HHS Public Access

Author manuscript

Drug Alcohol Depend. Author manuscript; available in PMC 2016 April 01.

Published in final edited form as:

Drug Alcohol Depend. 2015 April 1; 149: 194–202. doi:10.1016/j.drugalcdep.2015.01.044.

Synthetic Cannabinoid Use in a Nationally Representative Sample of US High School Seniors

Joseph J. Palamar[1,2] and **Patricia Acosta**[1]

[1]Department of Population Health, New York University (NYU) Langone Medical Center, New York, NY, USA

[2]Center for Drug Use and HIV Research, NYU College of Nursing, New York, NY, USA

Abstract

Background—Synthetic cannabinoids are marketed as “legal highs” and have similar effects to cannabis (marijuana). Although prevalence of synthetic cannabinoid use is now declining in the US, use has been associated with tens of thousands of poisonings and hospitalizations, particularly among teens. It is important to examine which teens are at highest risk for use of these new, potentially deleterious drugs as they are understudied and continue to emerge.

Methods—Data were analyzed from a nationally representative sample of high school seniors in the Monitoring the Future study (2011–2013; Weighted N = 11,863; modal age: 18). Bivariable and multivariable models were used to delineate correlates of recent (12-month) synthetic cannabinoid use.

Results—Ten percent reported any recent use and 3% reported more frequent use (used ≥6 times). Females were at low odds for use and going out 4–7 evenings per week for fun consistently increased odds of use. Black and religious students were at low odds until controlling for other drug use, and higher income increased odds of use until controlling for other drug use. Lifetime use of alcohol, cigarettes and other illicit drugs all robustly increased odds of use, but frequency of lifetime marijuana use was the strongest correlate with more frequent use further increasing odds of synthetic cannabinoid use. Only 0.5% of non-marijuana users reported use of synthetic cannabinoids.

Address correspondence to: Joseph J. Palamar, Department of Population Health, 227 E. 30th Street, 7th Floor, New York, NY 10016, joseph.palamar@nyumc.org, telephone: 646-501-2884.

Contributors

Both authors are responsible for this reported research. J. Palamar conceptualized and designed the study, conducted the statistical analyses, and drafted the initial manuscript. P. Acosta helped conduct literature searches and draft the manuscript. Both authors reviewed and revised the manuscript, and approved the final manuscript as submitted.

Conflict of Interest

No conflict declared.

Conclusions—This is among the first national studies to delineate correlates of synthetic cannabinoid use. Results can inform national and local efforts to prevent use and adverse consequences resulting from use.

Keywords

synthetic cannabinoids; marijuana; adolescents; sociodemographics

1. INTRODUCTION

Synthetic cannabinoids are a large family of compounds that produce similar effects to Δ^9-tetrahydrocannabinol (THC), the main psychoactive ingredient in cannabis (marijuana; Department of Justice [DOJ], 2014; Wiley et al., 2013). There are numerous compounds, mixtures and brands of synthetic cannabinoids, and two of the most well-known brands are K2 and Spice. Although many compounds are now illegal to possess or sell in the US (DOJ, 2014), synthetic cannabinoids remain available in many head shops and over the Internet, and they are often sold as herbal incense "not intended for human consumption." Despite efforts to control sales, new compounds continue to emerge worldwide (European Monitoring Centre for Drugs and Drug Addiction, 2013) and many compounds are not yet illegal or detectable (Castaneto et al., 2014). Use has led to numerous adverse health outcomes and there is a strong need for population data to help guide prevention efforts (Castaneto et al., 2014).

Novel psychoactive drugs such as synthetic cannabinoids are often used because they are "legal" and use generally does not result in arrest (Van Hout et al., 2011). Many individuals also use synthetic cannabinoids as opposed to natural marijuana to avoid detection during drug screenings (Castaneto et al., 2014; Vandrey et al., 2012). However, synthetic cannabinoids may be particularly dangerous as they may be perceived to be safe (Van Hout et al., 2011), marketed products are not regulated, and neither the scientific community nor the public has an adequate understanding of the potential risks involved with use.

While effects of synthetic cannabinoids are often similar to effects of THC in natural marijuana, they have been found to be much more potent and to have stronger effects than THC, and the stronger effects in particular appear to have led to numerous adverse outcomes ("poisonings"), which have often been more serious than adverse consequences resulting from natural marijuana use (Castaneto et al., 2014; Forrester et al., 2012; Kronstrand et al., 2013; Winstock and Barratt, 2013a). Adverse effects include severe agitation and anxiety, intense hallucinations, psychotic episodes, suicidal and other harmful thoughts or actions, hypertension, tachycardia, nausea and vomiting, muscle spasms, seizures, tremors, kidney injuries, and myocardial infarction and stroke, often in otherwise young healthy individuals (American Association of Poison Control Centers [AAPCC], 2014; Bernson-Leung et al., 2013; Castaneto et al., 2014; Centers for Disease Control and Prevention [CDC], 2013a,b; Forrester et al., 2012; Hoyte et al., 2012; Hurst et al., 2011; Mir et al., 2011; Winstock and Barratt 2013b). Use has also been found to be associated with more severe withdrawal when compared to natural marijuana (Nacca et al., 2013).

Some 11,561 poisonings were reported to AAPCC between January, 2009 and April, 2012 with the highest percentage of use among 13–19-year olds (Wood, 2013), and national data from the Drug Abuse Warning Network confirm that individuals at ages 18–20 are at highest risk for poisoning (60.8 per 100,000-population; Substance Abuse and Mental Health Services Administration, 2013). Although reported poisonings have begun to decrease nationally, there were at least 3,359 reported poisonings in the US in 2014 (AAPCC, 2014). Although reports do not always adequately reflect incidence, particularly when a new drug emerges, some areas appear to be experiencing increases. In New York City (NYC), for example, there was a 220% increase in reports of related poisonings by mid-2014 (NYC Department of Health and Mental Hygiene [NYC DOHMH], 2014). Increases in reported poisonings have often occurred in clusters due to “bad batches” (CDC, 2013a; Hoyte et al., 2012; NYC DOHMH, 2014).

