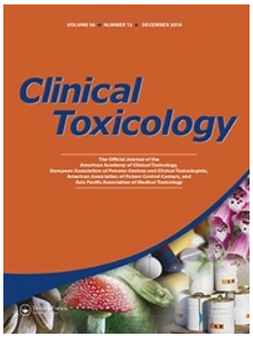

Clinical Toxicology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ictx20

Underreporting of drug use among electronic dance music party attendees

Joseph J. Palamar , Alberto Salomone & Katherine M. Keyes

To cite this article: Joseph J. Palamar , Alberto Salomone & Katherine M. Keyes (2020): Underreporting of drug use among electronic dance music party attendees, Clinical Toxicology, DOI: 10.1080/15563650.2020.1785488

To link to this article: https://doi.org/10.1080/15563650.2020.1785488

CLINICAL TOXICOLOGY
https://doi.org/10.1080/15563650.2020.1785488

Taylor & Francis
Taylor & Francis Group

CLINICAL RESEARCH

Underreporting of drug use among electronic dance music party attendees

Joseph J. Palamar[a], Alberto Salomone[b,c] and Katherine M. Keyes[d]

[a]Department of Population Health, New York University Grossman School of Medicine, New York, NY, USA; [b]Dipartimento di Chimica, Università di Torino, Torino, Italy; [c]Centro Regionale Antidoping e di Tossicologia, Orbassano, Italy; [d]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY, USA

ABSTRACT

Background and Objectives: Electronic dance music (EDM) party attendees are at high risk for drug use. However, little is known regarding the extent of underreporting of drug use in this population, in part, because use of synthetic drugs is often associated with unknown exposure to adulterant drugs. We estimated the extent of underreported drug use in this population by comparing self-reported use to hair toxicology results.

Methods: Time-space sampling was used to survey adults entering EDM events at nightclubs and dance festivals in New York City from January through August of 2019. Seven hundred ninety-four adults were surveyed and 141 provided analyzable hair samples. We queried past-year use of >90 drugs and tested hair samples using ultra-high performance liquid chromatography–tandem mass spectrometry. We compared hair test results to past-year self-reported use and adjusted prevalence estimates by defining use as reporting use or testing positive. Correlates of discordant reporting, defined as testing positive after not reporting use, were estimated.

Results: Prevalence of drug use increased when considering positive hair tests in estimates, with 43.8% of participants testing positive for at least one drug after not reporting use. For example, based on self-report, cocaine use prevalence was 51.1%, and increased by a factor of 1.6 to a prevalence of 80.0% when adding hair test results to self-report. Younger adults (ages 18–25), black and other/mixed race participants, those reporting "other" sexuality, and those with a college degree were at significantly higher risk for testing positive for drugs not reportedly used. Those who self-reported using more types of drugs were less likely to test positive after not reporting use (adjusted prevalence ratio = 0.53, 95% confidence interval = 0.41-0.68).

Conclusions: We detected underreporting of drug use, particularly cocaine and ketamine. More research is needed to determine whether this is driven by intentional underreporting or unknown exposure through adulterants.

ARTICLE HISTORY
Received 17 March 2020
Revised 14 June 2020
Accepted 16 June 2020

KEYWORDS
Club drugs; toxicology; reliability of self-report; electronic dance music

Introduction

Surveys are widely used for epidemiological investigations of drug use, and almost always rely on respondent self-report. However, a limitation to self-report is that it may reflect both intentional and unintentional underreporting of use [1–5]. Denial of known use is a common cause of underreporting [4,5], but an under-examined cause of underreporting is unknown exposure to drugs used as adulterants (e.g. methamphetamine, fentanyl) [6–8].

