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Hair Testing to Assess Both Known and Unknown Use of Drugs amongst Ecstasy Users in the Electronic Dance Music Scene

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Abstract

Background: Data on both known and unknown drug use in the electronic dance music (EDM) scene is important to inform prevention and harm reduction. While surveys are the most common method of querying drug use, additional biological data can help validate use and detect unknown/unintentional use of drugs such as new psychoactive substances (NPS). We sought to determine the extent of both known and unknown use of various substances in this high-risk scene.

Methods: We hair-tested 90 self-reported past-year ecstasy/MDMA/Molly users attending EDM parties in New York City during the summer of 2016 using UHPLC-MS/MS. Results were compared to self-reported past-year use.

Results: Three quarters (74.4%) tested positive for MDMA, a third (33.3%) tested positive for an NPS, and 27.8% tested positive specifically for one or more synthetic cathinones (e.g., butylone, ethylone, pentylone, methylone, alpha-PVP). Half (51.1%) of participants tested positive for a drug not self-reported, with most testing positive for synthetic cathinones (72.0%), methamphetamine (69.0%), other NPS stimulants (e.g., 4-FA, 5/6-APB; 66.7%), or new dissociatives (e.g., methoxetamine, diphenidine; 60.0%). Attending parties every other week or more often, reporting higher-frequency ecstasy pill use, having tested one's ecstasy, and having found out one's ecstasy was adulterated, were risk factors for testing positive for synthetic cathinones and NPS in general.

Conclusion: Hair testing appears to be a valuable addition to drug epidemiology studies. Many EDM party attendees—even those who test their ecstasy—are unknowingly using NPS and/or

other drugs. Prevention information and harm reduction may help reduce unknown/unintentional use.

Keywords: MDMA; new psychoactive substances; synthetic cathinones; hair-testing; adulterants

Introduction

Electronic dance music (EDM) parties are high-risk scenes for both known and unknown use of a variety of psychoactive substances. Recent studies indicate that illicit drug use is highly prevalent amongst nightclub and festival attendees (Hughes, Moxham-Hall, Ritter, Weatherburn, & MacCoun, 2017; Miller, Byrnes, Branner, Voas, & Johnson, 2013; Miller et al., 2015; Nordfjaern, Bretteville-Jensen, Edland-Gryt, & Gripenberg, 2016; Palamar, Barratt, Ferris, & Winstock, 2016; Palamar, Griffin-Tomas, & Ompad, 2015; Palamar, Salomone, Vincenti, & Cleland, 2016). A recent national survey of Australian dance festival-attending adults found that 78.1% of recent users reported using an illicit drug at their last-attended festival, and of users, 85.1% reported use of ecstasy (Hughes et al., 2017). A recent study of EDM party attendees in New York City (NYC) estimated lifetime use of ecstasy/MDMA or "Molly" amongst young adult (age 18-25) attendees to be 42.8% (95% CI: 32.8, 52.7) (Palamar, Acosta, Ompad, & Cleland, 2016). "Molly" is a common street name for powder or crystalline MDMA in the US; thus, since ecstasy and Molly are both street names for MDMA, some epidemiology surveys in the US now use these terms interchangeably or in combination (Palamar, 2017).

Dance festivals have become common in the US in recent years, and drug use amongst individuals in these scenes has been associated with severe adverse outcomes including death (Centers for Disease Control and Prevention, 2010; Friedman et al., 2017; Ridpath et al., 2014). For example, an investigation of 22 individuals poisoned at a large dance festival in NYC found that 65% (11 of 17) of individuals toxicology-tested after poisoning at a large dance festival tested positive for methylone (a synthetic cathinone) (Ridpath et al., 2014). However, it is unknown how many of these individuals were aware they were using methylone or if they

believed they were using MDMA. While use of more traditional drugs such as ecstasy in these environments is most common, hundreds of new psychoactive substances (NPS) such as methylone have emerged in recent years (European Monitoring Centre for Drugs and Drug Addiction, 2015; U.S. Drug Enforcement Administration, 2016) and many have been detected as adulterants in or replacements for traditional drugs such as ecstasy (Brunt et al., 2016; Caudevilla-Gálligo, Ventura, Indave Ruiz, & Fornís, 2013; Palamar et al., 2016a; Vidal Gine et al., 2016). Biological confirmation of self-reported use is informative as it helps validate prevalence, but research on unintentional or unknown use of drugs—particularly NPS—is important to further guide continued prevention, education, and harm reduction efforts within these high-risk scenes.

Researchers at European organisations such as Energy Control in Spain (Caudevilla-Gálligo et al., 2013; Gine, Espinosa, & Vilamala, 2014), the Drug Information Monitoring System (DIMS) in the Netherlands (Brunt & Niesink, 2011), and international collaborative organisations such as the Trans European Drug Information (TEDI) project (Brunt et al., 2016) have been testing contents of traditional drugs such as ecstasy and have been detecting NPS such as synthetic cathinones in samples. NPS such as synthetic cathinones—alone or in combination with ecstasy or one another—especially if taken unknowingly, can potentially lead to a higher likelihood of adverse effects than solely MDMA (Brunt, Koeter, Niesink, & van den Brink, 2012). While these studies provide great insight into drug adulteration in Europe, very few formal drug-testing studies have been conducted in the US and these studies were conducted decades ago (e.g., Baggott et al., 2000; Renfroe, 1986). Moreover, while test results of drug product (e.g., pill/powder testing) are informative, research is also needed to help determine the

characteristics of individuals who have already (often unknowingly) used specific NPS—often under the assumption it is ecstasy or “Molly”.

