Original Paper

Who is 'Molly'? MDMA adulterants by product name and the impact of harm-reduction services at raves

Journal of Psychopharmacology
1–5

DOI: 10.1177/0269881117715596
journals.sagepub.com/home/jop

Sarah Saleemi[1]*, Steven J Pennybaker[1]*, Missi Wooldridge[2] and Matthew W Johnson[3]

Abstract

Methylenedioxymethamphetamine (MDMA), often sold as 'Ecstasy' or 'Molly', is commonly used at music festivals and reported to be responsible for an increase in deaths over the last decade. Ecstasy is often adulterated and contains compounds that increase morbidity and mortality. While users and clinicians commonly assume that products sold as Molly are less-adulterated MDMA products, this has not been tested. Additionally, while pill-testing services are sometimes available at raves, the assumption that these services decrease risky drug use has not been studied. This study analyzed data collected by the pill-testing organization, DanceSafe, from events across the United States from 2010 to 2015. Colorimetric reagent assays identified MDMA in only 60% of the 529 samples collected. No significant difference in the percentage of samples testing positive for MDMA was determined between Ecstasy and Molly. Individuals were significantly less likely to report intent to use a product if testing did not identify MDMA (relative risk (RR) = 0.56, $p = 0.01$). Results suggest that Molly is not a less-adulterated substance, and that pill-testing services are a legitimate harm-reduction service that decreases intent to consume potentially dangerous substances and may warrant consideration by legislators for legal protection. Future research should further examine the direct effects of pill-testing services and include more extensive pill-testing methods.

Keywords

MDMA, Ecstasy, Molly, harm reduction, pill testing

Introduction

As music festivals/raves continue to receive media attention due to sustained popularity, reports of deaths among attendees associated with ingestion of 3,4-methylenedioxymethamphetamine (MDMA), more commonly known in Europe as 'Ecstasy' or in the United States (US) as 'Molly' (Ridpath et al., 2014), have also continued to accumulate. A national survey conducted by SAMHSA in 2014 estimated 609,000 people or 0.2% of the population in the US aged 12 or older had used Ecstasy in the last month, with 6.8% reporting lifetime use (SAMHSA, 2015). Furthermore, according to the Drug Abuse Warning Network, national emergency department visits due to MDMA toxicity increased by an additional 120% between 2004 and 2011, while visits due to other illicit drugs have remained relatively stable (SAMHSA, 2013).

While using MDMA by itself entails medical risk, particularly at dance events where hyperthermia and dehydration are common, some Ecstasy adulterants are known to have greater acute toxicity than MDMA alone, including paramethoxyamphetamine (PMA) and paramethoxymethamphetamine (PMMA), which are widely considered the most dangerous Ecstasy adulterants and which have led to cases of fatal overdose (Vevelstad et al., 2012). Additionally, MDMA adulterated with methamphetamine and caffeine may put drug users at risk for greater neurotoxicity (Clemens et al., 2007; Vanattou-Saifoudine et al., 2012).

There have been few studies of Ecstasy adulterants in North America in recent years. The most recent study conducted in the Americas involved 150 drug seizures by police in Brazil and found MDMA in only 44.7% of samples, with methamphetamine and caffeine the second and third most common active substances (Togni et al., 2015). Other studies of Ecstasy purity have been conducted in the past 10 years in the UK (Wood et al., 2011; Yamamoto et al., 2013), Iran (Khajeamiri et al., 2011), and the Netherlands (Vogels et al., 2009), yet to our knowledge, no study of Ecstasy contents has been conducted in the United States during this time period. This lack of data comes at a time when the illicit drug market now includes a greater number of sympathomimetic quasi-legal substances that have had limited research conducted as to their acute toxicology, abuse potential, and long-term sequelae (Abbott and Smith, 2015).

Ascertaining the purity of nominally MDMA-containing products is a task for which users have few resources. Users sometimes rely on the shape and logo imprinted on an Ecstasy

[1]Johns Hopkins University School of Medicine, Baltimore, MD, USA
[2]Healthy Nightlife, LLC, Denver, CO, USA
[3]Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD, USA

*These authors contributed equally to this work.

