

Health Risk Behaviors With Synthetic Cannabinoids Versus Marijuana

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abstract

BACKGROUND AND OBJECTIVES: Data are limited on the behavioral risk correlates of synthetic cannabinoid use. The purpose of this study was to compare the behavioral risk correlates of synthetic cannabinoid use with those among marijuana users.

METHODS: Data from the 2015 Youth Risk Behavior Survey, a cross-sectional survey conducted in a nationally representative sample of students in grades 9 through 12 ($N = 15\,624$), were used to examine the association between self-reported type of marijuana use (ie, never use of marijuana and synthetic cannabinoids, ever use of marijuana only, and ever use of synthetic cannabinoids) and self-report of 36 risk behaviors across 4 domains: substance use, injury/violence, mental health, and sexual health. Multivariable models were used to calculate adjusted prevalence ratios.

RESULTS: Students who ever used synthetic cannabinoids had a significantly greater likelihood of engaging in each of the behaviors in the substance use and sexual risk domains compared with students who ever used marijuana only. Students who ever used synthetic cannabinoids were more likely than students who ever used marijuana only to have used marijuana before age 13 years, to have used marijuana ≥ 1 times during the past 30 days, and to have used marijuana ≥ 20 times during the past 30 days. Several injury/violence behaviors were more prevalent among students who ever used synthetic cannabinoids compared with students who ever used marijuana only.

CONCLUSIONS: Health professionals and school-based substance use prevention programs should include strategies focused on the prevention of both synthetic cannabinoids and marijuana.

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WHAT'S KNOWN ON THIS SUBJECT: Although the effects of synthetic cannabinoids are similar to marijuana, synthetic cannabinoids can be more potent and may result in adverse health effects not commonly observed with marijuana. Information on synthetic cannabinoid use among high school students is limited.

WHAT THIS STUDY ADDS: This study contributes to the limited epidemiologic data on synthetic cannabinoid use among high school students. Furthermore, this study shows that synthetic cannabinoid use is associated with a higher prevalence of health risk behaviors than observed with marijuana use alone.

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Synthetic cannabinoids, frequently referred to as “synthetic marijuana” by the general public, are a group of compounds that produce an effect similar to the psychoactive ingredient in cannabis (tetrahydrocannabinol [THC]).¹⁻³ In contrast to marijuana, synthetic cannabinoids are not derived from a plant; instead, the compounds are synthesized in a laboratory. Although the effects of these synthetic compounds may be similar to the natural THC compound in cannabis, they may be more potent and can result in adverse health effects not commonly seen with THC.¹ According to data from poison centers in the United States, the use of synthetic cannabinoids has resulted in tachycardia, drowsiness/lethargy, nausea, vomiting, agitation/irritability, hypertension, chest pain, hallucinations/delusions, confusion, and dizziness/vertigo.³⁻⁵ Severe effects that have been noted include seizures, permanent cardiovascular damage, renal damage, stroke, psychosis, paranoia, aggression, anxiety attacks, dependence, and death (through suicide, adverse reaction, or overdose).^{1,4,6-11} The toxic effects of synthetic cannabinoids result from the type, mixture, and amount of product used.¹² Furthermore, producers of synthetic cannabinoid products frequently change formulas to avoid detection and regulation,⁴ so a user’s experience with synthetic cannabinoids can vary over time.^{13,14}

Synthetic cannabinoids have been marketed as herbal incense and may be available for purchase through gas stations, headshops and other specialized stores, as well as the Internet.^{1,3,4,15} Users of synthetic cannabinoids have cited several motivations for use, such as an expectation that it may provide a more intense high than that experienced with marijuana, affordability, ease of access, to avoid detection from standard drug tests, and the belief that it is safe.^{13,16,17}

Unfortunately, deceptive marketing techniques, such as labeling synthetic cannabinoids as a safe and “natural” blend of herbs, have been used, which gives users the false impression that synthetic cannabinoids are a safe drug alternative.¹⁵

To date, few epidemiologic data on the use of synthetic cannabinoids among adolescents and young adults have been available.^{1,18} Available research comes from case studies, poison center, and emergency department data, which have sought to describe the adverse outcomes associated with the use of synthetic cannabinoids.^{3-5,13,19} To our knowledge, only 1 study, which used the nationally representative Monitoring the Future (MTF) data to explore the use of synthetic cannabinoids among 12th-grade high school students, examined behavioral correlates of synthetic cannabinoid use in an adolescent population.¹ That study reported that past-year use of synthetic cannabinoids was 10.1% and that the use of synthetic cannabinoids was correlated with other substance use behaviors such as ever use of alcohol, cigarettes, marijuana, and other illicit drugs.¹ Unfortunately, because the MTF study does not collect data on other behavioral domains such as sexual health, injury, violence, and mental health among the sample of 12th-grade students, researchers have not been able to explore associations between other health risk behaviors and synthetic cannabinoid use among high school students.