Intentional underreporting of drug use occurs with regularity as use can be a sensitive topic for participants. Individuals who use or have used drugs may fear identification or judgment by others, and they may fear that disclosing use can compromise their personal life, career, or even lead to legal consequences [5]. However, not all underreporting is intentional. Individuals may forget their drug use, or they may not understand or pay attention to survey questions and thus answer questions inaccurately [5,9]. Unintentional underreporting can also occur when individuals who use drugs are unknowingly exposed to adulterants. Historically, various psychoactive drugs (e.g. heroin, ecstasy) have often been adulterated with other drugs [10–15]. For example, a study determined that people who use drugs like ecstasy (MDMA, Molly) are at high risk for unknowingly using drugs such as methamphetamine, synthetic cathinones, and other new psychoactive substances (NPS)[7,8]. Alarmingly, fentanyl, its analogs, and other opioid NPS are now being detected in drugs such as heroin, cocaine, and in counterfeit prescription pills [16–18]. Unintentional use of fentanyl and/or opioid NPS *via* adulterated drugs has been a major factor contributing to the recent spike in drug-related deaths in the US [19,20].

Biological testing can be used as an adjunct to surveys to detect underreporting of drug use and it can be used to adjust estimates of use. Biological testing was added to a population survey of adults in Chicago in 2001/2002 and

CONTACT Joseph J. Palamar joseph.palamar@nyulangone.org Department of Population Health, 180 Madison Avenue, Room 1752, New York 10016, NY, USA

Supplemental data for this article can be accessed here.

estimates of recent cocaine use increased from 4.2% to 13.1% when considering those who did not report use, but tested positive, as being exposed [3]. A more recent study of 279, 457 pregnant women found the estimated prevalence of prenatal cannabis use increased from 4.2% to 7.1% when correcting self-reported data to include urine testing [21]. While some studies have compared self-report to biological test results [1,7,8,22–27], few have used biological test results to *adjust* survey-based estimates of use. In addition, most studies that include biological testing for drug exposure use urine testing. Although urine and blood testing are often considered gold standard, these methods can typically only detect very recent use (e.g. that occurred within the past few days) [28]. Hair samples, however, can allow detection of various drugs months post-exposure [29–31]. In addition, unlike urine and blood testing, hair samples can be collected quickly, noninvasively, and in almost any environment (e.g. during street-intercept surveys) [32,33].

As deaths related to stimulant and opioid use continue to increase in the US [34], research is needed to accurately estimate drug use in order to better assess public health burden and allocate public health resources. In this study, we focus on individuals who attend electronic dance music (EDM) events at nightclubs or dance festivals. Individuals who attend such parties are at higher risk for use of various drugs than the general population [35] and use of drugs such as ecstasy and cocaine are particularly common in this population [36,37]. In this study, we aim to determine the extent of underreported drug use or drug exposure in this population and correlates of underreporting.

Methods

Procedure

Each week from January through August 2019, EDM parties in New York City (NYC) were randomly selected to survey individuals entering parties using time-space sampling [38]. The party sample space was based on (1) parties listed on EDM websites; (2) nightclubs that held EDM parties; and (3) through recommendations of key informants in the scene. Recruitment typically occurred 1–2 nights per week on Thursday through Sunday. While most parties were held at nightclubs or warehouses, we also surveyed participants outside of one large daytime EDM dance festival. To be eligible, individuals must have been ages ≥18 and about to enter the randomly selected event. Participants within parties, however, were not randomly selected. Individuals were approached by a recruiter, and if eligible, were asked if they were willing to take an anonymous survey. Recruiters did not approach people based on appearance but tried to ensure that potential participants were not visibly inebriated (e.g. impaired attention or gait, slurred speech). Surveys were taken on electronic tablets after informed consent was provided. During the survey, participants were asked their willingness to provide a hair sample. If the participant agreed, the recruiter cut a small lock of hair (∼100 hairs when possible) from the participant with a clean scissor as close to the skin/scalp as possible. While hair was usually taken from the head, participants were also able to provide body hair (e.g. from the armpit, arm, leg, face). Hair was folded into a piece of tin foil and stored in an envelope labeled with the participant's study ID number. This ID was used to link hair test results to survey responses.