Hair testing for NPS is an important new addition to biological testing. While blood, urine, and saliva are often adequate for assessing current intoxication or very recent use (use within the past few days) (Jufer, Walsh, Cone, & Sampson-Cone, 2006; Smith-Kielland, Skuterud, & Mørland, 1999; Vindenes et al., 2011; Wille et al., 2009), many drugs—including NPS—can be detected in hair months after use. For example, synthetic cathinones can be detected in hair samples 24 months after use (depending on length of hair) (Kintz, Salomone, & Vincenti, 2015; Lendoiro et al., 2017; Rust, Baumgartner, Dally, & Kraemer, 2012; Salomone, Palamar, Gerace, Di Corcia, & Vincenti, 2017; Vincenti, Salomone, Gerace, & Pirro, 2013). Most standard drug tests only test for select traditional drugs and not NPS; however, hair testing allows us to test for a wider array of substances and for a more extensive period after use. In 2015, we piloted our hair-testing methodology as an addition to a drug use epidemiology survey of individuals in the EDM scene and published data derived from 48 ecstasy users (Palamar, Salomone, et al., 2016). However, results were limited, in part, because only lifetime drug use was queried. In this paper, we expand upon this original study and report on and compare self-reported past-year drug use and biological hair test results of 90 individuals in the EDM scene in NYC who reported past-year ecstasy use. Specifically, our aims of this study were to 1) determine prevalence of testing positive for specific drugs and drug classes, 2) determine the extent of discordant reporting (defined as reporting no use of a drug, but testing positive for that drug), and 3) delineate characteristics of testing positive or providing a discordant report for select drug classes. While we expected most individuals to test positive for MDMA,

we hypothesized that a large portion of individuals would test positive for drugs not reportedly used.

Methods

Participants and Procedure

1,087 individuals entering EDM parties in New York City were surveyed from May through September, 2016. Parties were randomly selected using time-space sampling (MacKellar et al., 2007; Palamar, Acosta, Sherman, Ompad, & Cleland, 2016). Individuals were eligible if they 1) were about to attend the selected party and 2) identified as age 18-40. Individuals were approached and asked if they were attending the randomly selected party. Those determined eligible were asked if they would take a survey about drug use. After providing informed consent, participants completed the survey on a tablet. Participants who completed the survey were compensated $10. Upon completion, a subset of participants was asked if they were willing to provide a hair sample to be tested for "new drugs such as 'bath salts'". If the participant agreed, the recruiter cut a small lock of hair (~100 hairs) from the participant—as close to his or her scalp as possible using a clean scissor. In some cases, male participants volunteered to clip or buzz body hair from the arm, chest, or leg with an electronic razor. Hair was folded in a piece of tin foil and stored in an envelope labelled with the participant's study ID number which was linked to the participant's survey responses. We collected 178 hair samples from a subset of those surveyed. Due to limited funding and extreme environmental conditions not conducive to hair testing (e.g., windy/rainy days) on

some recruitment days, we only obtained hair samples from a convenience sample of those surveyed.

Measures

Participants were asked their age, sex, race/ethnicity, and educational attainment. Age, race/ethnicity, and educational attainment were dichotomised into variables indicating whether they identified as age 25-40 (vs. age 18-24 [“young adults”]), white (vs. non-white), and having earned a college degree or higher (vs. less than a college degree), respectively. Participants were also asked how often they attended rave/nightclub/festival/dance parties with answer options: never, a few times a year, every couple of months, every month, every other week, and every week or more often (Palamar, Barratt, et al., 2016). We recoded attendance into a dichotomous variable (via median-split) indicating whether they attended at least every other week. Answers were recoded into attend less than once every other week vs. attend at least every other week.

The survey asked participants about “known” lifetime and past-year use of a variety of traditional drugs and NPS. Drugs and drug classes queried included “ecstasy/MDMA/Molly”, other MDx drugs (e.g., MDA, MDEA), methamphetamine, amphetamine (nonmedical use), ketamine, PCP, and drugs commonly defined as NPS such as “bath salts” (synthetic cathinones), other NPS stimulants (e.g., 4-FA, 5/6-APB), dissociative NPS (e.g., methoxetamine [MXE]), 2C-B, and PMMA. Particular focus was paid to synthetic cathinones and participants were queried about use of 27 of these compounds including methylone (“M1”), butylone (“B1”), mephedrone (“MCAT”, “Meow Meow”), alpha-PVP (“Flakka”), and “bath salt unknown or not

listed". Participants were also provided the opportunity to type in names of drugs they have ever used that were not queried in the survey.

Those reporting lifetime use of ecstasy were asked "Have you ever tested your ecstasy/Molly using a drug testing kit?" and answer options were "yes" and "no". They were also asked "Did you ever find out that your ecstasy/Molly contained a drug other than MDMA?" and this question was not dependent on their response to the question about drug testing. Answer options were "yes", "no", and "unsure" and we dichotomised responses into "yes" vs. "no/unsure". Those indicating past-year ecstasy use were also asked frequency of ecstasy pill use on an ordinal measure (Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016) which we recoded into 0-2 times, 3-19 times, and 20+ times.

Hair analyses

Among the 178 collected samples, 38 participants (21.3%) reported no lifetime ecstasy use, 20 (11.2%) reported lifetime use, but not past-year use, 90 (50.6%) reported past-year use, and 30 (16.9%) were unanalyzable due to inadequate quantity. These analyses focus on the 90 participants with analysable hair samples who reported past-year ecstasy use.

Since past-year use (particularly of NPS such as synthetic cathinones) was the primary outcome of interest, only the proximal 0-12 cm segment was analysed whenever a longer head hair sample was collected. Shorter head hair, as well as arm, chest and leg hair samples were analysed in their full length. The average length was 8.4 ± 3.6 cm (median: 9.0 cm, IQR: 7.0). Assuming a normal hair growth rate (Kintz, 2013), the mean time frame is about 1 cm per month. A quantity of at least 20 mg was needed to perform the analysis. The specimens were

tested using two previously published methods using ultra-high performance liquid chromatography–tandem mass spectrometry (UHPLC-MS/MS). One (Di Corcia, D'Urso, Gerace, Salomone, & Vincenti, 2012) was used to screen for various common drugs including amphetamine, methamphetamine, MDA, MDMA, and MDEA. The other method (Salomone, Gazzilli, Di Corcia, Gerace, & Vincenti, 2016) screened for some of the most common NPS—namely 12 synthetic cathinones (i.e., mephedrone [4-MMC], 4-MEC, methylone, 3,4-MDPV, pentedrone, 3-MMC, ethylcathinone, alpha-PVP, butylone, buphedrone, mexedrone, amfepramone), 6 other euphoric stimulants (i.e., 4-FA, 5/6-APB, 5-MAPB, mCPP, PMA, PMMA), 3 dissociatives (i.e., MXE, 4-MeO-PCP, diphenidine), 6 psychedelic phenethylamines (i.e., 2C-B, 2C-P, 25B-NBOMe, 25C-NBOMe, 25H-NBOMe, 25I-NBOMe), and 4 designer benzodiazepines (i.e., diclazepam, flubromazepam, nifoxipam, pyrazolam). This second method also tested for ketamine and PCP. We also tested for trazodone as mCPP is a metabolite of this substance so a positive test for trazodone in light of a positive test for mCPP would likely indicate trazodone use rather than use of mCPP (Lendoiro, Jiménez-Morigosa, Cruz, López-Rivadulla, & de Castro, 2014).