The 2015 national Youth Risk Behavior Survey (YRBS) included, for the first time, a measure of ever synthetic cannabinoid use among high school students. The inclusion of this variable allows for an exploration of behavioral correlates of synthetic cannabinoid use among students in the United States. This study has 2 primary objectives: (1) to identify behavioral correlates of

ever synthetic cannabinoid use and (2) to compare observed behavioral correlates of ever synthetic cannabinoid use with those of ever marijuana only use.

METHODS

Study Population

The US Centers for Disease Control and Prevention has conducted the national YRBS biennially since 1991. The YRBS is a school-based, cross-sectional survey that uses an independent 3-stage cluster sample design to obtain a nationally representative sample of students in grades 9 through 12 who attend public and private schools in the 50 states and the District of Columbia.²⁰ Participation in the YRBS is both anonymous and voluntary, and the YRBS adheres to local parental permission requirements. Students complete a self-administered questionnaire during a regular class period, with responses recorded on an answer sheet or computer-scannable questionnaire booklet. For 2015, the school-level response rate was 69%, the student-level response rate was 86%, and the overall response rate was 60%.²¹ The sample size for the 2015 YRBS was 15 624 students.²¹ YRBS data are weighted to account for the oversampling of Hispanic and black students, as well as to adjust for school and student nonresponse. Imputation is not used for missing data. Information on the psychometric properties of the YRBS questionnaire as well as more detailed information on sampling strategies have been published elsewhere.^{20,22} The national YRBS was reviewed and approved by an institutional review board at the Centers for Disease Control and Prevention, Atlanta, Georgia.

Measures

All behavioral measures were assessed by self-report. Ever use of synthetic cannabinoids was assessed

with the following question: "During your life, how many times have you used synthetic marijuana (also called K2, Spice, fake weed, King Kong, Yucatan Fire, Skunk, or Moon Rocks)?" Ever use of marijuana was assessed with the question, "During your life, how many times have you used marijuana?" Response options for both ever use of synthetic cannabinoids and ever use of marijuana were combined to form 2 groups: "1 or more times" or "0 times." These variables were then combined to construct a 3-level variable to describe the type of marijuana use: (1) never use of marijuana and synthetic cannabinoids, (2) ever use of marijuana only, and (3) ever use of synthetic cannabinoids. It should be noted that most students in the category of "ever use of synthetic cannabinoids" also reported ever use of marijuana. In fact, only 1.6% of all students who ever used synthetic cannabinoids had not used marijuana. We examined 36 health risk behaviors from the domains of substance use, injury/violence, mental health, and sexual health (assessed on the YRBS) to determine the relative strength of their association with the 3-level marijuana use variable (Table 1). Demographic characteristics assessed in this analysis included sex, grade (9th, 10th, 11th, and 12th) race/ethnicity (non-Hispanic white, non-Hispanic black, and Hispanic), and geographic region.

Data Analysis

To account for the complex sample design of the survey, we conducted all analyses by using SUDAAN statistical software (Research Triangle Institute, Research Triangle Park, NC). We conducted descriptive analyses to present the distribution of demographic variables by type of marijuana use (never use versus ever use of marijuana only, never use versus ever use of synthetic

