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Short communication

"Flakka" use among high school seniors in the United States

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ABSTRACT

Background: Use of synthetic cathinones, commonly referred to as "bath salts", has been associated with tens of thousands of emergency department visits in the US; however, few national studies have estimated prevalence of use and we know very little about use among adolescents. In this study we estimate prevalence and correlates of use of "Flakka" (alpha-PVP), a highly-potent "bath salt" associated with at least 80 deaths in the US.

Methods: We analyzed data from the 2016/2017 Monitoring the Future study, which surveyed a nationally representative sample of high school seniors in the US (n = 3786). Bivariable and multivariable models were used to determine demographic and drug-related correlates of use.

Results: Overall, 0.8% (95% CI: 0.5–1.2) of high school seniors in 2016/2017 is estimated to have used Flakka in the past year. Students whose parents have less than a high school education were at higher odds for use (aOR = 4.12, 95% CI: 1.00–16.94). Flakka users reported high prevalence of use of other drugs, particularly synthetic cannabinoids (85.6%), ketamine (72.3%), marijuana (59.1%), and GHB (47.5%). Flakka use was also associated with use of a higher number of other drugs and higher frequency of use of other drugs, with 51.7% using 4–12 other drugs and 22.4% using 4–12 other drugs > 6 times.

Conclusions: Students who use multiple drugs are elevated risk for Flakka use, suggesting synthetic cathinone use alone is rare and the use of multiple substances may compound adverse effects of these drugs. Socio-economic disparities are concerning given reduced access to prevention and intervention.

1. Introduction

New psychoactive substances (NPS) continue to emerge in the US and globally at an alarming rate (European Monitoring Centre for Drugs and Drug Addiction [EMCDDA], 2018; U.S. Drug Enforcement Administration [DEA], 2018). Synthetic cathinones, commonly referred to as "bath salts" in the US, are a prevalent category of NPS. "Bath salt" use has been associated with tens of thousands of emergency department (ED) visits in the US, with over 22,000 in 2011 (Substance Abuse and Mental Health Services Administration, 2013). At least 127 different compounds have been discovered, but the "second generation" compound, α-pyrrolidinopentiophenone (alpha-PVP), commonly referred to as "Flakka" or "gravel", has received considerable attention in the US. Flakka has cocaine-like stimulant effects, and it is approximately equipotent to methamphetamine (Watterson and Olive, 2017) and a stronger reinforcer than other "bath salts" and cocaine (Gannon et al., 2018). Flakka use is commonly associated with adverse effects such as tachycardia, hyperthermia, anxiety, seizures, agitation, aggression, hallucinations, paranoia, excited delirium syndrome, and suicidality (European Monitoring Centre for Drugs and Drug Addiction, 2016; Zawilska and Andrzejczak, 2015).

Although there is a dearth of national data on poisonings or hospitalizations related to Flakka use, or "bath salt" use in general in recent years, at least 80 deaths related to Flakka use occurred in Florida between September 2014 and December 2015, with nearly 2000 related ED visits within Broward County, with most users exhibiting excited delirium syndrome (NDEWS Coordinating Center, 2016). Over 100 Flakka-related deaths have also occurred throughout Europe (European Monitoring Centre for Drugs and Drug Addiction, 2016). Between 2013 and 2015, Flakka was the second-most prevalent "bath salt" seized in the US in with nearly 15,000 confiscations (U.S. Drug Enforcement Administration, 2016), although there were only about 1000 confiscations in 2017 (U.S. Drug Enforcement Administration, 2018).

Of particular concern is use among adolescents, among whom early exposure to psychoactive drugs may be particularly problematic, given neuropsychiatric maturation (Volkow et al., 2014). Further, adolescents

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are developing drug use patterns, and higher early exposure to multiple substances predicts a longer course and higher frequency of drug use into adulthood (Grant and Dawson, 1998). Within the data on ED visits related to Flakka use in Florida (in 2014–2015), although the mean age of those visiting EDs after use was 34, about 15% of these ED visits were by users under the age of 25, with one as young as 13. No data are available on the age distribution of other harms associated with Flakka use, including hospitalization and death; thus the harm to adolescents is not well understood.