Corresponding author:
Matthew W Johnson, Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD 21224, USA.
Email: mwj@jhu.edu

tablet, as well as word-of-mouth when making these decisions (Duterte et al., 2009). More recently, MDMA users/sellers (Duterte et al., 2009; Kahn et al., 2012) and clinicians (Kahn et al., 2012) in the US have been reported to assume that substances sold as Molly are less-adulterated MDMA products, despite a lack of evidence.

Services marketed as harm reduction are sometimes available at electronic dance music parties ('raves') and music festivals. Harm-reduction organizations such as DanceSafe and EcstasyData.org in the US, and the Trimbos Institute in the Netherlands provide individual drug users with free or low-cost testing services to determine the identity of substances and possibly the amount of substances contained in drug samples.

A pill-testing organization such as DanceSafe, which conducts pill-testing through volunteers pulled from the music community whom they serve, might be expected to decrease risky substance-use decisions through a dual-process approach to health-risk decision making, such as the Prototype-Willingness Model (Gerrard et al., 2008). In dual-process decision making, decisions are understood both through: (1) *theories of reasoned action*, taking into account beliefs and values, perceptions of control, and self-efficacy and through the less tangible idea of (2) '*willingness*' *to take an action*, which is determined by how participants identify with their perceived prototype of a person engaging in a given behavior (Reyna and Rivers, 2008). Through informing participants of the chemical content of their substances and potential risks associated with use, and by empowering users to make informed decisions, a pill-testing organization such as DanceSafe may be expected to improve participant decision making away from consuming risky substances. More heuristically, since DanceSafe is staffed by volunteers of a similar demographic to participants, it may alter participants' perceived risk prototypes of persons who make informed decisions about consuming dangerous substances.

Despite this, no quantitative analysis has shown whether pill-testing services alter participant behavior. This issue is becoming more salient, as music festivals in the UK, as recently as July 2016, have begun to offer pill-testing services (Connolly, 2016), and as policy makers in the US and elsewhere debate the legality and value of these services. In this analysis, we examine the content of purported-MDMA-containing products, the relative purity of products known under different names, and the effect of pill-testing results on user behavior.

Methods

Setting and sample collection

Data were collected by DanceSafe volunteers operating in independent, regional teams at multi-day music events. Between July 2010 and July 2015, across 38 US states, 529 samples of nominally MDMA-containing products were collected and assayed. A total of 57% (310) of samples were collected from Midwest states (Illinois, Oklahoma, and Wisconsin) and approximately 60% of substances were tested between January 2013 and July 2015. Samples were solicited from individuals at music events who were informed through word-of-mouth advertising. Individuals at music events were informed of the availability of on-site, no-cost, anonymous pill-testing by the non-profit, harm-reduction organization DanceSafe. Participants were not offered any incentive beyond free pill testing. Prior to testing, participants were informed of the limitations of colorimetric reagent testing, including inability to quantify purity, possible failure to detect trace adulterants and difficulty in differentiating between closely related substances such as MDMA and MDA. Before testing, participants were asked to identify their substance(s). Participants used a variety of terms, which were grouped into four categories: 'Molly', 'E(cstasy)', 'MDMA', and 'Other' 'brand' names ('Pokéballs', 'Motorola', etc.)