Monitoring the Future (MTF) is one of few national surveys that ask about synthetic cannabinoid use. Results suggest that in 2011, annual prevalence of synthetic cannabinoid use was 11.4% among high school seniors (modal age: 18) making it the most prevalent drug used after natural marijuana (Johnston et al., 2014a). Likewise, the Global Drug Survey, conducted via Internet respondent-driven sampling, surveyed 3,300 Americans in 2012 and results suggest that 14% of respondents used synthetic cannabinoids that year (Rogers, 2012). However, recent MTF reports now suggest that use began to decline in 2013, with prevalence dropping to 6% among high school seniors in 2014 (Johnston et al., 2014a; University of Michigan, 2014).

Although use appears to be declining, we know very little about use in national samples because the very few epidemiological studies have been based on small, self-selected or convenience samples, or from adverse outcomes reported to emergency rooms (Castaneto et al., 2014; Community Epidemiology Work Group, 2014). We thus also know very little about higher-frequency use at the national level. This study seeks to help fill in the gaps and provide researchers, policymakers, and educators, information regarding which teens and young adults are at highest risk for this potentially deleterious drug.

2. METHODS

2.1. Procedure

MTF is a nationally representative study of US high school students. A cross-section of students is surveyed every year in approximately 130 public and private schools throughout 48 states. MTF uses a multi-stage random sampling procedure: geographic areas are selected, then schools within areas are selected, and then classes within schools are selected. Approximately 15,000 high school seniors are surveyed every year. MTF assesses content through six different survey forms, which are distributed randomly. All forms assess sociodemographic factors and use of various licit and illicit drugs; however, only survey Forms 3 and 6 assess (last 12-month) use of synthetic cannabinoids. Therefore, use is only assessed in about a third of the sample. MTF began asking about synthetic cannabinoid use in 2011. In order to have adequate power, this analysis focused on aggregated (and weighted) data collected from the three most recent cohorts with available data (2011–

2013). MTF protocols were approved by the University of Michigan Institutional Review Board (IRB) and the authors' IRB approved this secondary data analysis.

2.2. Measures

Students were asked to indicate their sex, age (predefined as <18, ≥18 years) and race/ethnicity (i.e., black, white, Hispanic). Population density of students' residences were predefined as non-, small-, or large-metropolitan statistical areas (MSAs). Small MSAs are defined as counties or groups of counties with at least one city of ≥50,000 inhabitants and the 24 largest MSAs are defined as large MSAs. Non-MSAs are the remaining areas. Level of religiosity was assessed via two ordinal items that asked about level of religious attendance and importance. These items were computed into a composite and divided into tertiles indicating low (1.0–2.0), moderate (2.5–3.0) and high (3.5–4.0) religiosity. To assess family composition, students were asked which parent(s) they resided with. Answers were coded into no parents, one parent or two parents. Students were also asked about parental level of educational attainment of each parent and answer options were 1) grade school, 2) some high school, 3) high school graduate, 4) some college, 5) college graduate, and 6) graduate school. A mean score for both parents (or a raw score if only one parent) was coded into tertiles representing low (1.0–3.0), medium (3.5–4.0), and high (4.5–6.0) education. Students were also asked how much money they earn during the average week from 1) a job or other work, and 2) from other sources. Responses for each of these two income items were coded into $10 or less, $11–50, or $51 or more. Coding of sociodemographic variables was based on previous MTF analyses that focused largely on socioeconomic status (SES; Palamar et al., 2014a; Palamar and Ompad, 2014; Wallace et al., 2009).

Lifetime use of marijuana ("pot, weed, hashish") was assessed and answer options were 1) 0 occasions, 2) 1–2 occasions, 3) 3–5 occasions, 4) 6–9 occasions, 5) 10–19 occasions, 6) 20–39 occasions, and 7) 40 or more occasions. Lifetime alcohol use was assessed using the same answer options and use was dichotomized into yes/no. Lifetime use of the following other illicit drugs was also assessed: powder cocaine, crack, LSD, hallucinogens other than LSD, heroin, and nonmedical use of opioids (other than heroin), tranquilizers (e.g., benzodiazepines), sedatives (e.g., barbiturates) and stimulants (e.g., amphetamine). Use of each was dichotomized and an indicator variable was created to indicate whether the student reported use of any. This variable was computed if the student provided data for at least six of these other illicit drugs. Therefore, those who did not provide responses for at least six other illicit drugs were removed from the analytic sample. Lifetime cigarette use was also assessed and answer options regarding use were: 1) never, 2) once or twice, 3) occasionally, but not regularly, 4) regularly in the past, and 5) regularly now.

Synthetic cannabinoid use was assessed via the following question: "During the last 12 months, on how many occasions (if any) have you taken 'synthetic marijuana' ('K2', 'Spice') to get high?" Answer options were the same as for other drugs previously mentioned and we dichotomized responses into 12-month ("recent") use: yes/no. In addition, to examine more "frequent" recent use we also created a variable indicating whether the student reported using on 6+ occasions.

2.3. Statistical Analyses

Analyses focused on students with complete drug use data (N = 11,863). Descriptive statistics for each variable were examined first, and then each covariate was examined in a bivariable manner to determine whether there were significant differences according to whether the student reported use of synthetic cannabinoids (i.e., no use vs. use). This was done using Rao-Scott chi-square tests for homogeneity, which correct for the complex study design (Rao and Scott, 1984). Regardless of significance of bivariable tests, all covariates predetermined from numerous other MTF analyses of sociodemographic correlates of use (e.g., Palamar et al., 2014b; Palamar and Ompad, 2014) were then fit into multivariable binary logistic regression models with recent synthetic cannabinoid use (yes/no) as the outcome. This was done to determine conditional associations of each factor while controlling for all other covariates. Model 1 contained only sociodemographic covariates and Model 2 retained these covariates, but also included all drug use covariates. Such blockwise multiple regression allows for the comparison of sociodemographics on their own to sociodemographics while controlling for drug use. These models produce an adjusted odds ratio (AOR) and 95% confidence interval (CI) for each covariate. While the main aim of this investigation was to examine correlates of ever-use in the last 12 months, all bivariable and multivariable analyses were then repeated in a supplementary manner to examine potential differences by more frequent use. No statistical correction was utilized for these additional models as this was merely a supplementary analysis to further examine correlates of higher frequency use.