The limits of detection (LOD) of the analytical methods were set as the minimum criterion to identify the positive samples (Di Corcia et al., 2012; Salomone et al., 2016). LOD values ranged from 0.006 ng/mg for MDMA and 0.027 ng/mg for amphetamine for one method (Di Corcia et al., 2012), and from 0.9 pg/mg for 4-MeO-PCP up to 17 pg/mg for 6-APB, for the second method (Salomone et al., 2016).

Statistical analysis

We first examined the prevalence of self-reported drug use and positive test results. While prevalence of each separate compound was examined, we also examined prevalence of detecting positive for any synthetic cathinone, any NPS, and any discordant result which was defined as reporting no use of a specific drug but testing positive for that drug. We examined bivariable relations between these key outcomes and covariates using chi-square. Building upon bivariable statistics focusing on those who tested positive for synthetic cathinones, we examined conditional associations between each covariate and testing positive using multiple binary logistic regression. Further, we examined associations between each covariate with total number of positive tests for synthetic cathinones and total number of positive tests for NPS in general. We first examined potential differences in a bivariable manner using independent samples t-tests and then we examined all covariates simultaneously by fitting them into generalised negative binomial regression models which are robust to skewed discrete data. All statistical analyses were conducted using Stata SE 13 (StataCorp, College Station, TX, USA; 2009). This study was approved by the authors' institutional review board.

Results

Most participants identified as young adults (54.4%), female (53.3%), white (76.7%), and having earned a bachelor's degree or higher (62.2%). The majority (55.6%) also reported attending an EDM party every other week or more often.

Table 1 presents positive test results in comparison to self-reported past-year use. Three-quarters (74.4%) of the sample tested positive for MDMA. All participants testing positive for MDA or MDEA also tested positive for MDMA. Half of the samples tested positive for MDA

and 2 out of 10 (22.2%) of those testing positive specifically reported past-year use of MDA (commonly referred to as “sass” or “sassafras” in the US). About a third of the sample (32.2%) tested positive for methamphetamine and over a quarter (27.8%) of the sample tested positive for a synthetic cathinone. Butylone (14.4%), ethylone (11.1%), and pentylone (10.0%) were the most common synthetic cathinones detected; however, no participants reported past-year use of any of these specific compounds. Likewise, alpha-PVP was detected in 2.2% of the sample with no participants reporting use. However, despite 8.9% of the sample reporting lifetime use of methylone, only 3.3% tested positive for this compound. Similarly, while 2C-B use was reported by 11.1% of participants, only one participant tested positive for use.

Some participants tested positive for 4-FA (5.6%) or 5/6-APB (2.2%) and roughly half of these participants who tested positive also reported use (Table 1). With regard to dissociatives, more than half the sample (57.8%) tested positive for ketamine, and the majority (71.2%) of those testing positive also reported use. All participants who tested positive for another dissociative also tested positive for ketamine, and half of those testing positive for MXE use also reported use. It should be noted that five participants tested positive for mCPP; however, these cases also tested positive for trazodone, suggesting that mCPP was not in fact used (Lendoiro, et al., 2014).

Table 2 presents sample characteristics according to whether the participant tested positive for MDMA, a synthetic cathinone, or any NPS, and whether the participant provided a discordant report meaning he or she tested positive for a drug despite reporting that the drug was never used. Those who tested positive for MDMA were more likely to report having used ecstasy pills in the last year more frequently, and all individuals reporting ecstasy pill use 20+

times tested positive (p = 0.003). Results were somewhat similar for testing positive for synthetic cathinones or for any NPS. Specifically, those testing positive for synthetic cathinones (27.8%) or any NPS (33.3%) were more likely to report having attended an EDM parties more frequently (p = 0.015 and 0.016, respectively), more likely to report more frequent ecstasy pill use in the past 12 months (p = 0.005 and 0.015, respectively), and having tested their ecstasy (p = 0.016 and 0.006, respectively), and finding out their ecstasy was adulterated (p = 0.011 and 0.047, respectively). Those testing positive for synthetic cathinones were also less likely to identify as white (p = 0.020). Regarding discordant findings, only those reporting having tested their ecstasy were at higher risk (p = 0.016).

Since there were many significant differences regarding testing positive for synthetic cathinone use, we fit all covariates into a multivariable logistic regression model (Table 3). With all else being equal, white participants were at 80% lower odds of testing positive compared to those of other races, and higher frequency ecstasy pill use was associated with higher odds of testing positive. Significance of bivariable tests focusing on party attendance, drug testing, and finding out ecstasy has been adulterated was lost in the multivariable model. Despite having somewhat similar results in bivariable models, an identical model with testing positive for NPS in general as the outcome was non-significant (poor fit) with no significant covariates.

Finally, we examined the total number of synthetic cathinones (mean: 0.4 ± 0.8, median: 0, range: 0-3) and overall NPS detected for each participant (mean: 2.1 ± 2.1, median: 1, range: 0-9) (Table 4). Those reporting attending parties more frequently, those reporting using ecstasy pills 20+ times in the past 12 months, and those who reported having found out their ecstasy had been adulterated, tested positive for more synthetic cathinones and for more NPS in

general. White participants tested positive for fewer synthetic cathinones than non-white participants and females tested positive for fewer NPS in general than males. Those who reported ever testing their ecstasy also tested positive for more NPS than those who did not.

Discussion

Data on both known and unknown drug use in the EDM scene is important for informing prevention and harm reduction as this is a high-risk scene for drug use and adverse outcomes associated with drug use. In this study, we 1) examined prevalence of testing positive for specific drugs and drug classes, 2) determined the extent of discordant reporting, and 3) delineated characteristics of testing positive and/or providing a discordant report for select drug classes. As expected, while most past-year ecstasy users tested positive for MDMA, a large portion tested positive for drugs not reportedly used.