cannabinoids, and ever use of marijuana only versus ever use of synthetic cannabinoids) and compared distributions by using the χ^2 test. We assessed the associations between type of marijuana use (independent variable) and the 15 variables in the substance use domain (outcome variables) with logistic regression models that calculated adjusted prevalence ratios (aPRs) and 95% confidence intervals (CIs). Three substance use outcome variables (first marijuana use at age <13 years, current marijuana use, and current frequent marijuana use, defined as using marijuana ≥ 20 times during the past 30 days) were not applicable to students who never used marijuana and, as a result, analyses with these 3 outcomes were conducted with a 2-level response variable: ever marijuana use only (referent value) and ever synthetic cannabinoid use. All models in the substance use domain included sex, race/ethnicity, and grade as covariates. Models excluded geographic region because this variable was not significant in bivariate analyses. The associations between type of ever use of marijuana only (independent variable) and the 21 outcome variables in the remaining health behavior domains (ie, injury/violence, mental health, and sexual health) were also assessed with logistic regression models that calculated aPRs and 95% CIs. Each of these models included sex, race/ethnicity, grade, nonmedical use of prescription drugs, and other illicit drug use (including inhalants, hallucinogens, cocaine, heroin, methamphetamines, and ecstasy) as covariates. It was necessary to include these substance use variables as covariates in the models for injury/violence, mental health, and sexual health domains because previous research has revealed that other types of substance use are associated with marijuana use as well as injury/violence, mental health, and

sexual health behaviors.^{1,18,23-25} Linear contrasts were conducted to compare results for all health behavior domains by type of marijuana use (never use versus ever use of marijuana only, never use versus ever use of synthetic cannabinoids, and ever use of marijuana only versus ever use of synthetic cannabinoids). Significant differences were denoted by $P < .05$.

RESULTS

Nationwide, 61.1% of students never used marijuana and synthetic cannabinoids, 29.5% ever used marijuana only, and 9.4% ever used synthetic cannabinoids (Table 2). Only 22.8% of students who ever used marijuana also ever used synthetic cannabinoids; however, 98.4% students who ever used synthetic cannabinoids reported ever use of marijuana (data not shown). The type of marijuana use varied significantly by sex, race/ethnicity, and grade, but not by geographic region (Table 2).

The adjusted prevalence of every substance use behavior included in our analysis was greater among students who ever used synthetic cannabinoids (aPRs ranged from 4.85 for current alcohol use to 151.90 for ever use of heroin) and students who ever used marijuana only (aPRs: 3.45 for current alcohol use to 15.78 for ever use of ecstasy) compared with students who never used marijuana and synthetic cannabinoids (Table 3). According to the results of the linear contrasts, students who ever used synthetic cannabinoids had a consistently greater likelihood of engaging in all other substance use behaviors than students who ever used marijuana only. In models that compared marijuana outcomes among students who ever used marijuana only versus students who ever used synthetic cannabinoids, those who ever used synthetic cannabinoids were more likely to

TABLE 1 Health Risk Behaviors Possibly Associated With Marijuana and Synthetic Cannabinoid Use: National YRBS, 2015.