Colorimetric reagents

Samples were assayed using DanceSafe colorimetric reagent kits, which utilize chemical reagents originally developed for the US Justice Department (Marquis, Mecke, Mandelin, Folin, and Simon) (NIJ, 2000). Although these tests have lower accuracy than quantitative methods such as gas chromatography–mass spectrometry or thin-layer chromatography, multiple independent studies have shown 100% sensitivity and 100% specificity for colorimetric reagent kits in detection of an MDMA-like drug in street Ecstasy pills when performed by a person trained in their use (Camilleri and Caldicott, 2005; Pradeille et al., 2008; Murray et al., 2003; Winstock et al., 2001). However, the accuracy of colorimetric reagent kits in detecting other substances is questioned (Camilleri and Caldicott, 2005; Murray et al., 2003). More generally, one comprehensive study comparing the results of club drugs tested with colorimetric reagents vs. thin-layer chromatography found them "…to be very sensitive with limits of detection typically 1 to 50 μg, depending on the test and the analyte…" (Namera et al., 2011). However, the colorimetric tests are thought to be less accurate for detecting the presence of small amounts of adulterant that exists in addition to the majority substance and are altogether unable to provide accurate information on the dose of a particular drug within a substance.

Testing procedure

A small sample of the substance (~1 mg) was collected (i.e. by scraping the pill) onto ceramic plates and assayed to determine content using colorimetric reagents described above. Color reactions were visually analyzed and compared with the official DanceSafe color chart to determine substance content. A full copy of the DanceSafe colorimetric reagent chart, as well as the organization's recommended pill-testing protocol are publically available at: https://dancesafe.org/testing-kit-instructions.

Samples were reported to be 'positive' for MDMA if they resulted in color changes in the range displayed on the DanceSafe reagent chart when the Marquis, Mecke and Mandelin reagents were applied. Substances that gave results inconsistent with MDMA were reported to be 'negative' and an attempt was made to determine the identity of the substances using the DanceSafe reagent chart. If reagent tests did not show results consistent with any listed substance, the substance was classified as 'Unknown'. After being informed of assay results and limitations, participants were asked if they still intended to ingest the product with the option to answer either 'Yes', 'No', or 'Unsure'. Participants did not have the option of expressing intent to consume only a portion of a pill. Data were independently collected by DanceSafe and lacked any personally identifiable demographic or health information. A research ethics committee, the Johns Hopkins Institutional Review Board, determined that analysis of these data did not constitute human subject research.