Testing positive for drugs (particularly NPS such as synthetic cathinones) after not reporting use was common with half of participants (51.1%) having such a discordant result. Assuming participants provided truthful responses (Taylor, Sullivan, Ring, Macleod, & Hickman, 2016), many unknowingly or unintentionally used drugs they did not report using. We hypothesise that many unreported drugs were likely present as adulterants in or replacements for drugs sold as ecstasy. Drugs such as PMMA and synthetic cathinones such as methylone and ethylone are frequently detected in drugs sold as ecstasy (Brunt et al., 2016; Brunt, Poortman, Niesink, & van den Brink, 2011; European Monitoring Centre for Drugs and Drug Addiction, 2003; Hondebrink, Nugteren-van Lonkhuyzen, Van Der Gouwe, & Brunt, 2015; Vidal Gine et al., 2016) or drugs that may have been sold as ecstasy (Caudevilla-Gálligo et al., 2013; Rust et al.,

2012). Likewise, a recent study in Europe also detected 2C-B, 4-FA, and 5/6-APB in ecstasy (Brunt et al., 2016; Hondebrink et al., 2015). These drugs are likely chosen as adulterants, in part, as many of these compounds have somewhat similar effects as MDx. Although it is widely known that there can be adulterants in ecstasy, our combined use of surveys and biological testing suggests that a large number of participants are unaware of what they have consumed in the past.

Unknown use of various drugs, however, could also have occurred resulting from use of other drugs sold as ketamine, methamphetamine, or LSD. For example, a drug testing study in Europe found 4-FA, 5/6-APB, MXE, and synthetic cathinones in cocaine and in amphetamine/methamphetamine (Hondebrink et al., 2015). The same study detected psychedelic phenethylamines such as 2C-B in LSD, and MXE and synthetic cathinones such as methylone in ketamine (Hondebrink et al., 2015). Energy Control in Spain recently reported that MXE was the most frequently discovered adulterant in ketamine (Energy Control, 2017) and likewise, we hypothesise that unknown use of NPS dissociatives was likely related to ketamine use as these drugs tend to have somewhat similar effects as ketamine (Winstock, Lawn, Deluca, & Borschmann, 2016).

Of note, there were participants who reported known use of synthetic cathinones such as methylone who tested positive for different synthetic cathinones such as butylone. It is unknown whether any of these participants actually used methylone or a different synthetic cathinone sold as methylone. The synthetic cathinone(s) may have been present in their ecstasy.

Females tested positive for fewer NPS compared to males, and white participants tested positive for fewer synthetic cathinones than non-white participants. While females in the EDM scene are less likely to report NPS use (Palamar, Barratt, et al., 2016), we found that they also tend to test positive for fewer NPS. Our findings also corroborate our recent similar hair testing study that also found that white party attendees were less likely to test positive for synthetic cathinones such as butylone (Palamar, Salomone, et al., 2016). Educational attainment was not related to testing positive for NPS such as synthetic cathinones in this study; however, those reporting lower educational attainment were found to be at higher risk in the previous study (Palamar, Salomone, et al., 2016). Race/ethnicity and socioeconomic status (as is often indicated by educational attainment) tend to be closely intertwined in the US (Williams, Priest, & Anderson, 2016), so further research is needed to determine whether this race/ethnicity finding is in fact related to socioeconomic status or perhaps different social networks from where drugs are obtained.

Higher frequency of party attendance more than tripled the odds of testing positive for a synthetic cathinone, but this association only approached significance when controlling for all other covariates. A similar finding occurred regarding number of positive tests for synthetic cathinones, but more frequent attendance was remained a risk factor for testing positive for more NPS independent of all other covariates. These results add to and corroborate a previous hair study which found higher levels of party attendance are related to a higher risk of testing positive for synthetic cathinones (Palamar, Salomone, et al., 2016). These results also corroborate multiple previous studies that have found higher levels of party attendance are related to robust increases in risk of using a variety of drugs including synthetic cathinones and

other NPS (Palamar, Acosta, Ompad, et al., 2016; Palamar, Acosta, Sherman, et al., 2016; Palamar, Barratt, et al., 2016; Palamar et al., 2015).

More frequent ecstasy users were not only more likely to test positive for synthetic cathinones and overall NPS, but they were also more likely to test positive for more compounds as frequency of use increased. Results were somewhat consistent when controlling for other covariates so results suggest that simply using ecstasy more frequently increases risk of using NPS. Testing ecstasy before use using reagent kits is a popular harm reduction method used to detect the presence of NPS such as synthetic cathinones. However, we found that reporting ever having tested one's ecstasy was actually associated with testing positive for synthetic cathinones, overall NPS, and for a discordant finding (testing positive, but not reporting use). The association of testing, however, lost significance in all multivariable models. In addition, reporting having ever found out one's ecstasy was adulterated was associated with testing positive for synthetic cathinones and overall NPS. This association disappeared regarding synthetic cathinone use in the multivariable model, but it remained a consistent risk factor for number of synthetic cathinones or NPS detected. More nuanced research is needed to determine whether drug testing (and results from such testing) is in fact an indicator of high risk for unknown or unintended consumption of NPS. Such tests help users detect adulterated samples as it is unknown, for example, whether some participants began testing their ecstasy after finding out they have used an adulterated product.

Limitations

Hair samples were taken from a convenience sample as part of a larger epidemiology survey study. While this subsample is largely representative of the larger study, white

participants were at twice the odds for providing a hair sample than other races/ethnicities (*P* = 0.002) which could have biased results. Our analyses were limited to self-reported past-12-month ecstasy users; however, it is possible that unknown use of some drugs was not directly related to ecstasy use. While "known" use of each drug was queried on the survey, some participants may not have considered adulterants when answering. Self-reported drug use is also has limitations as drug use is a sensitive topic and individuals may not always provide honest responses. Importantly, it is possible that some individuals did not recall specific drugs they had used, did not know the names of drugs they have used, and/or they may had believed they were using a specific drug, but were in fact using a different drug. We did however present street names of drugs when possible and provided an option to type names of drugs into a text box if we did not query a specific drug they believe they had used. In addition, we were not able to determine which instance(s) of drug use related to the specific compounds that tested positive, and hair was analysed in its full length in some cases which could bias results. Finally, some samples were not long enough to cover the past-year MDMA use, although they were still very informative about the past NPS use.

