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## Associations for Subgroups of E-cigarette, Cigarette, and Cannabis Use with Asthma in a Population Sample of California Adolescents

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### Abstract

Knowledge about the respiratory health consequences of adolescents' use of tobacco products with cannabis remains limited. We studied whether e-cigarettes, combustible cigarettes, and cannabis were independently associated with asthma in a population-based sample of 150,634 public high school students (10th and 12th graders), drawn in a two-stage design to be representative of the state of California in 2019–2020. Measures were obtained for use of e-cigarettes, combustible cigarettes, and cannabis; motives for use (three substances); method of use (for cannabis); ever being diagnosed with asthma; and having an asthma attack in past 12 months. Cross-classification indicated Nonuse for 64% of the sample; 15% Dual E-cigarette/Cannabis Use; 10% Exclusive Cannabis Use; 5% Exclusive E-cigarette Use; and 5% Triple Use. Multinomial logistic regression with a three-level criterion variable, controlling for age, sex, parental education, race/ethnicity, and three types of household use showed that compared with Nonuse, odds of Lifetime Asthma (vs. Never Had) was elevated for Triple Use (AOR = 1.14, CI 1.06–1.24), Dual E-cigarette/Cannabis Use (1.17, 1.12–1.23), Exclusive Cannabis Use (1.17, 1.11–1.23), and Exclusive E-cigarette Use (1.10, 1.02–1.18). Similar results were noted for Recent Asthma. Among persons who had used cannabis, 88% of the Triple group and 74% of the Dual E-cigarette/Cannabis group reported both smoking and vaping cannabis. Thus, co-occurrence of e-cigarette and cannabis use was a common pattern among adolescents in this study, and subgroups of cannabis and e-cigarette use showed

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#### Declaration of Interests

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.

similar associations with asthma. Preventive approaches should highlight the health implications of exclusive or combined e-cigarette and cannabis use.

## Keywords

Youth; E-cigarettes; Asthma; Cannabis; Smoking; Substance use

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## 1. Introduction

For the past several years, electronic nicotine delivery systems (hereafter, e-cigarettes) have been the most commonly used tobacco product among youth (Cooper et al., 2022). Data from 2022 show that 14% of U.S. high school students used e-cigarettes at least once in the past 30 days (Cooper et al., 2022). The prevalence of cannabis use remains high, with 2022 data showing that overall past-year use of cannabis was 31% among 12th graders (Miech et al., 2023). Surveillance studies indicate that exclusive use of cigarettes has been decreasing while exclusive use of cannabis has been increasing (Chadi et al., 2019; Odani et al., 2019), and innovative technologies for e-cigarettes have provided new ways for youth to consume cannabis (Harrell et al., 2022; Lim et al., 2021).

E-cigarette use has been associated with asthma and other respiratory conditions among adolescents (Schweitzer et al., 2017; Wills et al., 2020) and adults (Wills et al., 2021b; Xie et al., 2022). Concern has also been expressed about possible adverse effects of cannabis use on respiratory health including asthma and bronchitis (Biehl and Burnham, 2015; Chatkin et al., 2019; Volkow et al., 2014), and given recent increases in the prevalence of use and co-use, commentaries have suggested the possible emergence of a public health crisis (Carlini et al., 2022; Roberts et al., 2022). However, at present there is limited knowledge about the health consequences of current types of cannabis products in adolescence (Harrell et al., 2022; Love, Schichlein, Clapp, and Jaspers, 2022).

### Co-occurrence of use.

Recent prevalence studies have indicated a substantial correlation of e-cigarette and marijuana use among adolescents (Chadi et al., 2019) and among adults (Odani et al., 2019). This could be due in part to increased legalization of cannabis but could also be attributable to comorbidity with psychiatric symptomatology and risk-taking tendencies (Jacobs et al., 2021; Leventhal et al., 2020; Staff et al., 2020; Wills et al., 2021a). Initial e-cigarette use is also linked in longitudinal studies to subsequent onset of cannabis use (Lim et al., 2021; Unger et al., 2016; Cooper et al., 2022; Seidel et al., 2022). While there may be some bidirectionality in associations (Rogers et al., 2021; Wong et al., 2020), some studies have indicated that the primary direction is from e-cigarettes to marijuana (Bentivegna, et al., 2021; Westling et al., 2022).