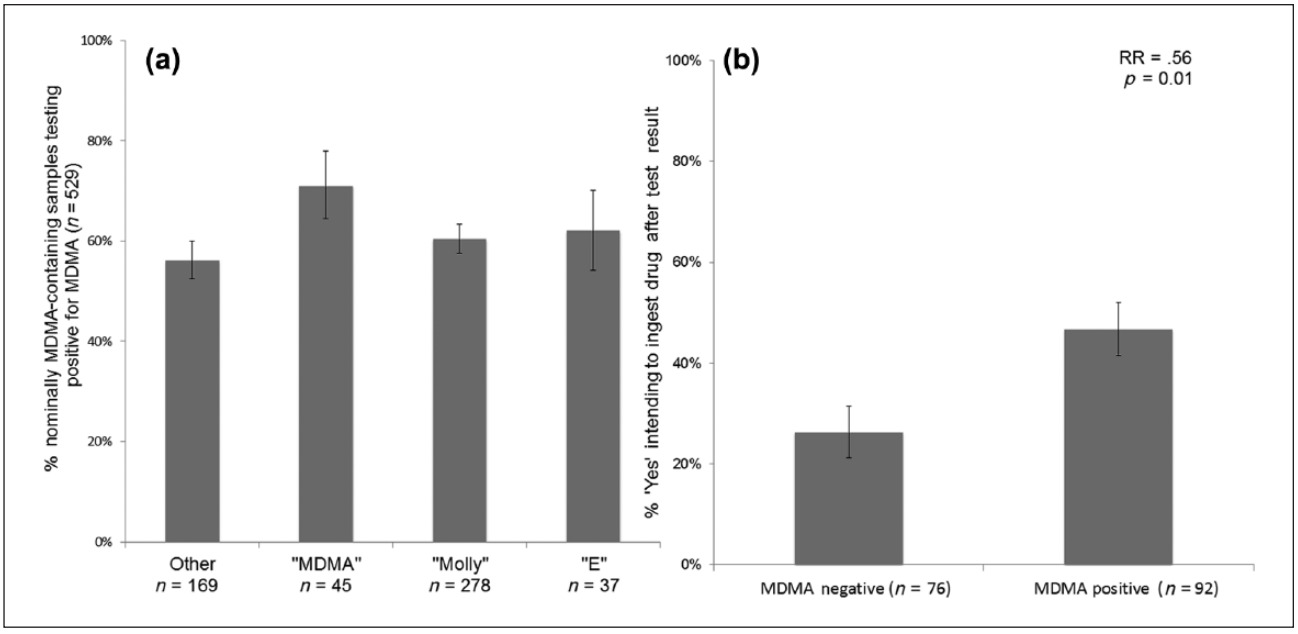

Figure 1. (a) Percentage of samples containing methylenedioxymethamphetamine (MDMA) by brand category (n = 529). (b) Percentage of users who reported intent to ingest nominally MDMA-containing products after learning test result (n = 168, RR = 0.56, p = 0.01). Users are less likely to take drug after learning it is not MDMA. Error bars indicate SEM.
RR: relative risk; SEM: standard error of mean.

Data analysis

For purposes of data analysis, our study n was defined as the number of substances tested. DanceSafe staff provided an informal estimate that approximately 5% of participants had multiple substances tested. However, the number of substances tested per person was not recorded. Pearson's χ^2 was used to examine differences in proportions of samples testing positive for MDMA among the four categories of MDMA products. Logistic regression was used to estimate the relative risk of participants stating they intended to consume the product ('Yes' vs. 'Unsure'/'No') in participants whose test result indicated the presence vs. absence of MDMA.

Results

A total of 60% (318) of 529 samples tested positive for MDMA or MDA (a drug with similar properties to MDMA but which is indistinguishable from MDMA with the reagent tests utilized). No significant difference was found between categories of product name in the proportion of samples testing positive for MDMA (Pearson χ^2 = 3.4, p = 0.33; Figure 1a). When an adulterant was detected, it was often impossible to identify the substance using the colorimetric assay. Among those adulterants which were identifiable, methylone, other cathinones, and methamphetamine were the most common (Figure 2). Three samples were found to contain PMA, although none were found to contain PMMA.

A total of 168 participants with nominally MDMA-containing products were asked if they still intended to consume their product after testing, although all volunteers were instructed to ask this as part of testing protocol. Responses to this question showed no significant differences based on geography, time of day, or year of study or testing result. Only 26% of participants whose substances tested negative for MDMA reported intent to consume their substance versus 46% of participants whose substances tested positive for MDMA.

Logistic regression revealed that participants whose substances tested negative for MDMA were significantly less likely to express intent to consume the substance as users whose substances tested positive for MDMA (RR 0.56, p = 0.01; Figure 1b).

Discussion

This is the first study in North America in over 10 years to sample nominally MDMA-containing products. Results suggest that the assumption in the literature that Molly is less adulterated is incorrect, and patients who report ingesting any nominally MDMA-containing product must be considered at risk for diverse clinical overdose syndromes. These results may also inform the public about the relevant risks of these products, and discourage a false sense of security about the purity of nominally MDMA-containing products labeled Molly.

This study is also the first to show how pill-testing services change participant intent to use substances, with a decrease in reported intent to ingest substances when MDMA was not detected. Quizzically, less than 60% of participants whose substance tested positive for MDMA verbally reported intent to consume their substances after testing, raising the question of why they were having their substances tested in the first place (Figure 1b). This may be due to participants having substances tested on behalf of friends or with the intent to otherwise distribute as opposed to consuming themselves. Because these possibilities would apply to both those whose pills ultimately tested positive or negative for MDMA, our data nonetheless suggest that a negative test for MDMA