Another limitation is that the questions asking about whether individuals had ever tested their ecstasy and had ever found out their ecstasy had been adulterated were not limited to the past-year timeframe. Despite this limitation, we believe these variables help determine whether individuals test their ecstasy (even if only once—regardless of recency) and whether individuals have experience learning their ecstasy has ever been adulterated (regardless of recency). In addition, while nearly 7 out of 10 cases testing positive for MDA did not report use, it should be noted that MDA frequently tests positive as a metabolite of MDMA

(Kintz, Cirimele, Tracqui, & Mangin, 1995; Liu, Liu, & Lin, 2006); therefore, despite increasing prevalence of MDA use (Palamar, Barratt, et al., 2016), MDA could have tested positive as a byproduct and may not have been directly ingested.

Conclusions

EDM parties are high-risk scenes due to both known and unknown drug use. Our results suggest drug-using EDM attendees in NYC are at risk for unintentionally or unknowingly using various psychoactive substances—particularly NPS such as synthetic cathinones. Although further research is needed to determine the drugs and instances in which these drugs were unknowingly used, our findings demonstrate that hair testing can serve as a valuable addition to epidemiology surveys in such high-risk scenes. There is still a strong need, however, for researchers to conduct studies on actual drug product (e.g., pills, powders) rather than biological specimens. Such results would not only provide better understanding of drug adulteration, but such studies would also be able to help determine whether providing users with results suggesting adulteration influence their decisions to continue use. Research is also needed to determine whether providing users with results from biological tests (e.g., hair-testing) suggesting adulteration affect future intentions to continue use.

We have confirmed unknown consumption of a variety of drugs within this scene. Regardless of the source of adulteration, individuals in this scene need to be targeted with evidence-based information regarding the risks of using adulterated drugs. Harm reduction information and tactics can also likely help reduce harm when an individual decides to take the risk of using a potentially dangerous and often-adulterated drug such as ecstasy. Policy allowing

"drug-checking"—whether conducted by researchers, government officials, or harm reduction organisations—would likely help prevent harm among ecstasy users. However, more research is still needed to determine the extent to which harm reduction techniques such as "drug-checking" are able to reduce ecstasy-related harm.

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References

Baggot, M., Heifets, B., Jones, R. T., Mendelson, J., Sferios, E.,& Zehnder, J. (2000). Chemical analysis of ecstasy pills. *Journal of the American Medical Association, 284*(17), 2190. http://doi.org/10.1001/jama.284.17.2184

Brunt, T. M., Nagy, C., Bucheli, A., Martins, D., Ugarte, M., Beduwe, C., et al. (2016). Drug testing in Europe: monitoring results of the Trans European Drug Information (TEDI) project. *Drug Testing and Analysis, 9*(2), 188–198. http://doi.org/10.1002/dta.1954.

Brunt, T. M., Koeter, M. W., Niesink, R. J., & van den Brink, W. (2012). Linking the pharmacological content of ecstasy tablets to the subjective experiences of drug users. *Psychopharmacology, 220*(4), 751–762. http://doi.org/10.1007/s00213-011-2529-4.

Brunt, T. M., & Niesink, R. J. (2011). The Drug Information and Monitoring System (DIMS) in the Netherlands: implementation, results, and international comparison. *Drug Testing and Analysis, 3*(9), 621–634. http://doi.org/10.1002/dta.323.

Brunt, T. M., Poortman, A., Niesink, R. J., & van den Brink, W. (2011). Instability of the ecstasy market and a new kid on the block: mephedrone. *Journal of Psychopharmacology, 25*(11), 1543–1547. http://doi.org/10.1177/0269881110378370.

Caudevilla-Gálligo, F., Ventura, M., Indave Ruiz, B. I., & Fornís, I. (2013). Presence and composition of cathinone derivatives in drug samples taken from a drug test service in Spain (2010-2012). *Human Psychopharmacology, 28*(4), 341–344. http://doi.org/10.1002/hup.2296.

Centers for Disease Control and Prevention. (2010). Ecstasy overdoses at a New Year's Eve rave--Los Angeles, California, 2010. *Morbidity and Mortality Weekly Report, 59*(22), 677–681.

Di Corcia, D., D'Urso, F., Gerace, E., Salomone, A., & Vincenti, M. (2012). Simultaneous determination in hair of multiclass drugs of abuse (including THC) by ultra-high performance liquid chromatography-tandem mass spectrometry. *Journal of Chromatography. B, Analytical Technologies in the Biomedical and Life Sciences, 899*, 154–159. http://dx.doi.org/10.1016/j.jchromb.2012.05.003.

Energy Control. (2017). Report on the Analyzed Substances in Spain by Energy Control during 2015. http://energycontrol-international.org/energy-control-national-drug-testing-service-report-2015/ (Accessed April 2017).

European Monitoring Centre for Drugs and Drug Addiction. (2003). Report on the risk assessment of PMMA in the framework of the joint action on new synthetic drugs. http://www.emcdda.europa.eu/system/files/publications/288/Risk5_62949.pdf (Accessed April 2017).

European Monitoring Centre for Drugs and Drug Addiction. (2015). New Psychoactive Substances in Europe. An Update From the EU Early Warning System (March 2015). http://www.emcdda.europa.eu/attachements.cfm/att_235958_EN_TD0415135ENN.pdf (Accessed April 2017).

Friedman, M. S., Plocki, A., Likourezos, A., Pushkar, I., Bazos, A. N., Fromm, C., et al. (2017). A prospective analysis of patients presenting for medical attention at a large electronic dance music festival. *Prehospital and Disaster Medicine, 32*(1), 78–82. https://doi.org/10.1017/S1049023X16001187.

Gine, C. V., Espinosa, I. F., & Vilamala, M. V. (2014). New psychoactive substances as adulterants of controlled drugs. A worrying phenomenon? *Drug Testing and Analysis, 6*(7–8), 819–824. http://doi.org/10.1002/dta.1610.

Hondebrink, L., Nugteren-van Lonkhuyzen, J. J., Van Der Gouwe, D., & Brunt, T. M. (2015). Monitoring new psychoactive substances (NPS) in The Netherlands: data from the drug market and the Poisons Information Centre. *Drug and Alcohol Dependence, 147*, 109–115. http://dx.doi.org/10.1016/j.drugalcdep.2014.11.033.

Hughes, C. E., Moxham-Hall, V., Ritter, A., Weatherburn, D., & MacCoun, R. (2017). The deterrent effects of Australian street-level drug law enforcement on illicit drug offending at outdoor music festivals. *International Journal of Drug Policy, 41*, 91–100. http://dx.doi.org/10.1016/j.drugpo.2016.12.018.