There are currently no epidemiologic data on prevalence and correlates of use of this substance among adolescents in the US. This information is needed to inform prevention and public health response to this substance and to similar NPS that emerge in the future.

2. Methods

2.1. Procedure

Monitoring the Future (MTF) is a nationally representative study of US high school students (Miech et al., 2018). A cross-section is surveyed every year in approximately 130 public and private schools throughout 48 states using a multi-stage random sampling procedure (Miech et al., 2018). MTF asked high school seniors (12^{th} graders) about past-year Flakka ("gravel") use in 2016 and 2017. MTF assesses content through six different survey forms, which are distributed randomly; one form assesses Flakka use. Response rates were 80% and 79% for 2016 and 2017, respectively, with 2118 students surveyed via this survey form in 2016 and 2272 surveyed via this form in 2017. Data from students who responded to the question about Flakka use were aggregated for analyses (n = 3786).

2.2. Measures

We examined past-year self-reported use of Flakka as the dependent variable and assessed its correlation with past-year use of alcohol and 11 other illegal drugs (i.e., marijuana, cocaine, ecstasy, methamphetamine, synthetic cannabinoids, ketamine, GHB, heroin, and non-medical use of opioids, amphetamine, and sedatives). Use of each drug was queried in an ordinal manner (i.e., used 0 times, 1–2 times, 3–5 times, 6–9 times, 10–19 times, 20–30 times, 40+ times) and we dichotomized use of each into yes vs. no. We also created binary variables for other drugs indicating use 3 or more times and 6 or more times. We then coded categorical variables indicating the number of other drugs used in the past year, and we created similar variables indicating number of other drugs used 3 or more times and 6 or more times in the past year.

With regard to demographic characteristics, students were asked to indicate their age (predefined as < 18, > 18 years), sex, and race/ethnicity (i.e., black, white, Hispanic). To assess family composition, students were asked which parent(s) they resided with. Responses were coded into a variable to indicate number of parents (i.e., 0, 1, 2). Students were also asked about educational attainment of each parent, and we coded a variable indicating the highest level of education by any reported parent. Average student weekly income from a job or other work was assessed, and this was recoded into < $125 vs. > $125 per week to indicate "high" income (top 25^{th} percentile). Population density of students' residences were pre-defined as non-, small-, or large-metropolitan statistical areas (MSAs).

2.3. Analyses

We first estimated the prevalence of Flakka use. We then determined demographic, and drug use-related correlates of Flakka use using chi-square, and we then fit covariates into a multivariable logistic regression model. This model contained all demographic variables and the variable indicating number of other illegal drugs used in the past year. We implemented multiple imputation by chained equations (MICE) to handle missingness due to nonresponse. Predictors included all variables in the case-complete model as well as auxiliary variables correlated with any missing variable at 0.4 or greater—past year use of GHB, ketamine, and synthetic cannabinoids. We imputed 10 datasets, on which we computed the multivariable logistic model and combined the results using Rubin's Rules (Rubin, 1987). We then repeated the model using the case-complete dataset to ensure that results across models were similar. All analyses utilized sample weights provided by MTF to correct for the complex survey design (Heeringa et al., 2010). MTF protocols were approved by the University of Michigan Institutional Review Board (IRB), and the authors' IRBs declared this secondary data analysis exempt from review.

3. Results

In 2016–2017, an estimated 0.8% (95% CI: 0.5–1.2) of high school seniors in the US used Flakka in the past year. Of those reporting use, about a quarter (27.7%) reported using 1–2 times in the past year, 37.8% reported using 3–5 times, 10.8% reported using 6–9 times, 3.8% reported using 10–19 times, 0.7% reported using 20–39 times, and almost a fifth (19.2%) reported using on 40+ times.