### Motives for use.

Harrell et al. (Harrell et al., 2022) noted that motives reported for co-use include physical, social, and mental health reasons, and Reboussin (2021) reported that college student co-users (compared to marijuana-only users) were more likely to cite instrumentality reasons

(i.e., increasing physical sensations) for use. Jacobs et al. (2021) found that nicotine vaping was associated with lower scores for reward responsiveness, whereas cannabis vaping was associated with lower behavioral inhibition (i.e., impulsivity). Wang et al. (2022) noted that e-cigarette use was positively associated with vaping cannabis and that vaping cannabis was correlated with variables such as perceiving less harm from e-cigarette use. Pedersen et al. (2021) studied a selected sample of young adult co-users and distinguished two latent classes of co-users; one class based on coping motives while the other was based on social and instrumentality motives. The coping group had heavier cannabis use and more adverse consequences of cannabis use. The diversity of samples and findings underscores the need for further research with a broad range of measures that allow comparisons across different substances.

The present research utilizes a grouping approach to study the implications for asthma of adolescents' exclusive and combined cigarette, e-cigarette, and cannabis use. A previous grouping study with high school students demonstrated substantial co-occurrence of the three substances and found that triple use (cigarettes, e-cigarettes, and cannabis) was significantly elevated on psychosocial risk profile above dual use (Wills et al., 2021a). However, this study was focused on psychosocial variables and aside from a regression-based study by Han et al. (2020) there is little evidence on how different patterns of co-use may be related to asthma. Grouping approaches have advantages through reducing the impact of collinearity (e.g., of e-cigarette and marijuana use) and allowing comparisons of naturally existing groups.

In the present research we constructed separate scores for e-cigarette use (only nicotine or flavorings), combustible tobacco use (cigarettes), and cannabis use (either smoking or vaping). From these variables we formed eight mutually exclusive groups of use and nonuse in a representative sample of California high school students and tested for independent associations with respiratory symptoms. We tested for associations of the substance use groups with both lifetime asthma and recent asthma, hypothesizing that groups with E-cigarette Use and Cannabis Use will both have elevated likelihood of asthma and that Triple Use will be particularly elevated. We also tested a hypothesis, derived from clinical research, suggesting that adolescents with asthma may be using e-cigarettes or cannabis to help cope with disease-related comorbidities such as anxiety, depression, and sleep disturbances (Blackman and Gurka, 2007; Boulet and Boulay, 2011; Licari et al., 2019; Zeiger et al., 2021).

## 2. Methods

### 2.1. Study Sample

This research used deidentified data from the 2019–2020 California Student Tobacco Survey, a 160-item school-based survey administered online during the school day. The primary proctors of the surveys were the teachers for the selected sections, while in some cases other school staff proctored the surveys. Instructions for teachers and proctors on how to administer the survey were provided with the consent forms in a teacher/proctor checklist. The study obtained a representative sample of 10th and 12th grade public school students across California using random sampling of schools within 35 geographic regions (Zhu et

al., 2021). This survey used a two-stage cluster sampling design, with school as the primary sampling unit and classroom as the secondary sampling unit. In total, 311 high schools and 150,634 high school students participated.

Parental consent procedures were based on school district guidelines, some districts requiring signed parental consent while others used alternative consent (opt-out) procedures. An assent form presented to eligible students informed them that their participation was confidential and their responses could not be identified. Assenting students thus participated with voluntary and anonymous participation. The overall school participation rate was 79% and the high school student participation rate was 68%. The procedures were approved by the Institutional Review Board for the University of California San Diego and the California State Committee for the Protection of Human Subjects.

## 2.2. Measures

Measures used in the analysis are described in Table 1. These include items on demographics, adolescent substance use, household substance use, and adolescents' motives for use of cigarettes, e-cigarettes, and cannabis. The criterion measures were student reports of lifetime diagnosis of asthma and recent asthma attack.

E-cigarette measures were based on items asking whether the participant had vaped (i.e., used e-cigarettes) Ever/In the Past 30 Days (Yes/No). For affirmative responses this was followed by subquestions about whether the vape(s) used contained nicotine, flavorings, or cannabis. Cigarette measures were based on items asking whether the participant had smoked cigarettes Ever/In the Past 30 Days (Yes/No). Two items asked specifically about cannabis use. One asked whether the participant had Ever/In Past 30 Days smoked marijuana. The second asked whether the participant had Ever/In Past 30 Days) vaped marijuana.

The analytic variable termed E-cigarette Use was coded if the participant reported using e-cigarettes with only nicotine and/or flavorings. The analytic variable termed Cigarette Smoking was coded if the participant reported consuming only tobacco in a combustible device (e.g., cigarette). The analytic variable termed Cannabis Use was coded if the participant reported either smoking cannabis or vaping cannabis. Thus, the coded variables for E-cigarette Use and Cigarette Smoking were mutually exclusive with consuming cannabis (for further details see Zhu et al., 2021).