Response rates to survey invitation were collected and we also tracked the number of people passing a predefined line (with a clicker) to inform weighting procedures [38]. Of 1,246 individuals approached, 794 completed the survey. Thus, the survey response rate was 64%. The source population underlying those approached was estimated with a click counter as approximately 6,863. Over a quarter of the sample (27.2%; $n = 216$) provided a hair sample for analysis. This study was approved by the first author's institutional review board.

Measures

Participants were asked about demographic characteristics, frequency of past-year EDM party attendance, and past-year use of >90 drugs. Drugs queried included cannabis, cocaine, MDMA/ecstasy/Molly, LSD, methamphetamine, ketamine, DMT, 2 C series drugs, synthetic cathinones ("bath salts", including ethylone), MDEA, heroin, and fentanyl. They were also asked about nonmedical use of amphetamine and prescription opioids. Nonmedical use was defined for participants as use without a prescription or in a manner in which it was not prescribed. Test-retest reliability of our drug use questions has been shown to be high ($\kappa = 0.88$-1.00) [39]. At the end of the survey, participants were asked how many of questions on the survey they answered honestly.

Hair analysis

216 participants provided a hair sample. 141 hair samples (17.8% of the full sample) were analyzable, with 75 samples not meeting our 20 mg criterion to perform analyses. Since we focused on past-year drug use, only the proximal 0–12 cm segment was analyzed when a longer hair sample was collected. The mean length was 8.1 ± 4.2 cm (median = 8.0 cm). While most samples (96.5%; $n = 136$) were obtained from participants' heads, 4 samples (2.8%) were collected from participant armpits and 1 sample (0.7%) was collected from a participant's beard. Assuming a normal hair growth rate [40], the mean time frame is ∼1 cm per month.

Specimens were tested *via* published methods using ultra-high performance liquid chromatography–tandem mass spectrometry [41–43]. We tested for common drugs including cannabis (THC), amphetamine, methamphetamine, cocaine, MDMA, ketamine, PCP, heroin (6-MAM), and prescription opioids including morphine, codeine, oxycodone, hydrocodone, hydromorphine, and oxymorphone. We also tested for a variety of uncommon drugs and NPS including 19 synthetic cathinones (i.e. mephedrone, 4-MEC, methylone, 3,4-MDPV, pentedrone, 3-MMC, ethylcathinone, alpha-PVP, butylone, buphedrone, mexedrone, amfepramone, pentylone, methedrone, ethylone, naphyrone, 4-F-methylcathinone, 3,4-DMMC, alpha-PHiP) and 7 psychedelic phenethylamines (i.e. 2 C-B, 2 C-P, 25B-NBOMe, 25 C-NBOMe, 25H-NBOMe,

25I-NBOMe, 4-EA-NBOMe). We also tested for 5 other euphoric stimulants (i.e. 4-FA, 5/6-APB, 5-MAPB, PMA, PMMA) and 3 dissociative NPS (i.e. MXE, 4-MeO-PCP, diphenidine). In addition, we tested for fentanyl, 8 fentanyl analogs (i.e. carfentanyl, acetylfentanyl, furanylfentanyl, butyrfentanyl, acryloylfentanil, 4-fluorofentanyl, 3-methylfentanyl, ocfentanyl), and for 5 other opioid NPS (i.e. U-47,700, U-49900, AH-7921, MT-45, U-51,754).

Once ingested, drugs are incorporated into the hair, leading to a potential chronological trace of exposure. Farther periods correspond to hair segments more distant from the root. Hair is most ideal to detect repeated exposure over a long diagnostic window (e.g. over months), and the continuous improvement of analytical procedures and instrumental technologies now allows us to detect very small amounts of drugs (including single exposures), and for many months post-exposure [44,45]. We set the limits of detection as the minimum criterion to identify positive samples, although a further criterion to confirm cocaine exposure was the presence of benzoylecgonine (BZE), the main cocaine metabolite [46]. We used the minimum criterion because we aimed to detect any amount of exposure (e.g. *via* adulterants).