Jufer, R., Walsh, S. L., Cone, E. J., & Sampson-Cone, A. (2006). Effect of repeated cocaine administration on detection times in oral fluid and urine. *Journal of Analytical Toxicology, 30*(7), 458–462.

Kintz, P. (2013). Issues about axial diffusion during segmental hair analysis. *Therapeutic Drug Monitoring, 35*(3), 408–410. http://doi.org/10.1097/FTD.0b013e318285d5fa.

Kintz, P., Salomone, A., & Vincenti, M. (2015). *Hair analysis in clinical and forensic toxicology*. San Diego, CA: Academic Press.

Kintz, P., Cirimele, V., Tracqui, A., & Mangin, P. (1995). Simultaneous determination of amphetamine, methamphetamine, 3,4-methylenedioxyamphetamine and 3,4-methylenedioxymethamphetamine in human hair by gas chromatography-mass spectrometry. *Journal of Chromatography. B, Biomedical Applications, 670*(1), 162–166.

Lendoiro, E., Jiménez-Morigosa, C., Cruz, A., López-Rivadulla, M., & de Castro, A. (2014). O20: Hair analysis of amphetamine-type stimulant drugs (ATS), including synthetic cathinones and piperazines, by LC-MSMS. *Toxicologie Analytique et Clinique, 26*(2, Supplement), S13. http://dx.doi.org/10.1016/S2352-0078(14)70028-9.

Lendoiro, E., Jimenez-Morigosa, C., Cruz, A., Paramo, M., Lopez-Rivadulla, M., & de Castro, A. (2017). An LC-MS/MS methodological approach to the analysis of hair for amphetamine-type-stimulant (ATS) drugs, including selected synthetic cathinones and piperazines. *Drug Testing and Analysis, 9*(1), 96–105. http://doi.org/10.1002/dta.1948.

Liu, R. H., Liu, H. C., & Lin, D. L. (2006). Distribution of methylenedioxymethamphetamine (MDMA) and methylenedioxyamphetamine (MDA) in postmortem and antemortem specimens. *Journal of Analytical Toxicology, 30*(8), 545–550.

MacKellar, D. A., Gallagher, K. M., Finlayson, T., Sanchez, T., Lansky, A., & Sullivan, P. S. (2007). Surveillance of HIV risk and prevention behaviors of men who have sex with men--a national application of venue-based, time-space sampling. *Public Health Reports, 122 Suppl 1*, 39–47. http://doi.org/10.1177/00333549071220S107.

Miech, R. A., Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2016). *Monitoring the future: National survey results on drug use, 1975–2015: Vol. I, Secondary School Students*. http://www.monitoringthefuture.org/pubs/monographs/mtf-vol1_2015.pdf (Accessed April 2017).

Miller, B. A., Byrnes, H. F., Branner, A. C., Voas, R., & Johnson, M. B. (2013). Assessment of club patrons' alcohol and drug use: the use of biological markers. *American Journal of Preventive Medicine, 45*(5), 637–643. http://dx.doi.org/10.1016/j.amepre.2013.06.014.

Miller, P., Curtis, A., Jenkinson, R., Droste, N., Bowe, S. J., & Pennay, A. (2015). Drug use in Australian nightlife settings: estimation of prevalence and validity of self-report. *Addiction, 110*(11), 1803–1810. http://doi.org/10.1111/add.13060.

Nordfjaern, T., Bretteville-Jensen, A. L., Edland-Gryt, M., & Gripenberg, J. (2016). Risky substance use among young adults in the nightlife arena: An underused setting for risk-reducing interventions? *Scandinavian Journal of Public Health*. http://doi.org/10.1177/1403494816665775.

Palamar, J. J. (2017). There's something about Molly: the underresearched yet popular powder form of ecstasy in the United States. *Substance Abuse, 38*(1), 15-17. http://dx.doi.org/10.1080/08897077.2016.1267070

Palamar, J. J., Acosta, P., Ompad, D. C., & Cleland, C. M. (2016). Self-reported ecstasy/MDMA/"Molly" use in a sample of nightclub and dance festival attendees in New York City. *Substance Use and Misuse, 52*(1), 82–91. http://dx.doi.org/10.1080/10826084.2016.1219373.

Palamar, J. J., Acosta, P., Sherman, S., Ompad, D. C., & Cleland, C. M. (2016). Self-reported use of novel psychoactive substances among attendees of electronic dance music venues. *The American Journal of Drug and Alcohol Abuse, 42*(6), 624–632. http://dx.doi.org/10.1080/00952990.2016.1181179.

Palamar, J. J., Barratt, M. J., Ferris, J. A., & Winstock, A. R. (2016). Correlates of new psychoactive substance use among a self-selected sample of nightclub attendees in the United States. *American Journal on Addictions, 25*(5), 400–407. http://dx.doi.org/10.1111/ajad.12403.

Palamar, J. J., Griffin-Tomas, M., & Ompad, D. C. (2015). Illicit drug use among rave attendees in a nationally representative sample of US high school seniors. *Drug and Alcohol Dependence, 152*, 24–31. http://dx.doi.org/10.1016/j.drugalcdep.2015.05.002.

Palamar, J. J., Salomone, A., Vincenti, M., & Cleland, C. M. (2016). Detection of "bath salts" and other novel psychoactive substances in hair samples of ecstasy/MDMA/"Molly" users. *Drug and Alcohol Dependence, 161*, 200–205. http://dx.doi.org/10.1016/j.drugalcdep.2016.02.001.

Renfroe, C. L. (1986). MDMA on the street: Analysis Anonymous. *Journal of Psychoactive Drugs, 18*(4), 363-369. http://dx.doi.org/10.1080/02791072.1986.10472371

Ridpath, A., Driver, C. R., Nolan, M. L., Karpati, A., Kass, D., Paone, D., et al. (2014). Illnesses and deaths among persons attending an electronic dance-music festival - New York City, 2013. *Morbidity and Mortality Weekly Report, 63*(50), 1195–1198.

Rust, K. Y., Baumgartner, M. R., Dally, A. M., & Kraemer, T. (2012). Prevalence of new psychoactive substances: A retrospective study in hair. *Drug Testing and Analysis, 4*(6), 402–408. http://dx.doi.org/10.1002/dta.1338.

Salomone, A., Gazzilli, G., Di Corcia, D., Gerace, E., & Vincenti, M. (2016). Determination of cathinones and other stimulant, psychedelic, and dissociative designer drugs in real hair samples. *Analytical and Bioanalytical Chemistry, 408*(8), 2035–2042. http://doi.org/10.1007/s00216-015-9247-4.