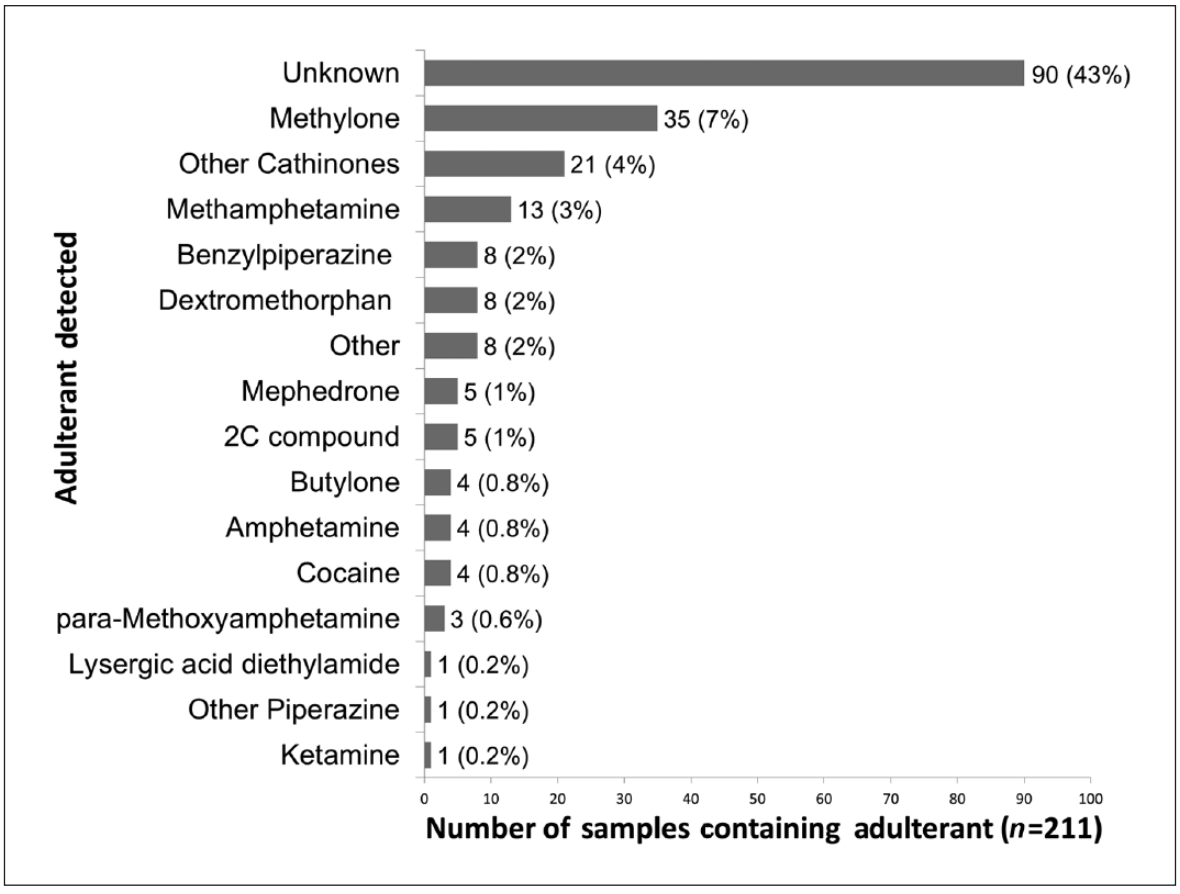

Figure 2. Adulterants found in all nominally methylenedioxymethamphetamine (MDMA)-containing products.
Type and number of adulterated substances found through DanceSafe's testing service among substances which tested negative for MDMA. Substances categorized as 'Unknown' could not be identified using the colorimetric assay.
2C, two carbon.

substantially decreased intent to consume the substance. Although participants whose substances tested negative for MDMA were informed of the most likely identity of their substance, there was insufficient sample size to detect if there was a relationship between the identified adulterant and the probability of a participant reporting intent to ingest a substance. This would be an interesting question for future research of pill-testing services.