Statistical analysis

We first examined descriptive statistics for the full survey sample and determined whether there were significant differences between those who provided an analyzable hair sample and those who did not. Comparisons were made using chi-square. Next, we estimated prevalence of past-year use of various drugs based on self-report, and then we estimated prevalence based on hair test results. We then compared self-report to hair test results, calculated the percentage of concordant-positive reporting (testing positive after reporting use) and discordant-positive reporting (testing positive after not reporting use), and determined what percentage of detection hair testing added to self-report. We then estimated adjusted prevalence of past-year use in which we defined use as self-reporting use or testing positive for use. Finally, we examined correlates of any discordant reporting, defined as testing positive for a drug after not reporting use. We examined whether demographic and drug use characteristics were related to providing any discordant drug report (meaning the participant tested positive after reporting no use for at least one drug). We used a multivariable generalized linear model with Poisson and log link to estimate adjusted prevalence ratios (aPRs) for each variable.

We calculated sample weights based on the proportion of all party attendees who completed a survey and on self-reported frequency of EDM party attendance, given that those who have higher response rates, and those who attend more frequently, had a higher likelihood of being sampled [38]. Specifically, weights were inversely proportional to reported frequency of attendance and to the number of people tracked entering each specific party. These weight components were combined *via* multiplication and normalized. This up-weighting of those believed to have a lower probability of selection and down-weighting of those believed to have a higher probability of selection is commonly used in studies that use venue-based sampling [38]. Parties were also accounted for as strata in this complex survey design. Weights were included to make results more generalizable to all NYC EDM party attendees, rather than frequent attendees who were more likely to be surveyed. Data were analyzed using Stata 13 SE and survey commands were used to generate estimates [47].

Results

Table 1 describes the full survey sample and the subsample of participants who provided an analyzable hair sample. Those providing a hair sample (large enough to analyze, $n = 141$) were similar to the full survey sample. However, compared to those not providing an analyzable sample, those providing an analyzable sample were less likely to report not having answered all or most survey questions honestly (0.3 vs. 8.2%, $p < .001$) and more likely to report past-year cocaine use (51.1 vs. 29.4%, $p = .036$). Supplemental Table 1 shows comparisons between those who provided an analyzable sample versus those who provided an unanalyzable sample. Those who reportedly answered all or most survey

Table 1. Sample characteristics.

	Full sample ($n = 794$) Weighted % (n)	Provided an analyzable hair sample ($n = 141$) Weighted % (n)
Age, years		
18–25	37.7 (399)	31.5 (79)
≥26	62.3 (395)	68.5 (62)
Sex		
Male	64.9 (467)	65.5 (75)
Female	35.1 (327)	34.5 (66)
Race/Ethnicity		
White	42.0 (383)	43.8 (77)
Black	11.9 (77)	14.5 (10)
Hispanic	20.9 (139)	31.0 (26)
Asian	17.3 (127)	5.3 (17)
Other/Mixed	7.8 (68)	5.4 (11)
Education		
Less than College Degree	33.8 (261)	42.4 (58)
College Degree	66.2 (533)	57.6 (83)
Sexual orientation		
Heterosexual	76.0 (563)	86.2 (98)
Gay/Lesbian	17.1 (120)	8.1 (14)
Bisexual	5.9 (84)	5.2 (22)
Other Sexuality	1.0 (27)	0.6 (7)
Answered all or most questions honestly		
Yes	93.4 (720)	99.8 (136)**
No	6.6 (73)	0.2 (5)
Past-year drug use (Self-report)		
Cannabis	61.3 (579)	71.9 (123)
Cocaine	33.9 (345)	51.1 (76)*
Ecstasy/MDMA/Molly	28.9 (332)	20.9 (72)
LSD	18.5 (208)	20.4 (43)
Amphetamine (nonmedical)	13.5 (175)	22.2 (42)
Ketamine	13.1 (148)	11.2 (30)
Methamphetamine	6.5 (47)	11.3 (9)
Number of Drugs Used, mean (SE)	1.9 (0.1)	2.3 (0.3)

Nonmedical use was defined for participants as using without a prescription or in a manner in which it was not prescribed—for example, to get high. SE: standard error. Asterisks indicate significant differences between those providing an analyzable hair sample and those not providing a hair sample. *$p < .05$, **$p < .001$.

