

Adolescent Δ^8 -THC and Marijuana Use in the US

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IMPORTANCE Gummies, flavored vaping devices, and other cannabis products containing psychoactive hemp-derived Δ^8 -tetrahydrocannabinol (THC) are increasingly marketed in the US with claims of being federally legal and comparable to marijuana. National data on prevalence and correlates of Δ^8 -THC use and comparisons to marijuana use among adolescents in the US are lacking.

OBJECTIVE To estimate the self-reported prevalence of and sociodemographic and policy factors associated with Δ^8 -THC and marijuana use among US adolescents in the past 12 months.

DESIGN, SETTING, AND PARTICIPANTS This nationally representative cross-sectional analysis included a randomly selected subset of 12th-grade students in 27 US states who participated in the Monitoring the Future Study in-school survey during February to June 2023.

EXPOSURES Self-reported sex, race, ethnicity, and parental education; census region; state-level adult-use (ie, recreational) marijuana legalization (yes vs no); and state-level Δ^8 -THC policies (regulated vs not regulated).

MAIN OUTCOMES AND MEASURES The primary outcome was self-reported Δ^8 -THC and marijuana use in the past 12 months (any vs no use and number of occasions used).

RESULTS In the sample of 2186 12th-grade students (mean age, 17.7 years; 1054 [48.9% weighted] were female; 232 [11.1%] were Black, 411 [23.5%] were Hispanic, 1113 [46.1%] were White, and 328 [14.2%] were multiracial), prevalence of self-reported use in the past 12 months was 11.4% (95% CI, 8.6%-14.2%) for Δ^8 -THC and 30.4% (95% CI, 26.5%-34.4%) for marijuana. Of those 295 participants reporting Δ^8 -THC use, 35.4% used it at least 10 times in the past 12 months. Prevalence of Δ^8 -THC use was lower in Western vs Southern census regions (5.0% vs 14.3%; risk difference [RD], -9.4% [95% CI, -15.2% to -3.5%]; adjusted risk ratio [aRR], 0.35 [95% CI, 0.16-0.77]), states in which Δ^8 -THC was regulated vs not regulated (5.7% vs 14.4%; RD, -8.6% [95% CI, -12.9% to -4.4%]; aRR, 0.42 [95% CI, 0.23-0.74]), and states with vs without legal adult-use marijuana (8.0% vs 14.0%; RD, -6.0% [95% CI, -10.8% to -1.2%]; aRR, 0.56 [95% CI, 0.35-0.91]). Use in the past 12 months was lower among Hispanic than White participants for Δ^8 -THC (7.3% vs 14.4%; RD, -7.2% [95% CI, -12.2% to -2.1%]; aRR, 0.54 [95% CI, 0.34-0.87]) and marijuana (24.5% vs 33.0%; RD, -8.5% [95% CI, -14.9% to -2.1%]; aRR, 0.74 [95% CI, 0.59-0.94]). Δ^8 -THC and marijuana use prevalence did not differ by sex or parental education.

CONCLUSIONS AND RELEVANCE Δ^8 -THC use prevalence is appreciable among US adolescents and is higher in states without marijuana legalization or existing Δ^8 -THC regulations. Prioritizing surveillance, policy, and public health efforts addressing adolescent Δ^8 -THC use may be warranted.

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Δ^8 -Tetrahydrocannabinol (THC) is an isomer of Δ^9 -THC, the principal psychoactive compound of marijuana (cannabis). Δ^8 -THC and Δ^9 -THC both act on cannabinoid-1 receptors and produce similar intoxicating effects,¹⁻³ but have different legal contexts. Δ^9 -THC is naturally abundant in marijuana—cannabis plant subtypes federally regulated as controlled substances. Δ^8 -THC is synthesized from hemp—cannabis plant subtypes with low Δ^9 -THC concentrations historically cultivated for industrial purposes, which were federally legalized by the 2018 Agriculture Improvement Act.⁴ Since 2018, commercially manufactured consumable hemp-derived Δ^8 -THC products have proliferated.⁵ Gummies and other edibles, electronic vaping devices, and combustible flower containing Δ^8 -THC are marketed as providing a user experience comparable to marijuana in a product that is federally legal (examples are shown in eFigure 1 in Supplement 1).⁵⁻⁷ Δ^8 -THC exposure may pose risks to adolescents, including addiction, neurodevelopmental changes, acute psychiatric reactions from accidental overdosing, and exposure to toxic by-products generated during Δ^8 -THC synthesis.^{5,6,8-11}

Adolescent Δ^8 -THC use prevalence estimates are lacking, leaving little evidence to guide policies. Currently, there is no federal minimum purchasing age for Δ^8 -THC products,¹² which are sold online (often without age verification)^{13,14} and in retailers frequented by youth (eg, convenience stores).¹⁵ Adolescents' access to Δ^8 -THC could be higher in states without Δ^8 -THC regulations or states without legal adult-use marijuana where Δ^8 -THC might be marketed as a legal cannabis substitute.¹⁶ This study estimated self-reported Δ^8 -THC use prevalence among US adolescents overall and stratified by sociodemographic factors and state-level cannabis policies. Marijuana use was studied for comparison.