## 2.3. Statistical Analyses

Prevalence estimates for the substance use and asthma variables were obtained with weighted analyses using SAS Proc SURVEYFREQ, accounting for stratum and school clustering. A 3-level variable was analyzed for Asthma Status: Never Had Asthma, Ever Had Asthma/Not Past Year (Lifetime Asthma), and Ever Had Asthma/Had Asthma Attack Past year (Recent Asthma); reports of Not Sure were coded as missing. Rates of missing data for the substance use items were quite low (all < 1% missing); asthma items had 11% missing for lifetime asthma and 6% for recent asthma attack. Subsequent analyses used listwise deletion for missing data. Data for ever and 30-day E-cigarette, Cigarette, and Cannabis Use were cross-classified in two analyses to form eight groups for Ever Use

of the substances and eight groups for Recent Use of the substances: Nonuse (never used any of the substances); three types of Exclusive Use; three types of Dual Use; and Triple Use (e-cigarettes, cigarettes, and cannabis). We did not analyze groupings for 30-day in multivariable analyses because of some small cell sizes owing to the low cigarette smoking prevalence among California adolescents.

Zero-order associations of the groups with respiratory outcomes were analyzed with cross-tabulation analyses. Multinomial logistic regression analysis determined adjusted associations of the substance use groups with lifetime asthma and recent asthma attack controlling for age, sex, parental education, race/ethnicity, and 3 types of household use. Race/ethnicity was analyzed dropping two small groups and coding race/ethnicity with five binary variables that contrasted Asian-American, Black, Hispanic, Hispanic Multiple Ethnicity, and Non-Hispanic Multiple Ethnicity against White as the reference group. Substance use group was analyzed as a set of seven binary variables that contrasted Exclusive Use (three variables), Dual Use (three variables) and Triple Use (one variable) against Nonuse as the reference group. Tests for additive effects used planned contrasts of groups who used 1, 2, or 3 substances, and the SAS option “estimate = prob” computed the adjusted probability of lifetime or recent asthma for each of the groups. For a validity check we tested the association of asthma variables with number of school days missed using cross-tabulation frequency analysis and Proc GLM for a continuous score. For data on motives for use, logistic regressions including covariates were performed to determine whether motives for use (for all three substances) differed significantly between persons who did or did not have asthma.

### 3. Results

A total of 150,634 students participated in the survey (54.2% 10<sup>th</sup> graders and 45.8% 12<sup>th</sup> graders). Descriptive statistics indicated the surveyed sample was 51.7% female and mean age was 16.2 years (SD = 1.1). The sample was 53.5% Hispanic, 20.7% Non-Hispanic White, 12.5% Non-Hispanic Asian, 2.7% Non-Hispanic Black, 2.4% Non-Hispanic Other Ethnicity, and 8.2% Non-Hispanic Multiple Ethnicity; 51.7% of students reported that either of their parents had a college degree. Missed school days (in the past 30 days) ranged from 40.3% of the sample with 0 missed days to 4.2% with 11 or more missed days.

Prevalence estimates indicated prevalence of 6.5% for ever cigarette smoking and 1.2% for recent (past 30-day) cigarette smoking. For e-cigarette use, the prevalence of e-cigarette ever-use (either nicotine and/or flavorings) was 24.4% and recent use was 8.2%. For cannabis use (either smoking and/or vaping cannabis), ever-use prevalence was 31.2% and recent use was 15.0%. Prevalence was 16.5% for household smoking, 10.9% for household e-cigarette use, and 16.8% for household cannabis use. The weighted prevalence estimate was 19.7% for lifetime asthma and 15.1% for asthma attack in the past year among persons with a history of asthma (3.6% of the total sample).

Weighted prevalence estimates for the substance use groups (Table 2) indicated the largest usage groups were Dual E-cigarette+Cannabis (14.7% of the adolescent sample), Cannabis

Only (10.9%), E-cigarette Only (4.7%), and Triple Use (E-cigarettes + Cigarettes + Cannabis; 4.7%). Three small groups constituted only 0.4% to 0.7% of the sample.

### 3.1. Multinomial Analysis for Asthma Status

Cross-tabulation analyses indicated a number of significant zero-order associations with asthma for the substance use groups (data not presented). Multinomial regression analysis with the three-level Asthma Status variable as criterion (Table 3) involved an uncontrolled model (Model 1) and a fully-controlled model (Model 2). In going from the uncontrolled model to the controlled model, demographics had minimal effect on coefficients for the substance use groups. Adding the household items reduced coefficients for some groups, more so for Recent Asthma than for Lifetime Asthma, but standard errors for maximum likelihood coefficients were similar. In the fully controlled model, compared with Nonuse, the odds of lifetime asthma was significantly higher for groups with Triple Use (AOR = 1.14), Dual E-cigarette/Cannabis Use (AOR = 1.17), Exclusive Cannabis Use (AOR = 1.17), and Exclusive E-cigarette Use (AOR = 1.10). Many of the same groups also had significant associations with Recent Asthma. An inverse effect was noted for Dual E-cigarette/Cigarette use (AOR = 0.71), but in the present data this was a very small group and this specific result is discrepant from grouping analyses in contexts with higher rates of cigarette smoking (Han et al., 2020; Wills, Choi, and Pagano 2020).