Table 2. Prevalence estimates based on self-report and hair test results.

	Prevalence estimate *via* self-reported use weighted % (95% CI)	Prevalence estimate *via* hair positive weighted % (95% CI)	Adjusted prevalence (self-report plus positive hair) Weighted % (95% CI)	Concordant positive weighted %	Discordant positive weighted %	What positive hair adds to self-report weighted %
Any drug	82.7 (61.7, 93.4)	76.1 (56.8, 88.6)	96.6 (82.9, 99.4)	75.3	80.2	13.9
Cannabis	71.9 (49.3, 87.0)	23.4 (11.7, 41.3)	71.9 (49.3, 87.0)	32.5	0.0	0.0
Cocaine + BZE	51.1 (31.8, 70.2)	59.1 (39.0, 76.6)	80.0 (60.7, 91.2)	59.1	59.0	28.9
Amphetamine	22.2 (9.9, 42.7)	21.2 (10.0, 39.5)	32.5 (17.1, 52.8)	49.3	13.2	10.3
MDMA	20.9 (11.3, 35.3)	27.1 (14.3, 45.1)	35.8 (21.0, 54.0)	57.9	18.9	14.9
LSD	20.4 (9.7, 37.9)	5.9 (1.0, 28.4)	20.4 (9.7, 37.9)	28.7	0.0	0.0
Methamphetamine	11.3 (3.1, 33.7)	10.2 (3.1, 28.9)	17.8 (6.5, 40.2)	33.1	7.3	6.5
Ketamine	11.2 (3.0, 33.8)	33.3 (18.8, 51.9)	36.0 (21.1, 54.2)	76.0	28.0	24.8
Any Opioid	9.3 (2.1, 33.4)	1.8 (0.6, 5.3)	10.0 (2.5, 32.9)	11.7	0.8	0.7
Prescription Opioid	9.3 (2.1, 33.4)	1.6 (0.5, 5.2)	9.8 (2.4, 33.0)	11.7	0.6	0.5
DMT	5.9 (1.0, 28.4)	5.5 (0.8, 29.5)	5.9 (1.0, 28.4)	92.8	0.0	0.0
2C-B	1.3 (0.4, 4.3)	0.0 (0.0, 0.1)	1.3 (0.4, 4.3)	0.8	0.0	0.0
Ethylone	0.0	4.0 (1.0, 1.6)	4.0 (1.0, 1.6)	–	4.0	4.0
MDEA	0.0	2.6 (0.7, 8.8)	2.6 (0.7, 8.8)	–	2.6	2.6
Fentanyl	0.0	1.1 (0.2, 5.7)	1.1 (0.2, 5.7)	–	1.1	1.1

Any drug refers to any drug reported in this table. To test positive for cocaine exposure participants must have also tested positive for benzoylecgonine (BZE). Concordant positive is defined as the percentage of those testing positive among those reporting past-year use. Discordant positive is defined as the percentage of those testing positive among those not reporting past-year use. CI: confidence interval.

questions honestly and those reporting nonmedical prescription opioid use were more likely to provide an analyzable sample (ps < .001).

Table 2 presents estimated prevalence of self-reported past-year drug use, prevalence according to hair-positive results, and adjusted prevalence accounting for both self-report and positive detection in hair. An estimated 82.7% used any drug examined in the past year (based on self-report) and 76.1% tested positive for any drug examined. However, estimated prevalence rose to 96.6% when considering both self-report and test results.