Methods

Data Source and Participants

The Monitoring the Future (MTF) study is a cross-sectional nationally representative classroom-based survey of US youth.¹⁷ The 2023 MTF survey (administered February 14, 2023, to June 2, 2023) included a question about Δ^8 -THC use to one-third of 12th-grade students selected at random. Survey responses were confidential. The MTF study was approved by the University of Michigan Institutional Review Board (#HUM00217920). Informed consent was obtained from parents of students younger than 18 years (passive or written active, per school policy) and from students 18 years or older (oral).

Measures

Participants self-reported the number of Δ^8 -THC and marijuana use occasions in the past 12 months (0, 1-2, 3-5, 6-9, 10-19, 20-39, and ≥ 40 occasions). Outcomes were any use (≥ 1 vs 0 occasions) and the number of occasions used.

Participants self-reported sex, race and ethnicity (self-identified based on fixed categories assessed to describe the study sample), and parental education; state census region was derived from school location. State-level Δ^8 -THC policies were

Key Points

Question What is the prevalence of self-reported Δ^8 -tetrahydrocannabinol (THC) and marijuana use among 12th-grade students in the US and its distribution across sociodemographic factors and state cannabis policies?

Findings In this nationally representative 2023 survey, 11.4% of 2186 US 12th-grade students self-reported Δ^8 -THC use and 30.4% self-reported marijuana use in the past year. Δ^8 -THC use prevalence was higher in the South and Midwest US and in states without legal adult-use marijuana or Δ^8 -THC regulations. Marijuana use prevalence did not differ by cannabis policies.

Meaning Δ^8 -THC use prevalence is appreciable among US adolescents and is a potential public health concern.

coded as having regulations (ie, bans or restrictions on Δ^8 -THC products) vs no Δ^8 -THC legislation. State-level policies for non-medical adult-use (ie, recreational) marijuana were coded as legal vs not legal. Policies were classified as of January 1, 2023 (eTables 1-2 in Supplement 1).

Analysis

Past-12-month Δ^8 -THC and marijuana use prevalence were calculated overall and stratified by sociodemographic and policy variables. Log-binomial models were used to estimate adjusted risk ratios (aRRs) for associations of sociodemographic and policy variables with Δ^8 -THC and marijuana use controlling for sex, race and ethnicity, and parental education.

In sensitivity analyses, prevalence estimates were recalculated and stratified by state-level cannabis policy variables classified as of January 1, 2022, (ie, earliest point in the 12-month recall interval) and a trichotomous Δ^8 -THC policy variable distinguishing full ban vs some restrictions vs no legislation.

Analyses in STATA (StataCorp LLC) were weighted to produce nationally representative estimates, accounting for complex survey designs and using multiple imputation with chained equations for missing correlate data (<1% missing).¹⁸ Statistical significance was 2-tailed $\alpha = .05$. Differences in aRRs for Δ^8 -THC vs marijuana use were assessed based on nonoverlapping CIs. This exploratory study did not correct for multiple testing. Additional methodological details are provided in the eMethods in Supplement 1.

Results

Descriptive Analyses

The sample included 2186 students (eFigure 2 in Supplement 1); 1054 (48.9%) were females, 1033 (45.8%) were males, and 99 (5.3%) reported another sex or preferred not to report sex; 69 (4.0%) were Asian, 232 (11.1%) were Black, 411 (23.5%) were Hispanic, 1113 (46.1%) were White, 328 (14.2%) were multiracial, and 33 (1.1%) identified as another race. Overall, 51.7% of the sample population had a parent with a college degree. Of the sample, 36.7% lived in South, 24.5% in

Table. Sample Characteristics and Prevalence and Correlates of Δ^8 -THC and Marijuana Use in US 12th-Grade Students in 2023 (N = 2186)^a