Health Risk Behavior	Questionnaire Item	Analytic Coding
Substance use		
Current cigarette use	During the past 30 days, on how many days did you smoke cigarettes?	≥1 vs 0 days
Current electronic vapor products use	During the past 30 days, on how many days did you use an electronic vapor product?	≥1 vs 0 days
Current alcohol use	During the past 30 days, on how many days did you have at least 1 drink of alcohol?	≥1 vs 0 days
≥5 drinks in a row (binge drinking)	During the past 30 days, on how many days did you have ≥5 drinks of alcohol in a row, that is, within a couple of hours?	≥1 vs 0 days
Ever took prescription drugs without a doctor's prescription	During your life, how many times have you taken a prescription drug (such as OxyContin, Percocet, Vicodin, codeine, Adderall, Ritalin, or Xanax) without a doctor's prescription?	≥1 vs 0 times
Ever used inhalants	During your life, how many times have you sniffed glue, breathed the contents of aerosol spray cans, or inhaled any paints or sprays to get high?	≥1 vs 0 times
Ever used cocaine	During your life, how many times have you used any form of cocaine, including powder, crack, or freebase?	≥1 vs 0 times
Ever used heroin	During your life, how many times have you used heroin (also called smack, junk, or China white)?	≥1 vs 0 times
Ever used methamphetamines	During your life, how many times have you used methamphetamines (also called speed, crystal, crank, or ice)?	≥1 vs 0 times
Ever used ecstasy	During your life, how many times have you used ecstasy (also called MDMA)?	≥1 vs 0 times
Ever used hallucinogenic drugs	During your life, how many times have you used hallucinogenic drugs, such as LSD, acid, PCP, angel dust, mescaline, or mushrooms?	≥1 vs 0 times
Ever injected any illegal drug	During your life, how many times have you used a needle to inject any illegal drug into your body?	≥1 vs 0 times
Tried marijuana before age 13 y	How old were you when you tried marijuana for the first time?	<13 vs ≥13 years
Current marijuana use	During the past 30 days, how many times did you use marijuana?	≥1 vs 0 times
Current frequent marijuana use	During the past 30 days, how many times did you use marijuana? (excludes students who did not report using marijuana in the past 30 days)	≥20 vs. <20 times
Injury/violence		
Rode with a driver who had been drinking alcohol	During the past 30 days, how many times did you ride in a car or other vehicle driven by someone who had been drinking alcohol?	≥1 vs 0 times
Drove when drinking alcohol	During the past 30 days, how many times did you drive a car or other vehicle when you had been drinking alcohol? (excludes students who did not drive a car or other vehicle during the past 30 days)	≥1 vs 0 times
Sexual dating violence	During the past 12 months, how many times did someone you were dating or going out with force you to do sexual things you did not want to do? (excludes students who did not date or go out with anyone during the past 12 months)	≥1 vs 0 times
Physical dating violence	During the past 12 months, how many times did someone you were dating or going out with physically hurt you on purpose? (excludes students who did not date or go out with anyone during the past 12 months)	≥1 vs 0 times
Ever physically forced to have sexual intercourse	Have you ever been physically forced to have sexual intercourse when you did not want to?	Yes versus no
Bullied on school property	During the past 12 months, have you ever been bullied on school property?	Yes versus no
Electronically bullied	During the past 12 months, have you ever been electronically bullied?	Yes versus no
Threatened or injured with a weapon on school property	During the past 12 months, how many times has someone threatened or injured you with a weapon such as a gun, knife, or club on school property?	≥1 vs 0 times
Did not go to school because of safety concerns	During the past 30 days, on how many days did you not go to school because you felt you would be unsafe at school or on your way to or from school?	≥1 vs 0 days
In a physical fight	During the past 12 months, how many times were you in a physical fight?	≥1 vs 0 times
Carried a weapon	During the past 30 days, on how many days did you carry a weapon such as a gun, knife, or club?	≥1 vs 0 days
Mental health		
Felt sad or hopeless	During the past 12 months, did you ever feel so sad or hopeless almost every day for ≥2 weeks in a row that you stopped doing some usual activities?	Yes versus no
Seriously considered attempting suicide	During the past 12 months, did you ever seriously consider attempting suicide?	Yes versus no
Attempted suicide	During the past 12 months, how many times did you actually attempt suicide?	≥1 vs 0 times
Sexual risk behaviors		
Ever had sexual intercourse	Have you ever had sexual intercourse?	Yes versus no
Had first sexual intercourse before age 13 y	How old were you when you had sexual intercourse for the first time?	<13 vs ≥13 years
Had sexual intercourse with ≥4 persons during their life	During your life, with how many people have you had sexual intercourse?	≥4 vs. <4 persons
Currently sexually active	During the past 3 months, with how many people did you have sexual intercourse?	≥1 vs 0 persons

TABLE 1 Continued

Health Risk Behavior	Questionnaire Item	Analytic Coding
Drank alcohol/used drugs before last sexual intercourse	Did you drink alcohol or use drugs before you had sexual intercourse the last time? (excludes students who were not currently sexually active)	Yes versus no
No condom use during last sexual intercourse	The last time you had sexual intercourse, did you or your partner use a condom? (excludes students who were not currently sexually active)	No versus yes
Did not use any method to prevent pregnancy	The last time you had sexual intercourse, what 1 method did you or your partner use to prevent pregnancy? (excludes students who were not currently sexually active)	No versus yes

TABLE 2 Demographic Characteristics by Type of Marijuana Use Among US High School Students: National YRBS, 2015.