While an estimated 71.9% used cannabis in the past year (according to self-report), only 23.4% tested positive for use. No participants who denied use tested positive for exposure. Although prevalence based on self-reported use of cocaine and positive detection of cocaine were comparable (51.1 vs. 59.1%), adjusted prevalence increased to 80.0% when considering both self-report and hair test results (with hair testing adding 28.9% higher prevalence to self-report). Prevalence estimates based on self-report and hair test results were comparable for amphetamine (22.2 vs. 21.2%) and MDMA (20.9 vs. 27.1%), but adjusted prevalence for amphetamine and MDMA use increased to 32.5% and 35.8%, respectively. Thus, hair test results added 10.3% to self-reported prevalence of amphetamine use and 14.9% to self-reported prevalence of MDMA use.

Although past-year LSD use was reported by 20.4% of participants, only 5.9% tested positive for exposure, and hair results did not add to self-report (Table 2 continued). While an estimated 11.2% used ketamine (based on self-report), hair detection was three-times higher (33.3%). Positive hair test results added 24.8% to adjusted prevalence of self-reported use. With regard to opioids, most reported use went undetected during hair testing, with hair testing adding <1% to self-reported prevalence of use. Of note, two cases (1.1% of the sample) tested positive for fentanyl exposure after not reporting use. Ethylone and MDEA were not reportedly used by any participants, but 4.0% and 2.6%, respectively, tested positive for these compounds. None of the other compounds we tested for were detected. Table 3 provides correct classification statistics (sensitivity, specificity, and positive and negative predictive value) regarding hair test results in comparison to self-report.

Table 3. Correct classification of hair test results with self-reported past-year use as "gold standard".

	Sensitivity	Specificity	PPV	NPV
DMT	1.00	0.99	0.50	1.00
2C-B	1.00	0.96	0.14	1.00
LSD	1.00	0.72	0.09	1.00
Cannabis	1.00	0.20	0.40	1.00
MDMA (ecstasy)	0.83	0.77	0.76	0.84
Cocaine	0.66	0.70	0.82	0.51
Amphetamine	0.65	0.80	0.48	0.89
Prescription opioids	0.38	0.93	0.25	0.96
Ketamine	0.37	0.93	0.83	0.61
Opioids	0.33	0.93	0.25	0.95
Methamphetamine	0.17	0.95	0.22	0.92
Ethylone	–	1.00	–	1.00
MDEA	–	1.00	–	1.00
Fentanyl	–	1.00	–	1.00

PPV: positive predictive value; NPV: negative predictive value. We could not compute sensitivity or PPV statistics for ethylone, MDEA, or fentanyl, because no participants reported use of these compounds.

An estimated 43.8% of participants tested positive for at least one drug after not reporting use. Table 4 presents correlates of such discordant reporting. Compared to older participants, younger participants (ages 18-25) were more likely to test positive after not reporting use (aPR = 1.85, 95% CI: 1.11-3.10), and compared to white participants, those identifying as black (aPR = 2.25, 95% CI: 1.02-4.95) or other/mixed race (aPR = 2.09, 95% CI: 1.23-3.53) were more likely to test positive after not reporting use. Compared to those without a college degree, those with a degree were more likely to test positive after not reporting use (aPR = 2.05, 95% CI: 1.19-3.51), and compared to heterosexuals, those identifying as gay/lesbian (aPR = 0.45, 95% CI: 0.22-0.93) were less likely to test positive after not reporting use and those identifying as

Table 4. Correlates of providing a discordant report by testing positive for at least one drug after not reporting past-year use.