We tested three planned contrasts with either Lifetime Asthma or Recent Asthma as the criterion: E-cigarette Only vs. Dual E-cigarette/Cannabis Use, Cannabis Only vs. Dual E-cigarette/Cannabis Use, and Dual E-cigarette/Cannabis vs. Triple Use. All the contrasts were nonsignificant for both Lifetime Asthma and Recent Asthma. Adjusted probabilities for each of the groups (Appendix) were all in a similar range, consistent with the finding that odds ratios of asthma for any use (compared with nonuse) were generally similar for each of the groups (Table 3).

Other results indicated the odds of both Lifetime Asthma and Recent Asthma elevated for families with higher parental education. Odds of Recent Asthma was higher for females but odds of Lifetime Asthma was higher for males. The odds of recent asthma decreased with age. Ethnic differences were found, but detailed discussion of these is beyond the scope of the present paper.

To determine whether smoking or vaping cannabis was more common we categorized cannabis use according to whether a participant had (1) only smoked cannabis, (2) only vaped cannabis, or (3) used both methods. Use of both methods was the majority pattern (Table 4; 65.3% overall) and was particularly common among the Dual E-cigarette/Cannabis use (74.2%) and Triple Use (88.3%) groups. For the Cannabis Only group, the plurality pattern was smoking (49.6%), and use of both methods was less prevalent (37.6%).

### 3.2. Asthma Status and Motives for Use

The motives inventory asked the participant to indicate (Yes/No) the most important reason for his/her cigarette, e-cigarette, or cannabis use. Across substances the most frequently endorsed reasons for e-cigarette and marijuana use were stress/anxiety relief, having a good time with friends, and for two substances, getting a nicotine buzz (Table 5). Asterisks in the



table show the results of logistic regression analyses testing for motive differences between persons with versus without asthma. In general, frequencies for motive endorsements did not differ significantly for persons with asthma and persons without asthma. For example, “get high” was endorsed as a cannabis motive by 21% of persons without asthma and 19% of persons with asthma (n.s.). Differences that were noted showed that compared to persons without asthma, persons with asthma scored lower on anxiety relief (for smoking), nicotine buzz (for e-cigarettes), and having good time with friends (all three substances). Persons with asthma scored higher on medical/health reasons (cannabis only) but did not differ significantly on sleep motives, and health reasons was not a frequently endorsed motive. These results generally fail to support a reverse causation interpretation (i.e., persons taking up e-cigarette use to cope with asthma) because the results were mostly nonsignificant or in the opposite direction to the expected one.

### 3.3. Days Missed from School

Cross-tabulation for missed school days indicated for example that 38% of students without asthma had missed 0 days (in the past 30 days) compared to 28% with recent asthma; and 11% without asthma missed 6 or more days compared to 17% with asthma; individual cell chi-squares indicated several significant associations. A Proc GLM analysis with covariates was conducted with a 0–4 missed-days numerical variable as the criterion. Persons with recent asthma had a significantly higher score, adjusted  $M = 1.42$  (SE 0.017) compared to persons without asthma, adjusted  $M = 1.11$  (SE 0.003),  $F = 338.4$ ,  $p < .0001$ ; they had missed more school days because they were out sick and/or making doctor visits. This provides an external validation of the self-reports of asthma.

## 4. Discussion

The aim of this research was to determine associations with asthma for different subgroups of cannabis, e-cigarette, and combustible cigarette use in a representative sample of California youth. We used a grouping approach to define groups with exclusive or co-occurring use of these products/substances. The descriptive data showed substantial co-occurrence of cannabis and e-cigarette use. The frequent co-occurrence of e-cigarette and cannabis use is similar to findings from a US national sample (Wills et al., 2021a), though because of the relatively low rate of cigarette smoking in California, the Triple Use group was 5% of this sample compared with 17% in the national sample.

The multivariate analysis (Table 3) tested for independent associations of the adolescent substance use groups with asthma controlling for covariates including household e-cigarette and cannabis use, which themselves had significant associations with asthma. Significant associations were found for two dual-use groups and two exclusive-use groups with both Lifetime Asthma and Recent Asthma. A collateral analysis for missed school days supported the validity of the self-reports of asthma, and analyses of motives for use generally did not support a reverse-causation explanation. The findings are consistent with previous research showing positive associations of e-cigarette use with asthma among adolescents (Wills et al., 2021b), but the present results draw attention to the association of asthma with both exclusive and combined e-cigarette or cannabis use.