This finding that MDMA-negative pill-testing results led to lower rates of intention to use, suggests that pill testing may be effective in reducing consumption of unknown substances and decreasing related harms. Whereas pill-testing services have received official recognition in the Netherlands and Austria through the DIMS program and 'Checkit!', respectively, such services have met legal resistance in both the UK (King, 2015) and the US, where event organizers and property owners are hesitant to have these services available due to legislation that may hold them liable (Sullum, 2014). Our findings that pill testing decreases intent to consume potentially dangerous substances indicates that this legislation may need to be reconsidered. Furthermore, if event organizers remain uncomfortable with allowing pill testing at their venues, it may be prudent for pill-testing organizations to consider further promoting pill testing at alternative sites accessible to users, for example, offering testing at sites near to but outside of the entrances to music events or through mail services, as some organizations (notably EcstasyData.org) have already done.

Although novel, our study has limitations. One limitation is that only 168 of the 529 total participants were asked if they still intended to consume their nominally MDMA-containing product, although this step was part of the DanceSafe volunteer testing protocol. This may have been due to high demands for testing and limited volunteer capacity leading to individual volunteers electing to skip this step. Although the authors were not able to find any significant differences in the data concerning participants who were or were not asked this question, it does introduce the risk of a non-random selection bias. Additionally, as alluded to within the Methods section, the accuracy of colorimetric reagent tests has been shown as relatively poor when testing substances such as ketamine and opiates (Camilleri and Caldicott, 2005; Murray et al., 2003), and the ability of colorimetric reagent tests to identify many of the adulterants discussed has not been thoroughly studied. Therefore, the results in Figure 2 should be interpreted with caution. That said, the ability of colorimetric reagent kits to accurately detect MDMA has been well established within a variety of testing environments and conditions (Camilleri and Caldicott, 2005; Pradeille et al., 2008; Murray et al., 2003; Winstock et al., 2001), lending further credence to our findings concerning the relative purity of MDMA products sold under different names. However, it should be emphasized that the presence of MDMA does not guarantee safety in an Ecstasy pill, since MDMA itself can result in acute toxicity, particularly in high

doses. Furthermore, while some MDMA adulterants (PMA, PMMA, etc.) are known to be more harmful than others (Vitamin B6, niacin, etc.) the reagent tests used within the present study are unable to distinguish between adulterants with greater and lesser amounts of health risk. Regardless, our data question the assumption that Molly differs in content from other nominally MDMA-containing products, showing that a significant proportion of nominally MDMA-containing products do not contain MDMA, and demonstrates that drug users alter their behavioral intentions due to pill-testing services.

Declaration of Conflicting Interest

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Author Missi Wooldridge has previously worked for Dancesafe.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Abbott RM and Smith DM (2015) The new designer drug wave: a clinical, toxicological, and legal analysis. *J Psychoactive Drugs* 47: 368–371.

Bossong MG, Brunt TM, Van Dijk JP, et al. (2010) mCPP: an undesired addition to the ecstasy market. *J Psychopharmacol* 24: 1395–1401.

Camilleri AM and Caldicott D (2005) Underground pill testing, down under. *Forensic Sci Int* 151: 53–58.

Clemens KJ, McGregor IS, Hunt GE, et al. (2007) MDMA, methamphetamine and their combination: possible lessons for party drug users from recent preclinical research. *Drug Alcohol Rev* 26: 9–15.

Connolly J (2016) First ever festival to test users' drugs. *BBC Newsbeat*. Available at: http://www.bbc.co.uk/newsbeat/article/36881070/first-ever-festival-to-test-users-drugs

Duterte M, Jacinto C, Sales P, et al. (2009) What's in a label? Ecstasy sellers' perceptions of pill brands. *J Psychoactive Drugs* 41: 27–37.

Gerrard M, Gibbons FX, Houlihan AE, et al. (2008) A dual-process approach to health risk decision-making: the prototype-willingness model. *Dev Rev* 28: 29–61.

Kahn DE, Ferraro N and Benveniste RJ (2012) 3 cases of primary intracranial hemorrhage associated with 'Molly', a purified form of 3,4-methylenedioxymethamphetamine (MDMA). *J Neurol Sci* 323: 257–260.