As shown in Table 1, students reporting Flakka use were more likely to report residing with no parents (28.9%) than non-users (5.9%; $p < .001$), and students reporting Flakka use were more likely to have parents with less than a high school education (28.1%) compared to non-users (9.7%, $p = .012$). Although past-year alcohol use was not related to Flakka use, past-year use of each of the other 11 drugs examined were all correlates of use, with particularly large portions of Flakka users reporting use of synthetic cannabinoids (85.6%), ketamine (72.3%), marijuana (59.1%), and/or GHB (47.5%). Flakka use was also associated with use of more drugs and higher frequency of use of more drugs. Specifically, over half of Flakka users reported using 4–12 other drugs (51.7%) compared to non-users (4.3%; $p < .001$); a third of Flakka users reported using 4–12 other drugs > 3 times (32.2%) compared to non-users (1.6%); and over a fifth of Flakka users reported using 4–12 other drugs > 6 times (22.4%) compared to non-users (0.8%; $p < .001$). Supplemental Table 1 presents row percentages as estimates of Flakka use according to each level of each covariate.

In the multivariable model (Table 2), students whose parent(s) had less than a high school education were at higher odds for reporting use than those with parents with higher education (aOR = 4.12, 95% CI: 1.00–16.94), and using 4 or more drugs in the past year was associated with a robust increase in odds of use (aOR = 32.66, 95% CI: 11.60–92.01) compared to those reporting use of 0–1 drugs. Results were similar when computing the same model on the case-complete dataset, giving us confidence that missingness did not bias results.

4. Discussion

This is the first study to estimate prevalence of Flakka use among adolescents in the US. To date, there have been no studies on use in the general population. Similar to previous MTF studies examining prevalence of overall self-reported "bath salt" use in recent years (Miech et al., 2018; Palamar, 2015), we estimate that only about 1% of high school seniors have used Flakka in the past year.

Adolescents in families with lower estimated socioeconomic status have higher prevalence of reported Flakka use, including adolescents in families with lower parental education, and adolescents not residing with parents. Although the majority (85%) of ED visits related to Flakka use in Florida in 2014/2015 were by individuals older than age 24, prevalence was highest among homeless individuals (NDEWS Coordinating Center, 2016). Studies of "bath salt" use among electronic dance music (EDM) party attendees have also found that "bath salt" use may be more common among those with estimated lower socioeconomic status. Specifically, a survey of nightclub attendees (age >

Table 1
Characteristics of Students in Relation to Self-Reported Past-Year Flakka Use.

