smart, R. (2017). Medical marijuana and marijuana legalization. *Annual Review of Clinical Psychology*, 13(1), 397–419. <https://doi.org/10.1146/annurev-clinpsy-032816-045128>
- Roberts, M. E., Tackett, A. P., Singer, J. M., Wagner, D. D., Lu, B., Wagener, T. L., Brinkman, M., Klein, E. G., Vickerman, K. A., Wold, L. E., Gumina, R. J., & Mohler, P. J. (2022). Dual use of E-cigarettes and cannabis among young people in America: A new public health hurdle? *Journal of Studies on Alcohol and Drugs*, 83(5), 768–770. <https://doi.org/10.15288/jsad.2022.83.768>
- Seaman, E. L., Green, K. M., Wang, M. Q., Quinn, S. C., & Fryer, C. S. (2019). Examining prevalence and correlates of cigarette and marijuana co-use among young adults using ten years of NHANES data. *Addictive Behaviors*, 96, 140–147. <https://doi.org/10.1016/j.addbeh.2019.04.014>
- Shah, A.C.S. (2024, February 29). Most Americans now live in a legal marijuana state – and most have at least one dispensary in their county. *Pew Research Center*. <https://www.pewresearch.org/short-read/2024/02/29/most-americans-now-live-in-a-legal-marijuana-state-and-most-have-at-least-one-dispensary-in-their-county/>.
- StataCorp. (2023). *Stata 18 Base Reference Manual*. StataCorp. <https://www.stata.com/manuals/rmlogit.pdf>.
- Substance Abuse and Mental Health Services Administration. (2021). Highlights for the 2021 National Survey on Drug Use and Health. *Substance Abuse and Mental Health Services Administration*. <https://www.samhsa.gov/data/sites/default/files/2022-12/2021NSDUHFRHHighlights092722.pdf>.
- Substance Abuse and Mental Health Services Administration. (2023). *2022 NSDUH Detailed Tables*. Table 1.28B – Marijuana Use in Past Month: Among People Aged 12 or Older; by Age Group and Demographic Characteristics, Percentages, 2021 and 2022. <https://www.samhsa.gov/data/report/2022-nsduh-detailed-tables>.
- Weinberger, A. H., Zhu, J., Lee, J., Xu, S., & Goodwin, R. D. (2020). Cannabis use and the onset of cigarette and E-cigarette use: A prospective, longitudinal study among youth in the United States. *Nicotine & Tobacco Research*, 23(3), 609–613. <https://doi.org/10.1093/ntr/ntaa158>
- Wills, T. A., Leventhal, A. M., Sargent, J. D., & Pagano, I. (2021). Concurrent Use of E-cigarettes, Combustible Cigarettes, and Marijuana. *Pediatrics*, 148(4). <https://doi.org/10.1542/peds.2021-050749>