Characteristic	Participants, No.	Participants (95% CI), %	Past 12-mo Δ^8 -THC use		Past 12-mo marijuana use	
			Prevalence (95% CI), %	Risk difference (95% CI) ^b	Prevalence (95% CI), %	Risk difference (95% CI) ^b
Overall	2186		11.4 (8.6 to 14.2)		30.4 (26.5 to 34.4)	
Sex						
Female	1054	48.9 (45.5 to 52.3)	9.6 (6.8 to 12.4)	Reference	29.6 (24.2 to 35.0)	Reference
Male	1033	45.8 (42.6 to 48.9)	12.3 (8.8 to 15.7)	2.7 (-0.4 to 5.7)	30.3 (26.5 to 34.1)	0.6 (-4.1 to 5.4)
Other or unreported	99	5.3 (3.8 to 6.8)	19.7 (4.0 to 35.3)	10.1 (-5.7 to 25.8)	38.8 (29.8 to 47.9)	9.2 (-1.1 to 19.5)
Race and ethnicity						
Asian	69	4.0 (0.9 to 7.1)	9.6 (2.2 to 17.1)	-4.8 (-11.8 to 2.2)	20.9 (6.9 to 34.8)	-12.1 (-25.2 to 1.0)
Black	232	11.1 (5.4 to 16.7)	9.7 (2.6 to 16.7)	-4.8 (-11.7 to 2.1)	31.8 (24.8 to 38.8)	-1.3 (-9.6 to 7.1)
Hispanic	411	23.5 (10.2 to 36.8)	7.3 (4.5 to 10.1)	-7.2 (-12.2 to -2.1)	24.5 (19.6 to 29.5)	-8.5 (-14.9 to -2.1)
White	1113	46.1 (34.3 to 57.8)	14.4 (10.3 to 18.6)	Reference	33.0 (28.4 to 37.6)	Reference
Multiracial	328	14.2 (11.9 to 16.5)	10.3 (6.2 to 14.4)	-4.1 (-9.6 to 1.3)	34.4 (25.6 to 43.2)	1.4 (-8.1 to 10.9)
Another race or ethnicity ^c	33	1.1 (0.3 to 1.8)	7.2 (-1.6 to 16.0)	-7.3 (-16.4 to 1.9)	16.6 (1.8 to 31.3)	-16.4 (-32.2 to -0.7)
Parental education						
College degree	1277	51.7 (40.9 to 62.6)	12.6 (8.8 to 16.3)	Reference	31.1 (26.7 to 35.5)	Reference
No college degree	909	48.3 (37.4 to 59.1)	10.1 (6.6 to 13.5)	-2.5 (-7.2 to 2.2)	29.7 (24.3 to 35.1)	-1.4 (-7.4 to 4.6)
US Census region						
Midwest	616	22.0 (12.3 to 31.6)	14.6 (10.9 to 18.2) ^d	0.2 (-6.0 to 6.4)	31.5 (23.9 to 39.0)	4.5 (-4.6 to 13.5)
Northeast	530	16.9 (7.8 to 26.0)	10.1 (5.3 to 14.9)	-4.2 (-11.2 to 2.7)	35.2 (27.7 to 42.7)	8.2 (-0.8 to 17.2)
South	813	36.7 (23.7 to 49.6)	14.3 (9.3 to 19.3)	Reference	27.0 (22.0 to 32.0)	Reference
West	227	24.5 (8.5 to 40.5)	5.0 (2.0 to 7.9) ^d	-9.4 (-15.2 to -3.5)	31.3 (20.1 to 42.6)	4.3 (-8.0 to 16.6)
Adult-use marijuana legalization						
Not legal ^e	1385	55.8 (40.7 to 70.8)	14.0 (10.2 to 17.8)	Reference	29.2 (25.0 to 33.3)	Reference
Legal ^f	801	44.2 (29.2 to 59.3)	8.0 (5.0 to 11.0)	-6.0 (-10.8 to -1.2)	32.0 (24.7 to 39.3)	2.8 (-5.6 to 11.2)
Δ^8 -THC regulation						
Regulated ^g	536	34.8 (19.0 to 50.5)	5.7 (3.1 to 8.4)	-8.6 (-12.9 to -4.4)	30.6 (22.4 to 38.9)	0.3 (-8.9 to 9.6)
No legislation ^h	1650	65.2 (49.5 to 81.0)	14.4 (11.1 to 17.6)	Reference	30.3 (26.1 to 34.5)	Reference

Abbreviations: RD, risk difference; THC, tetrahydrocannabinol.

^a Percentages are weighted to produce nationally representative estimates.

^b Reference group was the category with largest number of participants.

^c Includes American Indian and Alaska Native, Native Hawaiian or Other Pacific Islander, and Middle Eastern.