	No discordant reporting weighted % (95% CI)	Any discordant reporting weighted % (95% CI)	aPR (95% CI)
Age, years			
≥26	69.6 (48.0, 85.1)	67.0 (43.2, 84.5)	1.00
18-25	30.4 (14.9, 52.0)	33.0 (15.5, 56.8)	1.85 (1.11, 3.10)
Sex			
Male	57.7 (30.1, 81.3)	75.5 (54.9, 88.7)	1.00
Female	42.3 (18.7, 69.9)	24.5 (11.3, 45.1)	0.71 (0.37, 1.37)
Race/Ethnicity			
White	49.3 (23.4, 75.6)	36.7 (17.5, 61.3)	1.00
Black	14.7 (2.8, 50.2)	14.4 (2.7, 50.1)	2.25 (1.02, 4.95)
Hispanic	29.4 (10.9, 58.7)	33.0 (12.9, 62.1)	1.16 (0.52, 2.58)
Asian	6.2 (1.1, 27.8)	4.3 (1.0, 16.0)	0.52 (0.24, 1.14)
Other/Mixed	0.5 (0.1, 2.3)	11.7 (2.9, 36.6)	2.09 (1.23, 3.53)
Education			
Less than College Degree	31.1 (14.5, 54.5)	56.9 (32.5, 78.3)	1.00
College Degree	68.9 (45.5, 85.5)	43.1 (21.7, 67.5)	2.05 (1.19, 3.51)
Sexual orientation			
Heterosexual	93.4 (85.0, 97.2)	77.0 (52.7, 90.9)	1.00
Gay/Lesbian	1.4 (0.3, 6.2)	16.6 (4.9, 43.5)	0.45 (0.22, 0.93)
Bisexual	4.8 (1.7, 13.0)	5.6 (2.0, 14.4)	1.70 (0.68, 4.25)
Other Sexuality	0.4 (0.1, 1.5)	0.8 (0.2, 3.2)	1.94 (1.01, 3.72)
Answered all/most questions honestly			
Yes	99.7 (98.5, 99.9)	99.8 (99.2, 100.0)	1.00
No	0.3 (0.1, 1.5)	0.2 (0.0, 0.8)	1.26 (0.36, 4.37)
Number of drugs used in past year	M(SE) = 2.8 (0.3)	M(SE) = 1.6 (0.3)	0.53 (0.41, 0.68)
Number of drugs detected in hair	M(SE) = 1.2 (0.4)	M(SE) = 3.0 (0.3)	2.05 (1.71, 2.45)

Discordant reporting is defined as testing positive after not reporting past-year use of a drug. Any discordant reporting indicates that there was such a discordant report for any drug examined. CI: confidence interval; M: mean; SE: standard error.

other sexuality (aPR = 1.94, 95% CI: 1.01-3.72) were more likely to provide such a discordant report. With regard to number of drugs used, each additional drug self-reportedly used was associated with decreased risk of testing positive after not reporting use (aPR = 0.53, 95% CI: 0.41-0.68), and for each additional drug detected in one's hair, risk of providing a discordant report doubled (aPR = 2.05, 95% CI: 1.71-2.45).

Discussion

The present results suggest underreporting of drug use in this population, and when considering both self-report and hair test results, we estimate that almost all individuals (96.6%) in this population have used at least one drug in the past year. Cocaine and ketamine use in particular were underreported. It is unknown to what extent participants knowingly underreported use or to what extent they were unknowingly exposed. Of party drugs, ecstasy appears most likely to be adulterated with other illegal drugs. While most recent research on ecstasy adulteration focuses on NPS, historically, at least some ecstasy has contained ketamine, cocaine, and/or amphetamine [10,11]. In addition, other studies of people who use ecstasy in the NYC EDM scene have detected substantial unreported use of ketamine [8], and of participants who found out their ecstasy contained another drug (51.1% of the sample), 23.9% detected cocaine [48].