The present results are consistent with previous studies showing associations of cannabis use with respiratory symptoms among adolescents (Braymiller et al., 2020; Han et al., 2020), but the grouping approach circumvents the strong co-occurrence of e-cigarette and cannabis use. We found that any type of use was problematic, as similar odds ratios and adjusted asthma probabilities were noted for both exclusive and dual use groups (Table 3). Planned contrasts showed that with these naturally occurring groups, using more products did not necessarily result in greater likelihood of asthma. The hypothesis regarding triple use received inconsistent support; triple use was sometimes, but not always, more problematic. A programmatic implication is that prevention programs could be oriented toward deterring any type of use. A theoretical implication is that further research should examine biological pathways for both e-cigarettes (Clapp and Jaspers, 2017; Gordon et al., 2022) and cannabis (Maertens et al., 2013; Singh et al., 2009; Wong et al., 2020) in relation to respiratory disease.

Several studies have shown that e-cigarette use predicts initiation or progression of cannabis use (Audrain-McGovern et al., 2018; Dai et al., 2018; Evans-Polce et al., 2020; Unger et al., 2016; Wills et al., 2016; Wong et al., 2020). It is plausible that a proportion of lower-risk adolescents begin experimentation with e-cigarettes because these are perceived to be less hazardous than other substances (Barrington-Trimis et al., 2015; Wills et al., 2015) and they subsequently transition to cannabis use. Further research is needed to trace pathways from initial experimentation to dual and/or triple use (Chapman et al., 2019; Wong et al., 2020). We note that the frequent co-occurrence of e-cigarette and cannabis use is an important phenomenon in the current landscape of adolescent substance use (Carlini et al., 2022; Roberts et al., 2022; Wills et al., 2021b) and needs to be emphasized as a conceptual target for prevention programs. Results showing that smoking cannabis and vaping cannabis tend to co-occur in high-risk groups also have implications for prevention.

Data on motives for substance use showed coping with stress and anxiety was a commonly endorsed motive, consistent with other literature (Harrell et al., 2022). Social reasons and “getting high” also received substantial endorsement (cf. Pedersen et al., 2021). Frequencies of endorsement generally did not differ significantly between adolescents with and without asthma, counter to a reverse causation hypothesis. These results suggest that prevention programs should incorporate content that aligns with the most commonly expressed motives.

While this research had a large representative sample and validated measures, possible limitations can be noted. The data were cross-sectional and the study fundings do not by themselves establish a causal relationship between product use and asthma, although prospective evidence is available for e-cigarettes for some of the relations discussed here (Bhatta and Glantz, 2020; Reddy et al., 2021; Xie et al., 2020; Xie et al., 2022). Longitudinal research including cannabis would be desirable to determine the directionality of all relationships. Also, the asthma measures did not include data about age of onset or frequency of asthma attacks. Lastly, the definition for current asthma as having an asthma attack in the past 12 months may differ from other studies that measure self-reported current asthma directly.



## 5. Conclusions

This study found that groups involving either cannabis or e-cigarette use both showed significant associations with diagnosis of asthma. Moreover, co-occurrence of e-cigarette and cannabis use was a common pattern among adolescents in this study. Further research is needed to examine the use of inhalation products that may be associated with a diagnosis of asthma and to the use of inhalation products among youth currently with asthma, including studies of biological pathways for e-cigarettes and cannabis (Wills et al., 2021a). Educational approaches should recognize the health implications of either exclusive or combined e-cigarette and cannabis use.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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### Highlights

- The use of e-cigarette and cannabis was a common pattern among adolescents.
- Dual use of e-cigarettes and cannabis was associated with asthma in adolescents.
- Exclusive cannabis use was significantly associated with asthma in adolescents.
- Preventive approaches need to address this co-occurrence.

Table 1.