	Nonuse (n = 9049)	Ever Used Marijuana Only (n = 4585)	Ever Used Synthetic Cannabinoid (n = 1554)	P (χ ² test)
Total	61.1 (57.8–64.2)	29.5 (26.6–32.6)	9.4 (8.1–11.0)	
Sex				
Male	50.0 (45.6–54.4)	50.8 (47.9–53.6)	57.8 (54.8–60.7)	<.01
Female	50.0 (45.6–54.4)	49.2 (46.4–52.1)	42.2 (39.3–45.2)	
Race/ethnicity				
Non-Hispanic white	58.1 (52.0–64.0)	48.8 (43.0–54.6)	52.4 (45.7–58.9)	<.0001
Non-Hispanic black	11.6 (9.8–13.7)	17.0 (14.1–20.4)	11.4 (8.5–15.1)	
Hispanic	19.7 (15.5–24.7)	25.8 (20.8–31.6)	28.4 (23.0–34.6)	
Grade				
9th	32.7 (30.1–35.4)	17.5 (15.4–19.7)	21.0 (17.9–24.4)	<.0001
10th	27.0 (24.0–30.2)	23.2 (21.3–25.2)	24.8 (21.3–28.7)	
11th	21.3 (20.0–22.8)	28.6 (26.4–30.9)	26.3 (23.3–29.5)	
12th	18.9 (17.8–20.2)	30.8 (28.6–33.0)	27.9 (24.0–32.3)	
Geographic region				
Northeast	18.4 (9.5–32.6)	18.7 (9.8–33.0)	17.0 (8.1–32.2)	.1232
Midwest	26.6 (15.7–41.3)	16.9 (9.7–27.7)	21.3 (11.6–35.7)	
South	25.7 (16.0–38.6)	27.8 (17.3–41.3)	33.2 (20.7–48.7)	
West	29.3 (19.4–41.7)	36.6 (23.5–52.1)	28.5 (18.4–41.4)	

Data are presented as percentages (95% CIs).

have tried marijuana before 13 years of age (aPR = 2.35), be a current marijuana user (aPR = 1.36), and be a current frequent marijuana user (aPR = 1.88).

The adjusted prevalence of most health risk behaviors in the domains of injury/violence, mental health, and sexual health was greater among students who ever used synthetic cannabinoids and students who ever used marijuana only compared with students who did not use marijuana and synthetic cannabinoids (Table 4). In the injury/violence domain, compared with students who did not use marijuana and synthetic cannabinoids, ever use of marijuana only was significantly associated with 8 of the 11 behaviors and ever use of synthetic cannabinoids was significantly associated with 10 of the 11 behaviors. Linear contrasts showed that 3 of the injury/violence behaviors were significantly more

likely to occur among students who ever used synthetic cannabinoids compared with students who ever used marijuana only, as follows: (1) rode with a driver who had been drinking alcohol, (2) did not go to school because of safety concerns, and (3) engaged in a physical fight. Both ever use of marijuana only and ever use of synthetic cannabinoids were associated with the 3 outcomes in the mental health domain, but no significant differences were identified between ever use of marijuana only and ever use of synthetic cannabinoids in the observed associations. For the sexual health domain, ever use of marijuana only was associated with 6 of the 7 sexual risk behaviors and ever use of synthetic cannabinoids was associated with all 7 sexual risk behaviors. According to linear contrasts, all 7 of the sexual risk behaviors were significantly more

likely to occur among students who ever used synthetic cannabinoids compared with students who ever used marijuana only.

DISCUSSION

To our knowledge, this is the first study to explore the association between ever use of synthetic cannabinoids and health risk behaviors in domains such as injury/violence, mental health, and sexual health among a nationally representative sample of US high school students. Furthermore, this study contributes new evidence on how behavioral correlates differ by type of marijuana use. Overall, we observed that ever use of synthetic cannabinoids was associated with the majority of health risk behaviors included in our study and that those associations tended to be more pronounced for ever use of synthetic

TABLE 3 Prevalence of Substance Use Behaviors by Type of Marijuana Use and Associations Between Substance Use Behaviors and Type of Marijuana Use Among US High School Students: National YRBS, 2015