Salomone, A., Palamar, J. J., Gerace, E., Di Corcia, D., & Vincenti, M. (2017). Hair testing for drugs of abuse and new psychoactive substances in a high-risk population. *Journal of Analytical Toxicology*, 1–6. https://doi.org/10.1093/jat/bkx020.

Smith-Kielland, A., Skuterud, B., & Mørland, J. (1999). Urinary excretion of 11-nor-9-carboxy-delta9-tetrahydrocannabinol and cannabinoids in frequent and infrequent drug users. *Journal of Analytical Toxicology, 23*(5), 323–332.

Taylor, M., Sullivan, J., Ring, S. M., Macleod, J., & Hickman, M. (2016). Assessment of rates of recanting and hair testing as a biological measure of drug use in a general population sample of young people. *Addiction*, *112*(3), 477–485. http://doi.org/10.1111/add.13645.

U.S. Drug Enforcement Administration, Diversion Control Division. (2016). *Synthetic Cannabinoids and Synthetic Cathinones Reported in NFLIS, 2013–2015.* https://www.nflis.deadiversion.usdoj.gov/DesktopModules/ReportDownloads/Reports/NFLIS-SR-SynthCannabinoidCathinone.pdf (Accessed April 2017).

Vidal Gine, C., Ventura Vilamala, M., Fornis Espinosa, I., Gil Lladanosa, C., Calzada Alvarez, N., Fito Fruitos, A., et al. (2016). Crystals and tablets in the Spanish ecstasy market 2000-2014: Are they the same or different in terms of purity and adulteration? *Forensic Science International, 263*, 164–168. http://dx.doi.org/10.1016/j.forsciint.2016.04.016.

Vincenti, M., Salomone, A., Gerace, E., & Pirro, V. (2013). Role of LC-MS/MS in hair testing for the determination of common drugs of abuse and other psychoactive drugs. *Bioanalysis, 5*(15), 1919–1938. http://doi.org/10.4155/bio.13.132.

Vindenes, V., Yttredal, B., Oiestad, E. L., Waal, H., Bernard, J. P., Mørland, J. G., et al. (2011). Oral fluid is a viable alternative for monitoring drug abuse: Detection of drugs in oral fluid by liquid chromatography-tandem mass spectrometry and comparison to the results from urine samples from patients treated with methadone or buprenorphine. *Journal of Analytical Toxicology, 35*(1), 32–39.

Wille, S. M., Raes, E., Lillsunde, P., Gunnar, T., Laloup, M., Samyn, N., et al. (2009). Relationship between oral fluid and blood concentrations of drugs of abuse in drivers suspected of driving under the influence of drugs. *Therapeutic Drug Monitoring, 31*(4), 511–519. http://doi.org/10.1097/FTD.0b013e3181ae46ea.

Williams, D. R., Priest, N., & Anderson, N. (2016). Understanding associations among race, socioeconomic status, and health: Patterns and prospects. *Health Psychology, 35*(4):407-411. http://dx.doi.org/10.1037/hea0000242

Winstock, A. R., Lawn, W., Deluca, P., & Borschmann, R. (2016). Methoxetamine: An early report on the motivations for use, effect profile and prevalence of use in a UK clubbing sample. *Drug and Alcohol Review, 35*(2), 212–217. http://doi.org/10.1111/dar.12259.

Table 1 Prevalence of test results and self-reported use (*N*=90).

Drug Name	*Drug Positive % (n)*	*Self-Reported Past-Year Use % (n)*	*Discordant Positive (Lifetime Use) % (n)*
MDx			
MDx (any)	74.4 (n=67)	100.0 (n=90)	0.0 (n=0)
MDMA	74.4 (n=67)	100.0 (n=90)	0.0 (n=0)
MDA	50.0 (n=45)	22.2 (n=20)	60.0 (n=27)
MDEA	15.6 (n=14)	0.0 (n=0)	100.0 (n=1)
Common Stimulants			
Amphetamine	41.1 (n=37)	40.0 (n=36)	37.8 (n=14)
Methamphetamine	32.2 (n=29)	13.3 (n=12)	55.2 (n=16)
Synthetic Cathinones			
Synthetic Cathinone (any)	27.8 (n=25)	12.2 (n=11)	68.0 (n=17)
Butylone	14.4 (n=13)	0.0 (n=0)	100.0 (n=13)
Ethylone	11.1 (n=10)	0.0 (n=0)	100.0 (n=10)
Pentylone	10.0 (n=9)	0.0 (n=0)	100.0 (n=9)
Methylone	3.3 (n=3)	8.9 (n=8)	33.3 (n=1)
Alpha-PVP	2.2 (n=2)	0.0 (n=0)	100.0 (n=2)
Other Psychedelic Amphetamines			
2C-B	1.1 (n=1)	11.1 (n=10)	100.0 (n=1)
PMMA	1.1 (n=1)	0.0 (n=0)	100.0 (n=1)
Other Stimulants			
4-FA	5.6 (n=5)	3.3 (n=3)	60.0 (n=3)
5/6-APB	2.2 (n=2)	2.2 (n=2)	50.0 (n=1)
Dissociatives			
Dissociative (any)	57.8 (n=52)	45.6 (n=41)	28.8 (n=15)
Ketamine	57.8 (n=52)	45.6 (n=41)	28.8 (n=15)
Methoxetamine	4.4 (n=4)	4.4 (n=4)	50.0 (n=2)
PCP	2.2 (n=2)	0.0 (n=0)	00.0 (n=0)
Diphenidine	1.1 (n=1)	0.0 (n=0)	100.0 (n=1)

Note. The self-reported synthetic cathinone use categories included all synthetic cathinones assessed on the survey. Other than the five we tested for, there was one report of lifetime methedrone use, one report of lifetime methcathinone use, one report of lifetime mephedrone use, one report of past-year MPBP use, and one lifetime and one past-year report of use of an unknown "bath salt". Participants were not asked specifically about PMMA or diphenidine use, but those who tested positive did not report use of these drugs (or similar drugs) via the type-in method. Only nonmedical use of amphetamine was assessed on the survey so it is possible some participants used in an approved medical manner.

Table 2 Prevalence of positive and discordant results for specific drug categories according to participant characteristics.