## Measures for Analysis

Variable	Measure (Response Option)
<b>Demographics</b>	
Grade	What grade are you in? (10th, 12th)
Age	How old are you? (14 years, 15 years, 16 years, 17 years, 18 years or older).
Sex	How would you describe yourself? (male, female, female transgender, male transgender, genderqueerer, neither male nor female, choose not to respond)
Race/Ethnicity	<i>Race:</i> How would you describe yourself? (American Indian/Alaska Native, Asian, Black/African American, Native Hawaiian/Other Pacific Islander, White). <i>Ethnicity:</i> Are you of Hispanic (Latino or Latina) origin? (yes, no). <i>Race/ethnicity:</i> These two items were recoded in a measure of race/ethnicity that had eight mutually exclusive codes: NonHispanic White, NonHispanic Black, Hispanic, NonHispanic Asian, NonHispanic American Indian/Alaska Native, NonHispanic Native Hawaiian/Other Pacific Islander, NonHispanic Other Ethnicity, and NonHispanic Multiple Ethnicity
Parental Education	Do either of your parents have a college degree? (yes, no)
Missed School Days	In the last 30 days, how many days did you miss school, with or without permission? (0 days, 1 day, 2–5 days, 6–10 days, 11 or more days).
<b>Substance Use</b>	
Combustible Cigarettes	The next questions ask about cigarettes. Cigarettes (accompanied by pictures) are sold in packs and cartons; popular brands include Marlboro, Newport, Pall Mall, Camel, and Winston. Have you ever smoked cigarettes? (yes, no). Have you smoked cigarettes in the last 30 days? (yes, no).
E-cigarettes	The next questions ask about vapes. Vapes are electronic devices like vape pens, e-cigarettes, e-hookah, hookah pens, e-vaporizers, tanks, pods, or mods used to inhale a vapor. Can be used to vape many things, like nicotine, marijuana, or just flavorings. Popular brands are JUUL, Suorin, SMOK, starbuzz, E-hookah, Zodiac Constellation, Stilizzy, Brass Knuckles, and Heavy Hitter. Have you ever vaped? (yes, no). Have you vaped in the last 30 days? (yes, no). These items were followed by subquestions about vaping nicotine, marijuana, or just flavoring.
Cannabis	Cannabis use was assessed by questions about smoking or vaping marijuana. Ever use was assessed by two items asking “Have you ever smoked / vaped marijuana?” (yes/no) Recent use was assessed by two items asking “Have you smoked / vaped marijuana in the last 30 days?” (yes/no) These items were followed by subquestions about alternative modes of ingestion (e.g., edibles, liquids).
Household Use	<i>Cigarettes.</i> Does anyone who lives with you now smoke cigarettes? (yes, no). <i>E-cigarettes.</i> Does anyone who lives with you now use vapes? (yes, no). <i>Cannabis.</i> Does anyone who lives with you now use marijuana? (yes, no).
Reasons for Use	<i>Motives.</i> Multiple motives for smoking, vaping, and cannabis use were assessed using a range of items based on review of existing studies. Motives for use of a given substance were assessed with a forced-choice format. The participant was given a particular substance and asked to endorse which one of 11 (or 12) reasons for use was the most important for his/her use. Skip patterns were employed such that the particularly motive items were only administered for persons who were users of the given substance. <i>Reasons for smoking.</i> The measure for cigarettes asked: “Which is the MOST important reason you smoke cigarettes?” For cigarettes the possible responses were: To fit in/peer pressure; To relax or relieve stress and anxiety; For the nicotine buzz; To focus or concentrate; It looks cool; To have a good time with my friends; Because I am ‘hooked’; To try to quit using other products; They are available in flavors I like; I can use them unnoticed at home or at school; and To control my weight. <i>Reasons for e-cigarette use.</i> For e-cigarettes the stem was “Which is the MOST important reason you use vapes with nicotine or just flavoring?” There were 12 response options similar to cigarettes but adding the option: Cloud competitions. <i>Reasons for cannabis use.</i> For marijuana there were 12 similar response options but including To help with sleep; To get high; and For a medical health reason, and dropping the nicotine buzz and weight control options.
Asthma Status	<i>Ever Had Asthma:</i> Has a doctor or nurse ever told you that you have asthma? (yes, no). <i>Recent Asthma:</i> During the past 12 months, did you have an asthma attack? (yes, no).



**Table 2.**

Weighted Prevalence Estimates for Ever-Use Grouping Categories

	%	Unweighted N		
Group 1. Never use of any product	63.3	95,359		
Group 2. E-cigarette only	4.7	7,441		
Group 3. Cigarette only	0.6	698		
Group 4. Cannabis only	10.9	15,562		
Group 5. Dual (E-cigarette + Cigarette)	0.4	565		
Group 6. Dual (E-cigarette + Cannabis)	14.7	22,425		
Group 7. Dual (Cigarette + Cannabis)	0.9	1,072		
Group 8. Triple (E-cigarette + Cannabis + Cigarette)	4.5	6,985		

\* E-cigarette use is defined as vaping nicotine or just flavoring. Cannabis use is defined as smoking and/or vaping cannabis

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**Table 3.** Adjusted Odds Ratios and Confidence Intervals from Multinomial Analysis for Substance Use Groups