Indicators for cohort (with 2011 as the comparison) were included in models to adjust for potential cohort effects or secular trends. In addition, since there is a substantial amount of missing data in MTF surveys—particularly missing race (15.0%) and religiosity (24.8%), missing data indicators were entered into the models instead of deleting these cases. For example, for the 15% who were missing race, an additional indicator was included to account for the missing level of race. The models were recomputed again with case-complete data (the 51.7% with full data on every variable) to ensure that results (particularly regarding directionality) were similar to the results from the full sample (including missing data indicators), which are presented. This method has been used in numerous MTF analyses (e.g., Palamar and Ompad, 2014; Terry-McElrath et al., 2013). Retaining these cases allowed us to maintain power and allowed rates to match published nationally representative MTF rates (Johnston et al., 2014a). All analyses were design-based for survey data (Heeringa et al., 2010) using survey sample weights provided from MTF. SAS 9.3 software (SAS Institute, 2011) was utilized for all analyses.

3. RESULTS

Sample characteristics are presented in Table 1. One out of ten (10.1%) students reported using synthetic cannabinoid in the last 12 months and 3.2% of the full sample reported “frequent” use. Table 2 presents comparisons of sample characteristics (covariates) according to whether use of synthetic cannabinoid was reported. These bivariable comparisons suggest that males, students with higher income, students who go out more frequently, and students who have used alcohol, cigarettes, marijuana or other illicit drugs,

were more likely to report recent use. In addition, racial minorities (particularly blacks), students who are highly religious, live with two parents, or have parents with high educational attainment, were less likely to report use.

Next, all covariates were entered into multivariable models to delineate potential associations, controlling for all other covariates (Table 3). Compared to males, females were consistently at low odds for synthetic cannabinoid use. Compared to white students, black students were at low odds for use (AOR = 0.58, $p < .001$); however, when controlling for other drug use, identifying as a racial minority was no longer protective. Compared to those of lowest religiosity, those who are moderately (AOR = 0.72, $p < .001$) and highly religious (AOR = 0.39, $p < .001$) were at low odds for use; however, this protective effect also disappeared when controlling for other drug use. Likewise, students who reside with two parents were at low odds for use (AOR = 0.71, $p = .033$) until controlling for other drug use. Parent education was no longer significant in either of the multivariable models. High weekly income from a job increased odds of use, as did moderate or high income from other sources, but all income associations lost significance after controlling for other drug use. Number of evenings out for fun, however, was a more consistent correlate of use. More evenings out per week tended to increase the odds of use, and associations remained significant (although weaker) when controlling for other drug use.

With regard to drug use correlates (all controlling for sociodemographics), lifetime alcohol use nearly doubled the odds for synthetic cannabinoid use (AOR = 1.95, $p < .001$). All levels of ever-smoking increased the odds for use, particularly regular smoking either in the past or in the present, which both more than doubled the odds for use. All levels of lifetime marijuana use robustly increased the odds for use, and as frequency of marijuana use increased, odds for use of synthetic cannabinoids increased. AORs for frequent marijuana use are very large, in part, because so few never-users and infrequent users reported use of synthetic cannabinoids. In fact, only 0.5% of non-marijuana users reported using synthetic cannabinoids so the categories of “used 0 times” and “used 1–2 times” had to be combined. It should be noted that using marijuana 1–2 times was also a robust correlate, but without combining it with the never-used category, the AORs for more frequent use were more than double the size. Finally, reporting lifetime use of any other illicit drugs more than doubled the odds (AOR = 2.24, $p < .001$) for use.

With regard to frequent use of synthetic cannabinoid (used ≥6 times; compared to those who never used or used less frequently), bivariable comparisons (shown in Table 4) suggest that males, students with higher income, students who go out more frequently, and students who have used alcohol, cigarettes, marijuana or other illicit drugs, were more likely to report frequent use. Students who were highly religious or have parents with high educational attainment were less likely to have frequent use.

Results from the multivariable models examining correlates of frequent use (Table 5) suggest that identifying as female (AOR = 0.67, $p = .003$) was protective until controlling for other drug use. Compared to less religious students, those who were highly religious were at low odds for frequent use in the first model (AOR = 0.43, $p < .001$); however, not only was the association lost when controlling for other drug use, but moderate religiosity

became a risk factor for frequent use (AOR = 1.44, $p = .029$). High parental education was consistently protective against frequent use, and going out 4–7 evenings per week for fun was consistently a risk factor. Going out 2–3 nights per week was a risk factor for frequent use, as was high income; however, these associations were no longer significant after controlling for other drug use. Controlling for demographics, lifetime use of alcohol, cigarettes, and other illicit drugs were all strong risk factors for frequent use, and frequent marijuana use (used ≥40 times) in particular was a robust risk factor (AOR = 8.58, $p < .001$). Frequent synthetic cannabinoid use was so infrequent among less frequent marijuana users (e.g., most categories of use below 40 times contained fewer than 10 cases) that we had to collapse these categories for the analyses.

4. DISCUSSION

Synthetic cannabinoid use is a potentially dangerous trend in the US; however, there has been a lack of published research on correlates of national rates of use to inform prevention efforts. This is among the first studies to utilize a nationally representative sample and delineate correlates of use. Moreover, this national study was conducted on those in a high risk age group—adolescents approaching adulthood.

This study corroborates evidence from previous studies in that males are more likely to use synthetic cannabinoids than females (Hoyte et al., 2012; Hu et al., 2011; Vandrey et al., 2012; Wood, 2013). However, this study found that while males were also at increased risk for frequent use, this association disappeared when controlling for other drug use. We also found that blacks were protected against any use, but this association was also lost upon controlling for other drug use. Other MTF reports suggest that females and blacks are also at low risk for natural marijuana use (Johnston et al., 2014b); however, studies have not examined whether associations hold in light of other drug use.

We also found that religious students were at low risk for both use and frequent use until controlling for other drug use. Other studies have also found religiosity to be a protective factor against drug use (Degenhardt et al., 2007; Palamar and Kamboukos, 2014). Interestingly, when controlling for other drug use, moderate religiosity actually became a risk factor for frequent use. National poll data suggests that most American adults now view marijuana use as less of a moral issue (Pew Research Center, 2013). It may be that since religious students' intentions to use marijuana appear to be somewhat dependent on legal status (Palamar et al., 2014), availability of this "legal" version of marijuana may be particularly appealing to some moderately religious individuals whose drug-related moral choices are guided by legal status.