	Full Sample Characteristics n (Weighted %)	No Flakka Use (99.2%) n (Weighted %)	Flakka Use (0.8%) n (Weighted %)	*P*
Year				.669
2016	1,812 (48.2)	1794 (48.2)	18 (52.5)	
2017	1,974 (51.8)	1957 (51.8)	17 (47.5)	
Age, years				.321
< 18	1,651 (44.2)	1640 (44.3)	11 (33.3)	
> 18	2,046 (55.8)	2026 (55.7)	20 (66.7)	
Sex				.226
Male	1,709 (47.0)	1691 (46.9)	18 (61.9)	
Female	1,859 (53.0)	1850 (53.1)	9 (38.1)	
Race/Ethnicity				.991
White	1,963 (61.7)	1950 (61.7)	13 (60.6)	
Black	467 (16.6)	462 (16.6)	5 (17.6)	
Hispanic	669 (21.6)	662 (21.6)	7 (21.7)	
Parent Education				.012
Less than High School	327 (9.8)	321 (9.7)	6 (28.1)	
High School/Some College	1,275 (38.2)	1264 (38.2)	11 (44.3)	
College Degree or Higher	1,990 (52.0)	1980 (52.1)	10 (27.6)	
Number of Parents at Home				< .001
2 Parents	2,497 (65.0)	2483 (65.1)	14 (53.1)	
1 Parents	1,004 (28.9)	998 (29.0)	6 (18.0)	
0 Parents	216 (6.1)	206 (5.9)	10 (28.9)	
Weekly Income from Job				.066
< $125	2,744 (74.7)	2725 (74.8)	19 (57.0)	
> $125	901 (25.3)	890 (25.2)	11 (43.0)	
Population Density				.874
Non-MSA	718 (21.2)	712 (21.2)	6 (19.1)	
Small MSA	1,651 (46.7)	1634 (46.7)	17 (51.9)	
Large MSA	1,417 (32.1)	1405 (32.1)	12 (29.0)	
Past-Year Drug Use				
Alcohol				.315
No	1,617 (46.3)	1606 (46.2)	11 (57.9)	
Yes	1,993 (53.7)	1980 (53.8)	13 (42.1)	
Marijuana				.030
No	2,344 (64.9)	2333 (65.0)	11 (40.9)	
Yes	1,325 (35.1)	1310 (35.0)	15 (59.1)	
Cocaine				< .001
No	3,637 (98.1)	3615 (98.3)	22 (81.1)	
Yes	77 (1.9)	71 (1.8)	6 (18.9)	
Ecstasy/MDMA/Molly				< .001
No	3,630 (97.4)	3606 (97.6)	24 (75.7)	
Yes	108 (2.6)	100 (2.4)	8 (24.3)	
Methamphetamine				< .001
No	3,568 (99.4)	3547 (99.5)	21 (83.2)	
Yes	19 (0.6)	13 (0.5)	6 (16.8)	
Synthetic Cannabinoids				< .001
No	3,658 (96.7)	3653 (97.3)	5 (14.4)	
Yes	113 (3.3)	83 (2.7)	30 (85.6)	
Ketamine				< .001
No	3,731 (99.0)	3721 (99.6)	10 (27.7)	
Yes	42 (1.0)	18 (0.4)	24 (72.3)	
GHB				< .001
No	3,751 (99.3)	3732 (99.7)	19 (52.5)	
Yes	25 (0.7)	9 (0.3)	16 (47.5)	
Heroin				< .001
No	3,707 (99.7)	3684 (99.8)	23 (81.5)	
Yes	16 (0.3)	9 (0.2)	7 (18.5)	
Opioids (nonmedical use)				.003
No	3,531 (95.8)	3508 (95.9)	23 (84.2)	
Yes	152 (4.2)	146 (4.1)	6 (15.8)	
Amphetamine (nonmedical)				< .001
No	3,494 (93.9)	3470 (94.1)	24 (70.7)	
Yes	234 (6.1)	224 (5.9)	10 (29.3)	
Sedatives (Nonmedical)				< .001
No	3,613 (96.8)	3590 (96.9)	23 (80.5)	
Yes	108 (3.2)	101 (3.1)	7 (19.5)	
Total Used in Past Year				< .001
0-1	2,581 (69.7)	2573 (70.1)	8 (26.4)	
2-3	1,029 (25.6)	1018 (25.6)	11 (21.9)	
4-12	176 (4.7)	160 (4.3)	16 (51.7)	
Total Used 3+ Times in Past Year				< .001
0-1	3,018 (81.0)	3006 (81.3)	12 (41.2)	
2-3	704 (17.1)	692 (17.0)	12 (26.7)	

(*continued on next page*)

Table 1 (*continued*)

	Full Sample Characteristics n (Weighted %)	No Flakka Use (99.2%) n (Weighted %)	Flakka Use (0.8%) n (Weighted %)	*P*
4-12	64 (1.9)	53 (1.6)	11 (32.2)	
Total Used 6+ Times in Past Year				< .001
0-1	3,300 (87.9)	3281 (88.1)	19 (58.8)	
2-3	449 (11.1)	441 (11.1)	8 (18.7)	
4-12	37 (1.0)	29 (0.8)	8 (22.4)	

Note. Univariable and bivariable tests presented exclude missing data. MSA = metropolitan statistical area.