Predictor Variable	Asthma contrast (vs. never had)		Model 1		Model 2	
	AOR	(CI)	AOR	(CI)	AOR	(CI)
Group 2. E-cigarette only <sup>a</sup>	1.17	(1.03–1.33) *	1.12	(0.97–1.28)	1.10	(1.02–1.18) **
Group 2. E-cigarette only <sup>a</sup>	1.11	(1.04–1.19) **	0.95	(0.60–1.51)	0.79	(0.43–1.45)
Group 3. Cigarette only	0.89	(0.70–1.13)	0.89	(0.70–1.13)	0.80	(0.60–1.05)
Group 3. Cigarette only	1.28	(1.17–1.40) ****	1.28	(1.17–1.40) ****	1.13	(1.02–1.26) *
Group 4. Cannabis only	1.20	(1.14–1.26) ****	1.20	(1.14–1.26) ****	1.17	(1.11–1.23) ****
Group 5. Dual E-cigarette+Cigarette	0.56	(0.30–1.04)	0.56	(0.30–1.04)	0.68	(0.35–1.32)
Group 5. Dual E-cigarette+Cigarette	0.74	(0.56–0.98) *	0.74	(0.56–0.98) *	0.71	(0.52–0.96) *
Group 6. Dual E-Cigarette+Cannabis	1.33	(1.23–1.44) ****	1.33	(1.23–1.44) ****	1.09	(1.00–1.19)
Group 6. Dual E-cigarette+Cannabis	1.19	(1.14–1.24) ****	1.19	(1.14–1.24) ****	1.17	(1.12–1.23) ****
Group 7. Dual Cigarette+Cannabis	1.44	(1.06–1.96) *	1.44	(1.06–1.96) *	1.30	(0.90–1.88)
Group 7. Dual Cigarette+Cannabis	1.17	(0.98–1.39)	1.17	(0.98–1.39)	1.15	(0.95–1.40)
Group 8. Triple	1.60	(1.42–1.81) ****	1.60	(1.42–1.81) ****	1.19	(1.03–1.37) **
Group 8. Triple	1.19	(1.11–1.27) ****	1.19	(1.11–1.27) ****	1.14	(1.06–1.24) ***
Sex (Male)					0.54	(0.51–0.58) ****
Sex (Male)					1.32	(1.28–1.37) ****
Age (older)					0.92	(0.90–0.95) ****
Age (older)					1.01	(1.00–1.03)
Education (higher)					1.50	(1.40–1.61) ****
Education (higher)					1.14	(1.10–1.19) ****
Black <sup>b</sup>					1.12	(0.93–1.36)
Black <sup>b</sup>					1.86	(1.68–2.04) ****
Hispanic					0.84	(0.77–0.91) ****

Predictor Variable	Asthma contrast (vs. never had)		Model 1		Model 2	
			AOR	(CI)	AOR	(CI)
Hispanic	Lifetime asthma		1.20	(1.14–1.25)	1.20	(1.14–1.25) ****
Asian-American	Recent asthma		0.64	(0.57–0.72)	0.64	(0.57–0.72) ****
Asian-American	Lifetime asthma		1.09	(1.03–1.15)	1.09	(1.03–1.15) **
Non-Hispanic Other	Recent asthma		0.71	(0.54–0.92)	0.71	(0.54–0.92) **
Non-Hispanic Other	Lifetime asthma		0.92	(0.81–1.06)	0.92	(0.81–1.06)
Non-Hispanic Multiple	Recent asthma		1.27	(1.14–1.42)	1.27	(1.14–1.42) ****
Non-Hispanic Multiple	Lifetime asthma		1.38	(1.29–1.46)	1.38	(1.29–1.46) ****
Household smoking <sup>c</sup>	Recent asthma		1.16	(1.07–1.27)	1.16	(1.07–1.27) ****
Household smoking <sup>c</sup>	Lifetime asthma		1.08	(1.03–1.13)	1.08	(1.03–1.13) ****
Household vaping <sup>d</sup>	Recent asthma		1.31	(1.19–1.45)	1.31	(1.19–1.45) ****
Household vaping <sup>d</sup>	Lifetime asthma		1.02	(0.96–1.09)	1.02	(0.96–1.09)
Household marijuana <sup>e</sup>	Recent asthma		1.33	(1.22–1.46)	1.33	(1.22–1.46) ****
Household marijuana <sup>e</sup>	Lifetime asthma		1.10	(1.04–1.15)	1.10	(1.04–1.15) ****

Note. AOR= adjusted odds ratios; CI=confidence intervals; Recent Asthma = asthma attack in the past 12 months

Coefficients are from multivariate analysis, all variables entered simultaneously. Both asthma contrasts use Never Had Asthma as the reference group. Analytic Ns are 133,717 and 113,922 for Models 1 and 2, respectively.