Parent educational attainment, an indicator for SES, was not significantly related to any use; however, high parental education was consistently protective against frequent use. Therefore, it may be that students of higher SES may be just as willing to try synthetic cannabinoid as their lower-SES counterparts, but they are less likely to continue use. Of the psychosocial correlates examined, number of nights out per week for fun was the strongest and most consistent correlate. Specifically, students who go out 4–7 nights per week are at

high risk for experimenting and continuing use, perhaps due to increased exposure to others who use these products.

Unsurprisingly, use of other drugs—licit or illicit—was a robust correlate of synthetic cannabinoid use. Previous studies have shown that most users of synthetic cannabinoids have also used other illicit drugs (Barratt et al., 2013; Vandrey et al., 2012). However, we also demonstrated that many significant sociodemographic correlates of use diminish or disappear when controlling for use of other drugs; thus, drug use appears to largely override many other associations. We have reported similar findings with regard to use of ecstasy (Palamar and Kamboukos, 2014). This is important because many studies do not control for other drug use as a covariate. Lifetime use of alcohol, cigarettes or other illicit drugs, all robustly increase odds of use and continued use; however, marijuana use was the most robust risk factor. Other studies utilizing non-nationally representative samples have found that almost all synthetic cannabinoid users (e.g., 99%) have used natural marijuana, and that the majority are daily (or weekly) users of marijuana, and some users may be dependent on marijuana (Caviness et al., 2014; Gunderson et al., 2014; Winstock and Barratt, 2013a). We add to these findings as we found a dose-response with more frequent lifetime marijuana use further increasing odds for use and frequent use. In addition, we found that only 0.5% of non-lifetime-marijuana users have used synthetic cannabinoids.

Thus far, there is no evidence suggesting use of novel psychoactive drugs such as synthetic cannabinoids serve as a “gateway” to other illicit drugs (Bruno et al., 2012; McElrath and O’Neill, 2011; Moore et al., 2013). However, since use is extremely rare among non-drug users, it is possible that many students who have already used drugs try using synthetic cannabinoids as an alternative to other illicit drugs. Such “legal” highs are often used because use is less likely to result in arrest; they may be more available, less costly, and risk of harm or stigma (e.g., the “drug user” identity) is perceived to be lower (Castaneto et al., 2014; McElrath and O’Neill, 2011; Van Hout and Brennan, 2011). Temporality could not be determined given the cross-sectional nature of the study so we could not determine whether other drug use tended to precede synthetic cannabinoid use. Longitudinal research is needed to determine whether illegal marijuana use truly introduces increased risk of synthetic cannabinoid use or if use is merely an attempt at circumventing drug laws (e.g., as a “legal” replacement for natural marijuana). Research is now also deeded to determine how natural marijuana use relates to synthetic cannabinoid use in states where recreational use (or medical use) is now legal. Regardless, the robust associations suggest that illicit marijuana use—particularly frequent illicit marijuana use—may be the most important risk factor to target in our prevention efforts. We delineated numerous risk factors, but marijuana use appears to be the most important factor we need to target to prevent use. Most marijuana users prefer natural marijuana over synthetic cannabis as it is associated with fewer adverse effects (Winstock and Barratt, 2013a), and this may help explain use appearing to be more experimental than frequent. Prevention messages should also differentiate between those at risk for simply experimenting and those at risk for continued use, as frequent use likely increases the chances of adverse outcomes.

4.1. Limitations

As aforementioned, as with any cross-sectional study, we cannot establish temporality or causality. Missing data, particularly for race and religiosity, was problematic. However, analyses with both the case-complete and full samples with missing data indicators resulted in similar findings. Since synthetic cannabinoid use was only assessed in roughly a third of the sample each year, we collapsed all three available years of data into a single cohort to increase power. Additional analyses (not presented) with covariates × cohort (as a continuous variable) were conducted to ensure that collapsing cohorts in light of any potential non-homogenous trends over time was still acceptable. We also entered cohort indicators into each multivariable model to control for any effects of cohort or secular trends. We did not report on more frequent use (i.e., used 10+ times—the next ordinal response option) as an outcome because prevalence was too low (2%) and only 0.8% of synthetic cannabinoid users used natural marijuana fewer than 40 times. We did, however, compute additional models (not presented) and results of covariates explaining higher frequency use (10+ times) were nearly identical, although the covariates in additional models had wider CIs. High school dropouts were not surveyed by MTF and this can affect generalizability of findings.

4.2. Conclusions

Numerous adverse outcomes and hospitalizations have resulted from use of synthetic cannabinoids in the US. Results from our analyses of a nationally representative sample of high school seniors suggest that the majority of users experiment with the drug and do not continue use; however, any use may still place users at risk for adverse effects. Although our findings corroborated evidence from previous studies that use tends to be infrequent (Gunderson et al., 2014), adverse outcomes are common so it is important to prevent any use. We delineated various correlates of use and frequent marijuana use was the biggest risk factor. These findings can help guide educational efforts to prevent use among teens at highest risk for use.

Acknowledgments

Role of funding source

This project was funded by the NIH (K01 DA-038800, PI: Palamar). The Monitoring the Future principal investigators had no role in analysis, interpretation of results, or in the decision to submit the manuscript for publication.

The authors would like to thank the principal investigators of Monitoring the Future (PIs: Johnston, Bachman, O'Malley, and Schulenberg) at The University of Michigan, Institute for Social Research, Survey Research Center, and the Inter-university Consortium for Political and Social Research for providing access to these data (http://www.icpsr.umich.edu/icpsrweb/landing.jsp). Monitoring the Future data were collected through a research grant (R01 DA-01411) from the National Institute on Drug Abuse (NIDA).

References

American Association of Poison Control Centers. [accessed 03.01.15] Synthetic Cannabinoid Data. 2014. http://www.aapcc.org/alerts/synthetic-marijuana

Barratt MJ, Cakic V, Lenton S. Patterns of synthetic cannabinoid use in Australia. Drug Alcohol Rev. 2013; 32:141–146. [PubMed: 23043552]

Bernson-Leung ME, Leung LY, Kumar S. Synthetic cannabis and acute ischemic stroke. J Stroke Cerebrovasc. 2013; 23:1239–1241.