^d Estimates significantly different between 2 nonreference categories based on nonoverlapping 95% CIs.

^e Included states without adult-use marijuana legalization prior to January 1, 2023: Alabama, Florida, Georgia, Indiana, Kentucky, Louisiana, Minnesota, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, West Virginia, Wisconsin.

^f Included states with adult-use marijuana legalization prior to January 1, 2023: Arizona, California, Illinois, Maine, Michigan, Missouri, Montana, New York, Oregon, Vermont, Washington.

^g Included states with Δ^8 -THC regulations (either banned or restricted) prior to January 1, 2023: California, Louisiana, Michigan, Montana, New York, Oregon, Vermont, Washington.

^h Included states with no Δ^8 -THC legislation prior to January 1, 2023: Alabama, Arizona, Florida, Georgia, Illinois, Indiana, Kentucky, Maine, Minnesota, Missouri, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, West Virginia, Wisconsin.

West, 22.0% in Midwest, and 16.9% in Northeast US census regions; 44.2% lived in states with adult-use marijuana legalization; and 34.8% lived in states with Δ^8 -THC regulations (Table). The mean age of participants was 17.7 (95% CI, 17.5-17.8) years (range, 14-22).

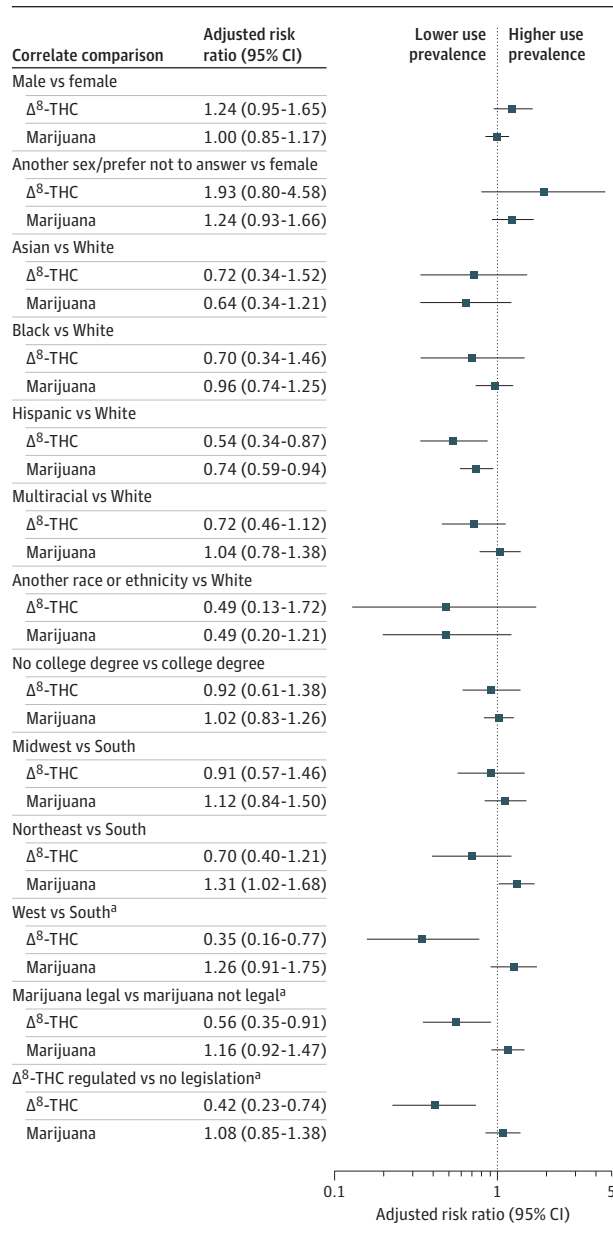
Self-Reported Δ^8 -THC Use

Prevalence of Δ^8 -THC use over the past 12 months was 11.4% (95% CI, 8.6%-14.2%) (Table). Among adolescents with Δ^8 -THC use in the past 12 months (n = 295), 68.1% used Δ^8 -THC at least 3 times, 35.4% used it at least 10 times, and 16.8% used

it at least 40 times in the past 12 months (eTable 3 in Supplement); 90.7% of those adolescents also reported marijuana use in the past 12 months.