Substance Use Behaviors	Nonuse			Ever Used Marijuana Only			Ever Used Synthetic Cannabinoid		
	%	aPR	95% CI	%	aPR	95% CI	%	aPR	95% CI
Current cigarette use ^a	2.3	—	Reference	17.7	7.98	(6.28–10.14) ^b	46.2	20.55	(15.57–27.11) ^{b,c}
Current electronic vapor products use ^a	9.4	—	Reference	41.7	4.56	(4.02–5.18) ^b	63.5	6.74	(5.89–7.70) ^{b,c}
Current alcohol use ^a	15.7	—	Reference	56.0	3.45	(3.09–3.85) ^b	78.6	4.85	(4.34–5.43) ^{b,c}
Binge drinking ^{a,d}	5.3	—	Reference	32.6	5.83	(4.74–7.17) ^b	55.0	9.82	(8.07–11.97) ^{b,c}
Ever took prescription drugs without a doctor's prescription	5.8	—	Reference	25.0	4.36	(3.74–5.09) ^b	60.6	10.36	(8.69–12.35) ^{b,c}
Ever used inhalants	2.9	—	Reference	7.3	2.80	(2.19–3.58) ^b	30.4	11.15	(8.52–14.60) ^{b,c}
Ever used hallucinogenic drugs	0.3	—	Reference	8.6	29.77	(12.95–68.40) ^b	40.5	133.04	(57.54–307.63) ^{b,c}
Ever used cocaine	0.3	—	Reference	5.9	19.10	(10.80–33.76) ^b	33.5	105.44	(60.83–182.74) ^{b,c}
Ever used heroin	0.1	—	Reference	1.2	12.52	(5.10–30.73) ^b	15.7	151.90	(62.29–370.41) ^{b,c}
Ever used methamphetamines	0.2	—	Reference	2.5	15.54	(8.83–27.35) ^b	21.9	133.57	(67.20–265.49) ^{b,c}
Ever used ecstasy	0.4	—	Reference	6.1	15.78	(8.41–29.61) ^b	31.4	77.98	(42.71–142.39) ^{b,c}
Ever injected any illegal drug	0.2	—	Reference	1.2	4.50	(2.24–9.04) ^b	12.5	49.65	(26.04–94.64) ^{b,c}
Tried marijuana before age 13 years	—	—	—	14.3	—	Reference	35.2	2.35	(1.93–2.88) ^c
Current marijuana use ^a	—	—	—	51.5	—	Reference	70.7	1.36	(1.28–1.45) ^c
Current frequent marijuana use ^e	—	—	—	23.3	—	Reference	43.0	1.88	(1.65–2.14) ^c

All models were adjusted for sex, grade, and race/ethnicity. —, not applicable.

^a On at least 1 day during the 30 days before the survey.

^b Linear contrast indicates significantly different from the nonusers group, $P < .05$.

^c Linear contrast indicates significantly different from the marijuana-only group, $P < .05$.

^d Defined as drinking ≥ 5 drinks of alcohol in a row within 2 hours.

^e Defined as using marijuana ≥ 20 during the 30 days before the survey among students who reported using marijuana during the 30 days before the survey.

cannabinoids than for ever use of marijuana only, particularly for substance use behaviors and sexual risk behaviors.

Given that synthetic cannabinoids are a relatively recent issue in the United States, high school students' use of the drug was not monitored in national surveillance systems until the 2011 MTF study cycle¹ and the 2015 YRBS cycle.²¹ As a result, much of the available literature on the use of synthetic cannabinoid is primarily focused on emergency department and poison center data.^{3–5,13,19} With such limited information available on the correlates of synthetic cannabinoid use, no studies were identified with which we can compare our findings on health behavior domains such as injury, violence, mental health, and sexual health. However, a small number of studies conducted in adolescent and/or adult populations identified similar associations between the use of synthetic cannabinoids and other substance use behaviors.^{1,18,26}

For example, Winstock and Barratt²⁶ conducted an anonymous online

survey of a nonrepresentative sample of >15 000 respondents from around the world and observed a high prevalence of other self-reported substance use behaviors among past-year users of synthetic cannabinoids: alcohol (97.8%), marijuana (95.0%), tobacco (84.2%), ecstasy (50.7%), and mushrooms (36.9%). Furthermore, in a study conducted in patients aged ≥ 18 years in a residential substance use disorder treatment program in the Midwest, ever users of synthetic cannabinoids, compared with never users of synthetic cannabinoids, had a significantly greater prevalence of using heroin, methadone, prescription opioids, prescription sedatives, amphetamines, ecstasy, marijuana, hallucinogens, inhalants, and tobacco.¹⁸ Last, in the MTF study of synthetic cannabinoid use among 12th-grade students, synthetic cannabinoid use was associated with ever use of alcohol, marijuana, and other illicit drugs and cigarette smoking.¹