Bruno R, Matthews AJ, Dunn M, Alati R, McIlwraith F, Hickey S, Burns L, Sindicich N. Emerging psychoactive substance use among regular ecstasy users in Australia. Drug Alcohol Depend. 2012; 124:19–25. [PubMed: 22209387]

Castaneto MS, Gorelick DA, Desrosiers NA, Hartman RL, Pirard S, Huestis MA. Synthetic cannabinoids: epidemiology, pharmacodynamics, and clinical implications. Drug Alcohol Depend. 2014; 144C:12–41. [PubMed: 25220897]

Caviness CM, Tzilos G, Anderson BJ, Stein MD. Synthetic cannabinoids: use and predictors in a community sample of young adults. Subst Abuse. 2014; 15 [Epub ahead of print].

Centers for Disease Control and Prevention. Notes from the field: severe illness associated with synthetic cannabinoid use - Brunswick, Georgia, 2013a. Morb Mortal Wkly Rep. 2013a; 62:939.

Centers for Disease Control and Prevention. Acute kidney injury associated with synthetic cannabinoid use--multiple states, 2012. Morb Mortal Wkly Rep. 2013b; 62:93–98.

Community Epidemiology Work Group. Epidemiologic trends in drug abuse: proceedings of the community epidemiology work group. National Institute on Drug Abuse; 2013. http://www.drugabuse.gov/sites/default/files/files/cewg_january_2013_vol1_508.pdf [accessed 28.10.14]

Degenhardt L, Chiu WT, Sampson N, Kessler RC, Anthony JC. Epidemiological patterns of extra-medical drug use in the United States: evidence from the national comorbidity survey replication, 2001–2003. Drug Alcohol Depend. 2007; 90:210–223. [PubMed: 17481828]

European Monitoring Centre for Drugs and Drug Addiction. [accessed 28.10.14] EU drug markets report: a strategic analysis. 2013. http://www.emcdda.europa.eu/publications/joint-publications/drug-markets

Forrester MB, Kleinschmidt K, Schwarz E, Young A. Synthetic cannabinoid and marijuana exposures reported to poison centers. Hum Exp Toxicol. 2012; 3:1006–1011. [PubMed: 22859662]

Gunderson EW, Haughey HM, Ait-Daoud N, Joshi AS, Hart CL. A survey of synthetic cannabinoid consumption by current cannabis users. Subst Abuse. 2014; 35:184–189.

Heeringa, SG.; West, BT.; Berglund, PA. Applied Survey Data Analysis. Chapman and Hall; London: 2010.

Hoyte CO, Jacob J, Monte AA, Al-Jumaan M, Bronstein AC, Heard KJ. A characterization of synthetic cannabinoid exposures reported to the National Poison Data System in 2010. Ann Emerg Med. 2012; 60:435–438. [PubMed: 22575211]

Hu X, Primack BA, Barnett TE, Cook RL. College students and use of K2: an emerging drug of abuse in young persons. Subst Abuse Treat Prev Policy. 2011; 11:6–16.

Hurst D, Loeffler G, McLay R. Psychosis associated with synthetic cannabinoid agonists: a case series. Am J Psychiatry. 2011; 168:1119. [PubMed: 21969050]

Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE, Miech RA. Monitoring the Future National Survey Results on Drug Use, 1975–2013. Secondary School Students. 2014a; I http://www.monitoringthefuture.org/pubs/monographs/mtf-vol1_2013.pdf.

Johnston, LD.; O'Malley, PM.; Bachman, JG.; Schulenberg, JE.; Miech, RA. Demographic subgroup trends among adolescents in the use of various licit and illicit drugs, 1975–2013 (Monitoring the Future Occasional Paper 81). Ann Arbor, MI: Institute for Social Research; 2014b. http://www.monitoringthefuture.org/pubs/occpapers/mtf-occ81.pdf [accessed 30.12.14]

Kronstrand R, Roman M, Andersson M, Eklund A. Toxicological findings of synthetic cannabinoids in recreational users. J Anal Toxicol. 2013; 37:534–541. [PubMed: 23970540]

McElrath K, O'Neill C. Experiences with mephedrone pre- and post-legislative controls: perceptions of safety and sources of supply. Int J Drug Policy. 2011; 22:120–127. [PubMed: 21242082]

Mir A, Obafemi A, Young A, Kane C. Myocardial infarction associated with use of the synthetic cannabinoid K2. Pediatrics. 2011; 128:1622–1627.

Moore K, Dargan PI, Wood DM, Measham F. Do novel psychoactive substances displace established club drugs, supplement them or act as drugs of initiation? The relationship between mephedrone, ecstasy and cocaine. Eur Addict Res. 2013; 19:276–282. [PubMed: 23615495]

Nacca N, Vatti D, Sullivan R, Sud P, Su M, Marraffa J. The synthetic cannabinoid withdrawal syndrome. J Addict Med. 2013; 7:296–298. [PubMed: 23609214]

New York City Department of Health and Mental Hygiene. [accessed 27.07.14] Health Department Warns New Yorkers of Dangers of Synthetic Cannabinoids. 2014. Press Release # 023-14. http://www.nyc.gov/html/doh/html/pr2014/pr023-14.shtml

Palamar JJ, Kamboukos D. An examination of sociodemographic correlates of ecstasy use among high school seniors in the United States. Subst Use Misuse. 2014; 49:1774–1783. [PubMed: 24955818]

Palamar JJ, Ompad DC. Demographic and socioeconomic correlates of powder cocaine and crack use among high school seniors in the United States. Am J Drug Alcohol Abuse. 2014; 40:37–43. [PubMed: 24191647]

Palamar JJ, Ompad DC, Petkova E. Correlates of intentions to use cannabis among US high school seniors in the case of cannabis legalization. Int J Drug Policy. 2014; 25:424–435. [PubMed: 24589410]

Palamar JJ, Zhou S, Sherman S, Weitzman M. Hookah use among US high school seniors. Pediatrics. 2014; 134:227–234. [PubMed: 25002664]

Pew Research Center. [accessed 28.10.14] Majority now supports legalizing cannabis. 2013. http://www.people-press.org/files/legacy-pdf/4-4-13%20Cannabis%20Release.pdf

Rao JNK, Scott AJ. On chi-squared tests for multi-way tables with cell proportions estimated from survey data. Ann Stat. 1984; 12:46–60.