	Full Sample %	*Positive for MDMA %*	*Positive for Synthetic Cathinones %*	*Positive for Any NPS %*	*Discordant Report of Any Drug %*
Prevalence	--	74.4	27.8	33.3	51.1
Age					
18-24	54.4	75.5	24.5	30.6	42.9
25-40	45.6	73.2	31.7	36.6	60.1
Sex					
Male	46.7	81.0	33.3	38.1	45.2
Female	53.3	68.8	22.9	29.1	56.3
Race/Ethnicity					
Non-White	23.3	81.0	47.6*	47.6	52.4
White	76.7	72.5	21.7	29.0	50.7
Educational Attainment					
Less than a Bachelor's Degree	37.8	70.6	32.4	32.4	50.0
Bachelor's Degree or Higher	62.2	76.8	25.0	33.9	51.8
Nightclub Attendance					
Less Than Once Every Other Week	44.4	70.0	15.0*	20.0*	42.5
Every Other Week or More Often	55.6	78.0	38.0	44.0	58.0
Frequency of Past-Year Ecstasy Pill Use					
0-2 Times	40.0	55.6**	11.1**	16.7*	38.9
3-19 Times	52.2	85.1	36.2	42.6	61.7
20+ Times	7.8	100.0	57.1	57.1	42.9
Has Tested One's Ecstasy					
No	60.0	68.5	18.5*	22.2**	40.7*
Yes	40.0	83.3	41.7	50.0	66.7
Ever Found Out Ecstasy Adulterated					
No or Not Sure	61.1	69.1	18.2*	25.5*	45.5
Yes	38.9	82.9	42.9	45.7	60.0

Note. "Discordant report" refers to when a participant's hair tested positive for a drug that he or she did not report using. Comparisons were computed using chi-square analyses. NPS = new psychoactive substance.
*$p < 0.05$, **$p < 0.01$

Table 3 Bivariable and multivariable associations between covariates and testing positive for synthetic cathinones.

	OR	*(95% CI)*	*aOR*	*(95% CI)*
Age				
18-24	1.00		1.00	
25-40	1.43	(0.57, 3.61)	2.35	(0.68, 8.16)
Sex				
Male	1.00		1.00	
Female	0.59	(0.23, 1.51)	1.05	(0.68, 8.16)
Race/Ethnicity				
Non-White	1.00		1.00	
White	0.31*	(0.11, 0.86)	0.20*	(0.05, 0.81)
Educational Attainment				
Less than a Bachelor's Degree	1.00		1.00	
Bachelor's Degree or Higher	0.70	(0.27, 1.78)	1.07	(0.29, 3.96)
Frequency of Party Attendance				
Never through Monthly	1.00		1.00	
Every Other Week or More	3.47*	(1.23, 9.82)	3.08	(0.94, 10.08)
Frequency of Past 12 Month Ecstasy Pill Use				
0-2 Times	1.00		1.00	
3-19 Times	4.40*	(1.23, 15.72)	4.63*	(1.00, 21.40)
20+ Times	6.15**	(1.63, 23.19)	5.53*	(1.06, 28.86)
Has Tested One's Ecstasy				
No	1.00		1.00	
Yes	3.14*	(1.21, 8.16)	1.79	(0.55, 5.78)
Ever Found Out Ecstasy was Adulterated				
No or Not Sure	1.00		1.00	
Yes	3.38*	(1.29, 8.80)	2.92	(0.93, 9.19)

Note. Estimates were computed using binary logistic regression. OR = odds ratio, aOR = adjusted odds ratio, CI = confidence interval.
*$p < 0.05$, **$p < 0.01$

Table 4 Number of positive test results according to participant characteristics.

	Sum of Samples Testing Positive for Synthetic Cathinones			*Sum of Samples Testing Positive for NPS*		
	M (SD)	*aIRR*	*(95% CI)*	*M (SD)*	*aIRR*	*(95% CI)*
Age						
18-24	0.3 (0.7)	1.00		2.2 (2.1)	1.00	
25-40	0.5 (0.8)	1.25	(0.88, 3.80)	1.9 (2.2)	0.83	(0.57, 1.22)
Sex						
Male	0.5 (0.7)	1.00		2.7 (2.4)	1.00	
Female	0.4 (0.8)	1.83	(0.58, 2.73)	1.5 (1.7)**	0.59**	(0.40, 0.88)
Race/Ethnicity						
Non-White	0.9 (1.2)	1.00		2.3 (2.0)	1.00	
White	0.3 (0.5)*	0.29**	(0.13, 0.63)	2.0 (2.2)	1.10	(0.71, 1.70)
Educational Attainment						
Less than a Bachelor's Degree	0.6 (1.0)	1.00		2.3 (2.0)	1.00	
Bachelor's Degree or Higher	0.3 (0.6)	1.06	(0.45, 2.48)	1.9 (2.2)	0.89	(0.60, 1.33)
Nightclub Attendance						
Less Than Once Every Other Week	0.2 (0.4)	1.00		1.4 (1.6)	1.00	
Every Other Week or More Often	0.6 (0.9)**	2.47*	(1.05, 5.83)	2.6 (2.4)**	1.56*	(1.07, 1.27)
Frequency of Past-Year Ecstasy Pill Use						
0-2 Times	0.2 (0.5)	1.00		1.2 (1.3)	1.00	
3-19 Times	0.6 (0.9)	2.57	(0.99, 6.71)	2.3 (2.1)	1.31	(0.82, 2.09)
20+ Times	0.7 (0.8)*	2.92*	(1.03, 8.25)	4.9 (2.9)***	1.88*	(1.16, 3.07)
Has Tested One's Ecstasy						
No	0.3 (0.7)	1.00		1.5 (1.6)	1.00	
Yes	0.6 (0.9)	1.39	(0.64, 3.01)	2.9 (2.5)**	1.34	(0.92, 1.95)
Ever Found Out Ecstasy Adulterated						
No or Not Sure	0.2 (0.4)	1.00		1.6 (1.8)	1.00	
Yes	0.7 (1.0)**	2.45*	(1.15, 5.24)	2.8 (2.4)*	1.67**	(1.16, 2.40)

Note. Bivariable comparisons of means were computed using independent samples *t*-tests. Generalised negative binomial regressions were used to compute multivariable statistics. M = mean, SD = standard deviation, aIRR = adjusted incidence rate ratio, CI = confidence interval, NPS = new psychoactive substance. *p <0 .05, **p < 0.01, ***p <0 .001