Khajeamiri AR, Kobarfard F, Ahmadkhaniha R, et al. (2011) Profiling of ecstasy tablets seized in Iran. *Iran J Pharm Res* 10: 211–220.

King LA (2015) Facilitate recreational drug testing to help save lives. *Pharm J* 294: 176–177.

Ling LH, Marchant C, Buckley NA, et al. (2001) Poisoning with the recreational drug paramethoxyamphetamine ('death'). *Med J Aust* 174: 453–455.

Murray RA, Doering PL, Boothby LA, et al. (2003) Putting an Ecstasy test kit to the test: harm reduction or harm induction? *Pharmacotherapy* 23: 1238–1244.

Namera A, Nakamoto A, Saito T, et al. (2011) Colorimetric detection and chromatographic analyses of designer drugs in biological materials: a comprehensive review. *Forensic Toxicol* 29: 1–24.

NIJ NIoJ (2000) *Color Test Reagents/Kits for Preliminary Identification of Drugs of Abuse NIJ Standard - 0604.01*. Rockville, MD: National Law Enforcement and Corrections Technology Center.

Pradeille J, Chakroun N, Beltran V, et al. (2008) The Marquis reaction as a harm reduction element in party atmospheres: an assessment of the on-site testing of ecstasy tablets. *161th Annual Meeting of the American Psychiatric Association*, Washington, DC.

Reyna VF and Rivers SE (2008) Current theories of risk and rational decision making. *Dev Rev* 28: 1.

Ridpath A, Driver CR, Nolan ML, et al. (2014) Illnesses and deaths among persons attending an electronic dance-music festival - New York City, 2013. *MMWR Morb Mortal Wkly Rep* 63: 1195–1198.

SAMHSA (2013) *Drug Abuse Warning Network, 2011: National Estimates of Drug-Related Emergency Department Visits*. HHS Publication No. (SMA) 13–4760, DAWN Series D-39. Rockville, MD: Substance Abuse and Mental Health Services Administration.

SAMHSA (2015) *Behavioral Health Trends in the United States: Results from the 2014 National Survey on Drug Use and Health HHS Publication No. SMA 15–4927, NSDUH Series H-50*. Rockville, MD: Substance Abuse and Mental Health Services Administration.

Sullum J (2014) *Ignoring Drug Use at Musical Events Only Makes It More Dangerous*. Available at: http://www.forbes.com/sites/jacobsullum/2014/12/30/ignoring-drug-use-at-musical-events-only-makes-it-more-dangerous/

Togni LR, Lanaro R, Resende RR, et al. (2015) The variability of ecstasy tablets composition in Brazil. *J Forensic Sci* 60: 147–151.

Vanattou-Saifoudine N, McNamara R and Harkin A (2012) Caffeine provokes adverse interactions with 3,4-methylenedioxymethamphetamine (MDMA, 'ecstasy') and related psychostimulants: Mechanisms and mediators. *Br J Pharmacol* 167: 946–959.

Vevelstad M, Øiestad EL, Middelkoop G, et al. (2012) The PMMA epidemic in Norway: Comparison of fatal and non-fatal intoxications. *Forensic Sci Int* 219: 151–157.

Vogels N, Brunt TM, Rigter S, et al. (2009) Content of ecstasy in the Netherlands: 1993–2008. *Addiction* 104: 2057–2066.

Winstock AR, Wolff K and Ramsey J (2001) Ecstasy pill testing: Harm minimization gone too far? *Addiction* 96: 1139–1148.

Wood DM, Stribley V, Dargan PI, et al. (2011) Variability in the 3,4-methylenedioxymethamphetamine content of 'ecstasy' tablets in the UK. *Emerg Med J* 28: 764–765.

Yamamoto T, Kawsar A, Ramsey J, et al. (2013) Monitoring trends in recreational drug use from the analysis of the contents of amnesty bins in gay dance clubs. *QJM* 106: 1111–1117.