Rogers, S. [accessed 28.10.14] Which drugs do you take? US and the UK compared by the Global Drug Survey. The Guardian. 2012. http://www.theguardian.com/society/datablog/2012/mar/15/global-drug-survey-us-uk#data

SAS Institute. SAS® 9.3. Cary, NC: 2011.

Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. [accessed 28.10.14] The DAWN Report: Highlights of the 2011 Drug Abuse Warning Network (DAWN) Findings on Drug-Related Emergency Department Visits. 2013. http://www.samhsa.gov/data/sites/default/files/DAWN127/DAWN127/sr127-DAWN-highlights.htm

Terry-McElrath YM, O'Malley PM, Johnston LD. Simultaneous alcohol and marijuana use among U.S. high school seniors from 1976 to 2011: trends, reasons, and situations. Drug Alcohol Depend. 2013; 133:71–79. [PubMed: 23806871]

University of Michigan. [accessed 18.12.14] Use of alcohol, cigarettes, and a number of illicit drugs declines among US teens [press release]. 2014. http://www.monitoringthefuture.org/pressreleases/14drugpr.pdf

US Drug Enforcement Administration. Schedules of Controlled Substances: Temporary Placement of Four Synthetic Cannabinoids into Schedule I. 21 CFR Part 1308. Fed Regist. 2014; 79:7577–7282. [PubMed: 24605391]

Van Hout MC, Brennan R. 'Heads held high': an exploratory study of legal highs in pre-legislation Ireland. J Ethn Subst Abuse. 2011; 10:256–272. [PubMed: 21888502]

Vandrey R, Dunn KE, Fry JA, Girling ER. A survey study to characterize use of spice products (synthetic cannabinoids). Drug Alcohol Depend. 2012; 120:238–241. [PubMed: 21835562]

Wallace JM Jr, Vaughn MG, Bachman JG, O'Malley PM, Johnston LD, Schulenberg JE. Race/ethnicity, socioeconomic factors, and smoking among early adolescent girls in the United States. Drug Alcohol Depend. 2009; 104:S42–49. [PubMed: 19628345]

Wiley JL, Marusich JA, Huffman JW. Moving around the molecule: relationship between chemical structure and in vivo activity of synthetic cannabinoids. Life Sci. 2013b; 23:531–534.

Winstock AR, Barratt MJ. Synthetic cannabis: a comparison of patterns of use and effect profile with natural cannabis in a large global sample. Drug Alcohol Depend. 2013a; 131:106–111. [PubMed: 23291209]

Winstock AR, Barratt MJ. The 12-month prevalence and nature of adverse experiences resulting in emergency medical presentations associated with the use of synthetic cannabinoid products. Hum Psychopharmacol. 2013b; 28:390–393. [PubMed: 23881887]

Wood KE. Exposure to bath salts and synthetic tetrahydrocannabinol from 2009 to 2012 in the United States. J Pediatr. 2013; 163:213–216. [PubMed: 23391041]

HIGHLIGHTS

- One out of ten high school seniors used synthetic cannabinoids in the last 12 months
- 3% used ≥6 times, suggesting most users experiment and do not continue use
- Use of alcohol, cigarettes and other illicit drugs all robustly increased odds of use
- Marijuana use—especially frequent use—was the biggest risk factor for use
- Going out 4–7 evenings per week for fun consistently increased odds of use

Table 1

Sample characteristics (Weighted *N* = 11,863).

	N	%
Sex		
Male	5,647	47.6
Female	5,848	49.3
Missing	368	3.1
Age, years		
<18	5,115	43.1
≥18	6,657	56.1
Missing	91	0.8
Race		
White	7,304	61.6
Black	1,129	9.5
Hispanic	1,649	13.9
Missing	1,781	15.0
Population Density		
Non-MSA	2,345	20.5
Small MSA	5,892	49.7
Large MSA	3,540	29.8
Religiosity		
Low	3,574	30.1
Moderate	2,493	21.0
High	2,849	24.0
Missing	2,947	24.8
Family Structure		
0 Parents	635	5.4
1 Parent	3,146	26.5
2 Parents	8,028	67.7
Missing	54	0.5
Parent Education		
Low	3,339	28.1
Moderate	3,336	28.4
High	4,769	40.2
Missing	389	3.2
Weekly Income from Job		
$10 or Less	5,518	46.5
$11–50	1,397	11.8
$51 or More	4,608	38.8
Missing	340	2.9
Weekly Income from Other Source		
$10 or Less	6,407	54.0

	N	%
$11–50	3,863	32.6
$51 or More	1,124	9.5
Missing	469	4.0
Evenings Out Per Week for Fun		
0–1	3,412	28.8
2–3	5,724	48.2
4–7	2,564	21.6
Missing	164	1.4
Lifetime Alcohol Use		
No	3,720	31.4
Yes	8,143	68.6
Cigarette Smoking		
Never Smoked	7,306	61.6
Smoked once or twice	2,091	17.6
Smoked Regularly in the Past	1,184	10.0
Smoke Occasionally	514	4.3
Smoke Regularly	769	6.5
Lifetime Marijuana Use		
Used 0 Times	6,551	55.2
Used 1–2 Times	1,130	9.5
Used 3–5 Times	699	5.9
Used 6–9 Times	449	3.8
Used 10–19 Times	639	5.4
Used 20–39 Times	561	4.7
Used 40+ Times	1,834	15.5
Lifetime Use of Other Illicit Drugs		
No	9,102	76.7
Yes	2,761	23.3
12-Month Synthetic Cannabinoid Use		
No	10,665	90.9
Yes	1,198	10.1
12-Month Frequent Synthetic Cannabinoid Use (Used ≥6 Times)		
No	11,480	96.8
Yes	384	3.2

Note. MSA = metropolitan statistical area. Weighted percentages are rounded so they do not always add up to exactly 100%.

Table 2

Bivariable comparisons according to synthetic cannabinoid use in the last 12 months.