Δ^8 -THC use prevalence was 9.6% among females, 12.3% among males, and 19.7% among those with another or unreported sex, with no significant differences between sex. Prevalence was significantly lower among Hispanic participants than White participants (7.3% vs 14.4%; risk difference [RD], -7.2% [95% CI, -12.2% to -2.1%]; aRR, 0.54 [95% CI, 0.34-0.87]) and was 9.6% in Asian participants, 9.7% in Black participants, 10.3% in multiracial participants,

Figure. Adjusted Risk Ratios for Associations of Sociodemographic and Policy Factors With Δ^8 -THC and Marijuana Use



Subgroup analysis from multivariable models for adjusted estimates of association of sociodemographic and policy variables with past 12-month Δ^8 -THC use and marijuana use. Models include the regressor of interest as well as sex, race and ethnicity, and parental education. The reference category was the category with the largest number of participants.

^a Risk ratios for respective regressor are significantly different between Δ^8 -THC and marijuana use outcomes based on nonoverlapping 95% CIs.

and 7.2% in other race or ethnicity groups. Δ^8 -THC use did not significantly differ by parental education (Table and Figure).

Past 12-month Δ^8 -THC use varied by US census region (14.6% in the Midwest, 14.3% in the South, 10.1% in the Northeast, and 5.0% in the West), with significantly lower prevalence in the West than the South (RD, -9.4% [95% CI,

-15.2% to -3.5%]; aRR, 0.35 [95% CI, 0.16-0.77]). Past 12-month Δ^8 -THC use was also significantly higher in the Midwest than the West based on nonoverlapping 95% CIs of 2 prevalence estimates. Δ^8 -THC use prevalence was lower in states with adult-use marijuana legalization vs those without (8.0% vs 14.0%; RD, -6.0% [95% CI, -10.8% vs -1.2%]; aRR, 0.56 [95% CI, 0.35-0.91]) and in states with Δ^8 -THC regulation vs no legislation (5.7% vs 14.4%; RD, -8.6% [95% CI, -12.9% to -4.4%]; aRR, 0.42 [95% CI, 0.23-0.74]).

Self-Reported Marijuana Use

Prevalence of marijuana use over the past 12 months was 30.4% (95% CI, 26.5%-34.4%) overall, was significantly lower for Hispanic (24.5%) vs White (33.0%) participants (RD, -8.5% [95% CI, -14.9% to -2.1%]; aRR, 0.74 [95% CI, 0.59-0.94]), and did not significantly differ by sex or parental education (Table and Figure). Marijuana use prevalence was significantly higher in the Northeast vs South in adjusted models only (RD, 8.2% [95% CI, -0.8% to 17.2%]; aRR, 1.31 [95% CI, 1.02-1.68]). There were no differences in marijuana use by state-level cannabis policies.

Differences in Factors Associated With Self-Reported Δ^8 -THC and Marijuana Use

Census region and cannabis policy aRRs were significantly different for Δ^8 -THC and marijuana use, with nonoverlapping 95% CIs (Figure).

Sensitivity Analyses

Results applying an earlier policy cutoff date aligned with the primary results (eTable 4 in Supplement 1). Δ^8 -THC use prevalence was lower where Δ^8 -THC was banned (5.3%) or restricted (6.1%) vs places in which there were no regulations (14.4%) (eTable 5 in Supplement 1).

Discussion

In 2023, an appreciable percentage of surveyed 12th-grade students in the US reported using Δ^8 -THC in the past year. Δ^8 -THC use was disproportionately concentrated in the South and Midwest US and in states without adult-use marijuana legalization or Δ^8 -THC regulations. Marijuana use did not differ by cannabis policies, aligning with some previous research.¹⁹

Given the federal policy context and divergent regional and policy correlates of Δ^8 -THC and marijuana use found in this study, Δ^8 -THC may be marketed to and/or used by adolescents as a psychoactive cannabis substitute in places in which adult-use marijuana is illegal.¹⁶ This study provides preliminary evidence that state-level Δ^8 -THC regulations may be associated with lower adolescent use. Further research using data from multiple years and methodologies appropriate for policy evaluation¹⁹ could bolster inferences.

Limitations

This study has limitations. First, census region and state-level policy variables were correlated, precluding testing associations net of each other. Second, the survey sample

did not include all states. Third, those who were absent or not enrolled in school were not sampled. Fourth, the mean age of participants was 17.7 years, so results may not represent younger adolescents. Fifth, use of other hemp-derived products (eg, Δ^{10} -THC, hexahydrocannabinol, or THC-O)²⁰ was not measured. This study might underestimate the scope of adolescent use of Δ^8 -THC or other psychoactive hemp-derived products.

Conclusions

Δ^8 -THC use prevalence is appreciable among US adolescents and is higher in states without marijuana legalization or existing Δ^8 -THC regulations. Prioritizing surveillance, policy, and public health efforts addressing adolescent Δ^8 -THC use may be warranted.

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Concept and design: All authors.

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