\* indicates p < .05;

\*\* p < .01;

\*\*\* p < .001;

\*\*\*\* p < .0001.

<sup>a</sup>For substance use group contrasts, reference group = Nonusers.

<sup>b</sup>For race/ethnicity, contrasts are with White as reference group.

<sup>c</sup>Referent = no household smoking.

<sup>d</sup>Referent = no household vaping.

Referent = no household cannabis use.

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**Table 4.**

Smoking/Vaping Cannabis (%) By Cannabis Use Groups

	All cannabis users (N=41,044)	Cannabis use group			
		Cannabis use only (N=11,867)	Dual use of cannabis and e-cigarettes (N=21,093)	Dual use of cannabis and cigarettes (N=964)	Triple use of cannabis, e-cigarettes, and cigarettes (N=6,805)
<b>Only smoke cannabis</b>	20.7%	49.6%	8.0%	47.9%	6.6%
<b>Only vape cannabis</b>	14.0%	12.8%	17.8%	7.1%	5.2%
<b>Smoke and vape cannabis</b>	65.3%	37.6%	74.2%	45.0%	88.3%
<b>Total</b>	100%	100%	100%	100%	100%

Note. Data are for ever use of a product

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**Table 5.**

Results from Logistic Regressions of Participants' Most Important Reason for Smoking Cigarettes, Vaping, or Using Cannabis (Column %) by Lifetime or Recent Asthma Status

	Smoking Cigarette Reason		Vaping Reason		Cannabis Use Reason	
<b>Substance Use Reason by Ever Asthma Status</b>						
Reason	Never had Asthma	Ever had Asthma	Never had Asthma	Ever had Asthma	Never had Asthma	Ever had Asthma
Relieve stress/anxiety	44	40	39	38	48	48
Nicotine buzz	22	25	24	22	n.a.	n.a.
Good time with friends	10	6*	13	11*	13	11*
Looks cool	7	8	4	4	1	1
“Hooked”	4	4	3	5**	1	1
Control weight	4	7	2	3	n.a.	n.a.
Focus/concentrate	3	3	3	4	3	4
Fit in / peer pressure	3	4	3	3	1	2
Quit other products	1	<1	1	1	<1	<1
Flavors I like	1	1	2	3	<1	<1
Cloud chasing	n.a.	n.a.	3	3	n.a.	n.a.
Use unnoticed	1	2	2	3	1	2*
Medical/health	n.a.	n.a.	n.a.	n.a.	3	4**
Sleep	n.a.	n.a.	n.a.	n.a.	8	8
Get high	n.a.	n.a.	n.a.	n.a.	21	19
	100%		100%	100%	100%	100%
Asthma Marginal	75%	25%	77%	23%	77%	23%
Total N	1,500		11,381		19,398	
<b>Substance Use Reason by Recent Asthma Status</b>						
	Smoking Reason		Vaping Reason		Cannabis Use Reason	
Reason	Never had Asthma	Recent Asthma	Never had Asthma	Recent Asthma	Never had Asthma	Recent Asthma
Relieve stress/anxiety	44	30*	38	39	48	43
Nicotine buzz	23	24	23	17**	n.a.	n.a.
Good time with friends	9	7	13	10*	13	11
Looks cool	7	12	3	6**	1	2
“Hooked”	4	6	3	5**	<1	1**
Control weight	4	8*	2	4*	n.a.	n.a.
Focus/concentrate	3	5	3	5*	3	4
Fit in / peer pressure	3	5	4	3	1	3
Quit other products	1	1	1	1	<1	<1
Flavors I like	1	1	2	3	<1	<1



Cloud chasing	n.a.	n.a.	3	4	n.a.	n.a.
Use unnoticed	1	3	2	2	1	2 <sup>**</sup>
Medical/health	n.a.	n.a.	n.a.	n.a.	3	6 <sup>**</sup>
Sleep	n.a.	n.a.	n.a.	n.a.	8	8
Get high	n.a.	n.a.	n.a.	n.a.	21	19
	100%	100%	100%	100%	100%	100%
Asthma Marginal	92	8%	95%	5%	95%	5%
Total N	1,569		11,805		20,240	

Note. In skip patterns, motive items were only administered for participants who reported recent (30-day) use of a given substance: For smoking, this was using combustible cigarettes; for vaping, this was using e-cigarettes with flavorings and/or nicotine; for cannabis, this was smoking or vaping cannabis. Significance levels are from logistic regressions predicting endorsement of a given motive for persons with/without asthma controlling for age, sex, parental education, and race/ethnicity.

\* indicates  $p < .05$ ;

\*\*  $p < .01$ .

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