	Raw Proportions		
	No Use, % (*N* = 10,665)	**Use, % (*N* = 1,198)**	**p-value**
Sex			<.001
Male	87.2	12.8	
Female	92.7	7.3	
Age, years			.486
<18	90.2	9.8	
≥18	89.7	10.3	
Race			<.001
White	88.7	11.3	
Black	94.1	5.9	
Hispanic	90.8	9.2	
Population Density			.935
Non-MSA	89.7	10.3	
Small MSA	90.0	10.0	
Large MSA	89.9	10.1	
Religiosity			<.001
Low	85.7	14.3	
Moderate	89.7	10.3	
High	94.6	5.4	
Family Structure			.004
0 Parents	88.1	11.9	
1 Parent	88.5	11.5	
2 Parents	90.6	9.4	
Parent Education			.023
Low	89.5	10.5	
Moderate	88.7	11.3	
High	90.8	9.2	
Weekly Income from Job			<.001
$10 or Less	91.1	8.1	
$11–50	90.7	9.3	
$51 or More	87.2	12.8	
Weekly Income from Other Source			<.001
$10 or Less	91.0	9.0	
$11–50	89.0	11.0	
$51 or More	86.2	13.8	
Evenings Out Per Week for Fun			<.001
0–1	95.0	5.0	
2–3	90.6	9.4	
4–7	81.7	18.3	

	Raw Proportions		
	No Use, % (*N* = 10,665)	**Use, % (*N* = 1,198)**	**p-value**
Lifetime Alcohol Use			<.001
No	98.8	1.2	
Yes	85.8	14.2	
Cigarette Smoking			<.001
Never Smoked	97.0	3.0	
Smoked once or twice	86.8	13.2	
Smoked Regularly in the Past	75.2	24.8	
Smoke Occasionally	77.3	22.7	
Smoke Regularly	61.7	38.3	
Lifetime Marijuana Use			<.001
Used 0 Times	99.5	0.5	
Used 1–2 Times	95.4	4.6	
Used 3–5 Times	88.3	11.7	
Used 6–9 Times	84.3	15.7	
Used 10–19 Times	82.1	17.9	
Used 20–39 Times	78.9	21.1	
Used 40+ Times	60.2	39.8	
Lifetime Use of Other Illicit Drugs			<.001
No	95.8	4.2	
Yes	70.3	29.7	

Note. Only case-complete data were used for bivariable comparisons (not including missing data). MSA = metropolitan statistical area.

Table 3

Multivariable models explaining synthetic cannabinoid use in the last 12 months.

	Model 1		Model 2	
	AOR	**(95% CI)**	**AOR**	**(95% CI)**
Sex				
Male	1.00		1.00	
Female	0.60***	(0.52–0.70)	0.71***	(0.59–0.84)
Age, years				
<18	1.00		1.00	
≥18	0.96	(0.83–1.11)	0.89	(0.76–1.06)
Race				
White	1.00		1.00	
Black	0.58***	(0.42–0.79)	0.80	(0.55–1.15)
Hispanic	0.85	(0.68–1.07)	0.89	(0.69–1.16)
Population Density				
Non-MSA	1.00		1.00	
Small MSA	1.01	(0.84–1.21)	0.83	(0.67–1.02)
Large MSA	1.04	(0.85–1.27)	0.86	(0.67–1.08)
Religiosity				
Low	1.00		1.00	
Moderate	0.72***	(0.60–0.87)	1.05	(0.85–1.30)
High	0.39***	(0.31–0.49)	0.99	(0.76–1.29)
Family Structure				
0 Parents	1.00		1.00	
1 Parent	0.89	(0.64–1.22)	1.18	(0.83–1.68)
2 Parents	0.71*	(0.52–0.97)	1.26	(0.89–1.78)
Parent Education				
Low	1.00		1.00	
Moderate	1.05	(0.87–1.28)	0.98	(0.79–1.22)
High	0.88	(0.73–1.06)	1.00	(0.81–1.24)
Weekly Income from Job				
$10 or Less	1.00		1.00	
$11–50	1.22	(0.95–1.55)	1.02	(0.77–1.36)
$51 or More	1.58***	(1.34–1.85)	1.08	(0.90–1.27)
Weekly Income from Other Source				
$10 or Less	1.00		1.00	
$11–50	1.22*	(1.04–1.43)	0.98	(0.82–1.19)
$51 or More	1.38**	(1.10–1.73)	0.98	(0.75–1.28)
Evenings Out Per Week for Fun				
0–1	1.00		1.00	

	Model 1		Model 2	
	AOR	**(95% CI)**	**AOR**	**(95% CI)**
2–3	1.80***	(1.47–2.20)	1.26*	(1.00–1.58)
4–7	3.44***	(2.78–4.26)	1.52***	(1.19–1.93)
Lifetime Alcohol Use				
No			1.00	
Yes			1.95***	(1.33–2.85)
Cigarette Smoking				
Never Smoked			1.00	
Smoked once or twice			1.70***	(1.34–2.17)
Smoked Regularly in the Past			2.22***	(1.72–2.86)
Smoke Occasionally			1.57**	(1.13–2.19)
Smoke Regularly			2.20***	(1.67–2.91)
Lifetime Marijuana Use				
Used 0–2 Times			1.00	
Used 3–5 Times			7.11***	(4.87–10.39)
Used 6–9 Times			8.71***	(5.82–13.05)
Used 10–19 Times			9.82***	(6.67–14.44)
Used 20–39 Times			10.83***	(7.41–15.83)
Used 40+ Times			19.58***	(14.12–27.15)
Lifetime Use of Other Illicit Drugs				
No			1.00	
Yes			2.24***	(1.86–2.69)
Nagelkerke R^2	11%		42%	
Correct Classification Rate	90%		91%	

Note. The comparison group for synthetic cannabinoid users (Weighted *N* = 1,198) is non-synthetic cannabinoid users (Weighted *N* = 10,665). Adjusted Odds Ratios (AORs) were adjusted for all other covariates including cohort and missing data indicators. Raw MSA = metropolitan statistical area. CI = confidence interval. Only 0.5% of non-lifetime marijuana users reported use of synthetic cannabinoids so we combined "Used 0 Times" and "Used 1–2 Times " into a single category for comparison to prevent further inflation of AORs.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 4

Bivariable comparisons according to frequent synthetic cannabinoid use in the last 12 months.