In our study, >98% of students who ever used synthetic cannabinoids

also ever used marijuana. This almost complete overlap in marijuana use among users of synthetic cannabinoids has also been observed by other researchers.^{18,26} We observed that students who ever used synthetic cannabinoids were more likely to have currently used marijuana and to have currently frequently used marijuana compared with students who ever used marijuana only. Furthermore, students who ever used synthetic cannabinoids were more than twice as likely to have tried marijuana before age 13 years compared with students who ever used marijuana only, suggesting that early marijuana use may have been a risk factor for subsequent synthetic cannabinoid use among our study population. Youth may progress from marijuana use only to the use of synthetic cannabinoids for a variety of reasons, such as ease of access, perception of safety, and ability to be undetected by many drug tests. Because our data are cross-sectional, and the 2015 YRBS did not have a question that captured the age of initiation of synthetic cannabinoid use (which

TABLE 4 Prevalence of Selected Health Behaviors by Type of Marijuana Use and Associations Between Selected Health Behaviors and Type of Marijuana Use Among US High School Students: National YRBS, 2015

Selected Health Behaviors	Nonuse			Ever Used Marijuana Only			Ever Used Synthetic Marijuana		
	%	aPR	95% CI	%	aPR	95% CI	%	aPR	95% CI
Injury/violence									
Rode with a driver who had been drinking alcohol	13.2	—	Reference	26.1	1.67	(1.48–1.87) ^a	41.4	2.02	(1.67–2.45) ^{a,b}
Drove when drinking alcohol	2.1	—	Reference	11.6	3.64	(2.52–5.23) ^a	24.8	4.54	(2.89–7.14) ^a
Sexual dating violence ^c	7.4	—	Reference	11.5	1.27	(0.94–1.71)	20.0	1.39	(1.03–1.87) ^a
Physical dating violence ^c	5.7	—	Reference	11.2	1.47	(1.22–1.78) ^a	21.2	1.84	(1.43–2.36) ^a
Ever physically forced to have sexual intercourse	3.4	—	Reference	9.5	2.20	(1.69–2.86) ^a	17.3	2.87	(1.98–4.16) ^a
Bullied on school property ^d	19.2	—	Reference	20.7	1.07	(0.96–1.20)	25.9	1.04	(0.85–1.28)
Electronically bullied ^d	13.0	—	Reference	18.2	1.34	(1.14–1.57) ^a	23.8	1.34	(1.07–1.68) ^a
Threatened or injured with a weapon on school property ^d	3.5	—	Reference	6.6	1.51	(1.14–2.01) ^a	16.1	2.13	(1.44–3.13) ^a
Did not go to school because of safety concerns ^e	3.8	—	Reference	5.7	1.26	(0.99–1.60)	14.9	2.14	(1.60–2.86) ^{a,b}
In a physical fight ^d	14.5	—	Reference	28.9	1.79	(1.58–2.01) ^a	51.6	2.37	(2.02–2.78) ^{a,b}
Carried a weapon ^e	12.0	—	Reference	18.7	1.36	(1.14–1.61) ^a	34.3	1.72	(1.36–2.18) ^a
Mental health									
Felt sad or hopeless	23.5	—	Reference	36.8	1.39	(1.29–1.50) ^a	47.5	1.52	(1.32–1.75) ^a
Seriously considered attempting suicide	13.3	—	Reference	22.2	1.44	(1.23–1.70) ^a	32.7	1.54	(1.22–1.95) ^a
Attempted suicide ^d	5.4	—	Reference	11.1	1.61	(1.29–2.00) ^a	22.0	1.93	(1.46–2.57) ^a
Sexual health									
Ever had sexual intercourse	22.5	—	Reference	66.5	2.32	(2.07–2.60) ^a	82.4	2.75	(2.42–3.14) ^{a,b}
Had first sexual intercourse before age 13 years	1.6	—	Reference	5.4	2.38	(1.80–3.14) ^a	14.8	4.11	(2.84–5.94) ^{a,b}
Had sexual intercourse with ≥4 persons during their life	3.1	—	Reference	20.4	4.15	(3.29–5.23) ^a	38.3	6.20	(4.71–8.15) ^{a,b}
Currently sexually active ^f	15.5	—	Reference	48.6	2.45	(2.13–2.81) ^a	66.5	3.17	(2.72–3.68) ^{a,b}
Drank alcohol/used drugs before last sexual intercourse ^g	3.3	—	Reference	22.8	4.33	(3.00–6.25) ^a	43.9	5.62	(3.83–8.23) ^{a,b}
No condom use during last sexual intercourse ^g	35.0	—	Reference	43.7	1.20	(1.05–1.38) ^a	55.1	1.47	(1.19–1.81) ^{a,b}
Did not use any method to prevent pregnancy	10.6	—	Reference	13.2	1.20	(0.90–1.60)	20.1	1.92	(1.47–2.49) ^{a,b}

All models were adjusted for sex, grade, race/ethnicity, lifetime nonmedical use of prescription drugs, and other illicit drugs (including inhalants, hallucinogens, cocaine, heroin, methamphetamines, and ecstasy). —, not applicable.