Table 2
Multivariable Model Examining Correlates of Self-Reported Past-Year Flakka Use.

	aOR (95% CI)
Year	
2016	1.00
2017	0.94 (0.43, 2.06)
Age, years	
< 18	1.00
> 18	1.37 (0.55, 3.37)
Sex	
Male	1.00
Female	0.55 (0.22, 1.38)
Race/Ethnicity	
White	1.00
Black	2.51 (0.66, 9.58)
Hispanic	1.19 (0.42, 3.39)
Parent Education	
College Degree or Higher	1.00
High School/Some College	1.91 (0.60, 6.04)
Less than High School	4.12 (1.00, 16.94)*
Number of Parents at Home	
2 Parents	1.00
1 Parent	0.54 (0.17, 1.66)
0 Parents	3.10 (0.89, 10.76)
Weekly Income from Job	
< $125	1.00
> $125	1.30 (0.51, 3.30)
Population Density	
Non-MSA	1.00
Small MSA	1.15 (0.37, 3.51)
Large MSA	1.13 (0.30, 4.32)
Total Drugs Used in Past Year	
0-1 Drugs	1.00
2-3 Drugs	2.28 (0.80, 6.47)
4-12 Drugs	32.66 (11.60, 92.01)**

Note. MSA = metropolitan statistical area. *$p <$ .05, **$p <$ .001.

16) in 2013 found that individuals who were unemployed were at higher odds of reporting "bath salt" use (Palamar et al., 2016a) and a survey of EDM party attendees in 2017 found that those reporting lower weekly income were also at high odds of reporting use (Palamar, 2018). Taken together, this suggests that youth at risk for poverty and homelessness may be a high risk group for Flakka use; given that these youth are also less likely to receive evidence-based prevention and intervention messages, Flakka and other drugs may increase health disparities.

Flakka use rarely occurs in isolation, and most users also use other drugs. Specifically, use of each of 11 psychoactive drugs examined were all correlated with use, and we found that using a higher number of other drugs—especially at higher frequency—was a robust correlate of Flakka use. While we could not determine the order in which each drug was initiated, and thus we could not deduce temporal associations, results suggest that Flakka is most likely to be incorporated into drug repertoires consisting of a larger number of drugs and often drugs that have been more frequently used. Other studies have also found that "bath salt" use is most common among individuals who report using many other illegal drugs (Fernandez-Calderon et al., 2017; Palamar, 2015; Sutherland et al., 2016). Thus, prevention efforts need to consider that Flakka use is more likely to occur alongside use of various other drugs.

It should be noted that although prevalence of (known) use of Flakka or other "bath salts" among adolescents is relatively rare, surveys likely underestimate use because these compounds are often used unknowingly as adulterants in drugs such as ecstasy in the US (Oliver et al., 2018). For example, a recent study that saliva-tested EDM festival attendees in Florida found that 30% of ecstasy users tested positive for "bath salts", including some cases of unknown Flakka exposure (Krotulski et al., 2018). Likewise, recent hair-testing studies of ecstasy-using EDM party attendees in New York City found that 50–68% of those testing positive for "bath salts" denied known use, with 2% testing positive for Flakka (Palamar et al., 2017, 2016b). However, while survey data are limited for estimating use of NPS such as Flakka, estimating the extent of both known and unknown use is important to informing prevention and harm reduction.

4.1. Limitations

This sample of high school seniors does not include dropouts and results are not necessarily generalizable to the full adolescent population in the US. Data on Flakka use were missing among 13.8% of adolescents, but results were similar with and without multiple imputation. Under-reporting of exposure to Flakka and other "bath salts" is also common as these drugs are commonly adulterants in drugs such as ecstasy (Oliver et al., 2018); thus we report known use. Results may also not be generalizable to adults.

4.2. Conclusions

Flakka is used among almost 1% of high school seniors in the US; it is a highly-potent and potentially dangerous drug that deserves continued surveillance. Past-year use of other drugs—particularly a higher number of other drugs—is a robust risk factor for Flakka use. Prevention needs to target those at highest risk for use, especially focusing on reducing health disparities. In addition, surveys and other studies should continue to monitor newly-emergent drugs in a timely manner in order to track prevalence of use as such data are needed to inform proper public health response.

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Contributors

All authors are responsible for this reported research. J. Palamar conceptualized and designed the study. J. Palamar and C. Rutherford conducted the statistical analyses under the mentorship of K. Keyes. All

authors drafted the initial manuscript, interpreted results, and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted.

Conflict of interest

No conflict declared.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2018.12.014.

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