	Raw Proportions		
	No Use or Sustained Use, % (*N* = 11,480)	Sustained Use, % (*N* = 384)	p-value
Sex			<.001
Male	96.0	4.0	
Female	97.7	2.3	
Age, years			.664
<18	96.9	3.1	
≥18	96.8	3.2	
Race			.078
White	96.4	3.6	
Black	98.0	2.0	
Hispanic	96.5	3.5	
Population Density			.508
Non-MSA	96.4	3.6	
Small MSA	96.7	3.3	
Large MSA	97.0	3.0	
Religiosity			<.001
Low	95.7	4.3	
Moderate	96.2	3.8	
High	98.4	1.6	
Family Structure			.137
0 Parents	96.0	4.0	
1 Parent	96.3	3.7	
2 Parents	97.0	3.0	
Parent Education			.001
Low	96.1	3.9	
Moderate	96.2	3.8	
High	97.6	2.4	
Weekly Income from Job			.001
$10 or Less	97.4	2.6	
$11–50	97.2	2.8	
$51 or More	95.9	4.1	
Weekly Income from Other Source			.001
$10 or Less	97.2	2.8	
$11–50	96.6	3.4	
$51 or More	94.8	5.2	
Evenings Out Per Week for Fun			<.001
0–1	98.6	1.4	
2–3	97.2	2.8	
4–7	93.3	6.7	

	Raw Proportions		
	No Use or Sustained Use, % (*N* = 11,480)	**Sustained Use, % (*N* = 384)**	**p-value**
Lifetime Alcohol Use			<.001
No	99.7	0.3	
Yes	95.4	4.6	
Cigarette Smoking			<.001
Never Smoked	99.3	0.7	
Smoked once or twice	97.0	3.0	
Smoked Regularly in the Past	91.5	8.5	
Smoke Occasionally	93.5	6.5	
Smoke Regularly	82.8	17.2	
Lifetime Marijuana Use			<.001
Used 0–39 Times	99.2	0.8	
Used 40+ Times	83.4	16.6	
Lifetime Use of Other Illicit Drugs			<.001
No	98.9	1.1	
Yes	89.7	10.3	

Note. Only case-complete data were used for bivariable comparisons (not including missing data). MSA = metropolitan statistical area. Most categories of the original ordinal lifetime marijuana use variable had fewer than 10 cases so these cases were collapsed into “Used 0–39 Times.”

Table 5

Multivariable models explaining frequent synthetic cannabinoid use in the last 12 months.

	Model 1		Model 2	
	AOR	**(95% CI)**	**AOR**	**(95% CI)**
Sex				
Male	1.00		1.00	
Female	0.67**	(0.51–0.87)	0.89	(0.67–1.19)
Age, years				
<18	1.00		1.00	
≥18	0.95	(0.74–1.23)	0.88	(0.67–1.15)
Race				
White	1.00		1.00	
Black	0.64	(0.39–1.07)	1.16	(0.66–2.03)
Hispanic	0.97	(0.66–1.44)	1.24	(0.81–1.91)
Population Density				
Non-MSA	1.00		1.00	
Small MSA	1.00	(0.75–1.35)	0.88	(0.64–1.21)
Large MSA	0.90	(0.64–1.25)	0.79	(0.55–1.13)
Religiosity				
Low	1.00		1.00	
Moderate	0.91	(0.67–1.23)	1.44*	(1.04–1.99)
High	0.43***	(0.29–0.65)	1.18	(0.76–1.82)
Family Structure				
0 Parents	1.00		1.00	
1 Parent	0.90	(0.56–1.43)	1.28	(0.77–2.11)
2 Parents	0.79	(0.50–1.23)	1.51	(0.92–2.48)
Parent Education				
Low	1.00		1.00	
Moderate	0.98	(0.71–1.35)	0.85	(0.60–1.18)
High	0.64**	(0.47–0.87)	0.69*	(0.49–0.97)
Weekly Income from Job				
$10 or Less	1.00		1.00	
$11–50	1.08	(0.70–1.66)	0.96	(0.60–1.55)
$51 or More	1.43*	(1.08–1.89)	1.03	(0.76–1.38)
Weekly Income from Other Source				
$10 or Less	1.00		1.00	
$11–50	1.12	(0.85–1.48)	0.96	(0.71–1.29)
$51 or More	1.53*	(1.07–2.17)	1.16	(0.79–1.70)
Evenings Out Per Week for Fun				
0–1	1.00		1.00	

	Model 1		Model 2	
	AOR	**(95% CI)**	**AOR**	**(95% CI)**
2–3	1.89***	(1.30–2.73)	1.33	(0.90–1.96)
4–7	4.20***	(2.89–6.10)	1.68*	(1.13–2.50)
Lifetime Alcohol Use				
No			1.00	
Yes			2.74**	(1.31–5.74)
Cigarette Smoking				
Never Smoked			1.00	
Smoked once or twice			1.51	(0.95–2.39)
Smoked Regularly in the Past			2.93***	(1.87–4.59)
Smoke Occasionally			1.77*	(1.02–3.09)
Smoke Regularly			3.50***	(2.17–5.63)
Lifetime Marijuana Use				
Used 0–39 Times			1.00	
Used 40+ Times			8.58***	(5.88–12.50)
Lifetime Use of Other Illicit Drugs				
No			1.00	
Yes			2.08***	(1.46–2.95)
Nagelkerke R^2	9%		33%	
Correct Classification Rate	97%		91%	

Note. The comparison group for synthetic cannabinoid users (Weighted N = 1,198) is non-synthetic cannabinoid users (Weighted N = 10,665). Adjusted Odds Ratios (AORs) were adjusted for all other covariates including cohort and missing data indicators. Raw MSA = metropolitan statistical area. CI = confidence interval. MSA = metropolitan statistical area. CI = confidence interval. Most categories of the original ordinal lifetime marijuana use variable had fewer than 10 cases so these cases (serving as the comparison) were collapsed into “Used 0–39 Times.”

* $p < .05$,

** $p < .01$,

*** $p < .001$.