^a Linear contrast indicates significantly different from the nonusers group, $P < .05$.

^b Linear contrast indicates significantly different from the marijuana-only group, $P < .05$.

^c Among students who reported dating during the 12 months before the survey.

^d One or more times during the 12 months before the survey.

^e On at least 1 day during the 30 days before the survey.

^f Had sexual intercourse with at least 1 person during the 3 months before the survey.

^g Among students who were currently sexually active.

we could have compared with the age of marijuana initiation), we are limited in our ability to investigate this relationship further. Although data on the relationship between marijuana use and the use of synthetic cannabinoids are limited, it should be noted that researchers have described marijuana use as a risk factor for subsequent use of other illicit drugs.^{27,28} For example, in a retrospective cohort study on drug use in 29 393 French adolescents, the risk of other illicit drug use was 21 times greater among

cannabis experimenters and 124 times greater among daily cannabis users compared with nonusers.²⁷ Much of the published literature has focused on identifying predictors of progression from cannabis use to other illicit drug use.²⁷ Some predictors that have been described include a genetic predisposition, depressive symptoms, stress, peer influence, early onset of cannabis use, high frequency of cannabis use, and drug availability.^{27,29–35} Some of these predictors are a difficult target for public health prevention efforts

(ie, genetic predisposition), but preventing the initiation of marijuana use, particularly among early adolescents (before age 13 years), may have an impact on reducing the use of synthetic cannabinoids and other illicit substance use behaviors. According to data from the nationally representative 2014 School Health Policies and Practices Study, many elementary and middle schools do not emphasize substance use prevention in health education instruction (50.0% of elementary schools, 66.7% of middle schools,

and 86.9% of high schools require instruction on alcohol or other drug use prevention).³⁶ Nationwide, opportunities to provide coverage of substance abuse prevention topics in school health education programs aimed at early adolescents are certainly being missed.

It is unclear what impact the legalization of marijuana will have on the use of synthetic cannabinoids. If marijuana use becomes more socially acceptable, adolescents may be more likely to try marijuana, although the evidence is conflicting.^{37–40} There is a concern that if marijuana use increases, the use of synthetic marijuana may also increase. Fortunately, federal and state legislative and enforcement efforts have greatly reduced access to synthetic cannabinoids. For example, changes in the legal status of synthetic cannabinoids are thought to have contributed to declining use among high school students, with past-year use of synthetic cannabinoids decreasing among 12th-graders from 11.3% in 2012 to

5.3% in 2015.⁴¹ Despite the evidence that synthetic cannabinoid use is declining, recent reports indicate that synthetic cannabinoids are still available and that acute poisonings from synthetic cannabinoids have increased.^{4,42,43}

There are several limitations of our study. Because our data are cross-sectional, it was not possible to determine the temporality of the associations we observed between type of marijuana use and health risk behavior domains. Furthermore, behaviors were self-reported; therefore, it was not possible to determine the extent to which over- or underreporting occurred, but it should be noted that YRBS questions have generally shown good test-retest reliability.^{20,22} Because these data apply only to adolescents who attend school, they are not representative of all individuals in this age group.⁴⁴ Nationwide, in 2012, only ~3% of individuals aged 16 through 17 years were either not enrolled in a high school program or had not completed high school.

CONCLUSIONS

The use of synthetic cannabinoids has emerged as an important public health issue among high school students due to the popularity of the behavior (1 of 10 students) and the severity of the adverse consequences associated with use. Our results indicate that students who use synthetic cannabinoids tend to engage in more risky behaviors than students who use marijuana only. To prevent marijuana use and the use of synthetic cannabinoids, it is important that health professionals and school-based substance prevention programs include strategies that reduce the initiation of marijuana and synthetic cannabinoid use, particularly among students younger than 13 years of age.

ABBREVIATIONS

aPR: adjusted prevalence ratio
CI: confidence interval
MTF: Monitoring the Future
THC: tetrahydrocannabinol
YRBS: Youth Risk Behavior Survey

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