An unexpected finding was that there were very few cases of underreported NPS use, given that hair testing of EDM party attendees in NYC in 2015 and 2016 suggested extensive unreported use or exposure (>40%) among people reporting ecstasy use [7,8]. While overdose deaths related to fentanyl have increased substantially in the US (in part, due to fentanyl present in purported heroin)[49], our results suggest that adulteration of party drugs (e.g. ecstasy) with NPS has declined [7,8]. Although, we did detect unreported exposure to fentanyl in two cases. It should be noted that neither of these participants reported heroin use, but both reported use of drugs such as ecstasy and cocaine. Cocaine use in NYC in particular appears to be associated with increased risk of fentanyl exposure [18,50]. We believe it is important to continue to conduct biological testing on party drug users to determine whether risk for unintentional fentanyl exposure is increasing.

Our findings also add to previous studies which found that underreporting of drug use is not random. Although most large studies examining underreporting were conducted decades ago, many of our findings corroborate these older studies. For example, like other studies, we estimate that younger adults are more likely than older adults to underreport [3,27,51]. These findings are of interest because many older adults may be likely to have "more to lose" if their drug use is detected. For example, older adults are at lower risk for using illegal drugs, in part, because they often have different family roles, and/or have a career that can be compromised by others learning of one's drug use [52]. Thus, we would expect that older adults would be more likely to deny known use. More research is needed to determine reasons for such differences.

We also estimate that individuals who identify as black or other/mixed race were more likely to test positive after not reporting use, and this finding corroborates results from many other studies finding that black individuals were more likely to test positive for drugs such as cannabis and/or

cocaine after not reporting use [3,24,27,51,53]. However, it should be noted that these racial minority participants did not test positive for cannabis after not reporting use, so differences in this study are relevant to drugs other than cannabis. While we could not deduce intentional versus unintentional underreporting, a 2013 report estimated that black individuals are 37-times more likely than white individuals to be arrested for cannabis possession [54]; thus, some racial minority individuals in particular may be more suspicious about drug surveys and may intentionally underreport use. If this is the case, then researchers must find a way to address potential mistrust.

With regard to sexual orientation, we estimate that gay/lesbian individuals were less likely than heterosexuals to underreport, and this finding corroborates findings from the Chicago population study which found that men who have sex with men were more likely to accurately report drug use than heterosexual men [1]. With respect to education, we found that individuals with a college degree were more likely to provide discordant reports. This finding was surprising as individuals with lower education are more likely to satisfice on surveys [55], which is when participants do not pay attention to questions or take shortcuts to finish sooner [56]. However, previous studies yield mixed results regarding level of education and underreporting [1,53]. While satisficing indeed may have contributed to underreporting, 99.8% of participants providing an analyzable hair sample reported answering all or most questions honestly.

Our results also suggest that self-reported use of more drugs was associated with decreased risk of underreporting use of any drug. Thus, it appears that more extensive drug users may be less inclined to underreport use (of any drug), but users of fewer drugs are more likely to underreport any use. In addition, testing positive for more drugs was associated with increased risk of not reporting use but then testing positive. However, we are unable to deduce whether individuals who report use of fewer drugs and/or test positive for more drugs are more likely to intentionally or unintentionally underreport use. This study was also among the first to estimate sensitivity and specificity of hair test results for multiple drugs using self-report as the gold standard, and results were nearly identical to a recent study comparing hair test results to self-reported use of cannabis, cocaine, and methamphetamine, among people who use opioids [33].

This study has limitations. Hair testing has limited ability to detect very recent drug use (e.g. in the past week) so recent use, including use the day of the event, could have been underestimated. Urine, blood, and saliva are more ideal for detecting use within the past few days. Thus, the most ideal procedure to most accurately detect drug use over long window periods would be hair testing plus urine, blood, and/or saliva testing [33]. Many participants provided hair samples <12 cm. In such cases, we were not able to detect use that last occurred closer to a year prior to collection. Unfortunately, we do not have information regarding how many people could not provide a hair sample due to their hair being too short as these individuals were simply coded as refusals. However, even when hair appeared too short for analysis, if the participant was willing to provide a sample, we still attempted to collect a sample to later determine whether it was analyzable (hence our omission of analysis of 75 collected samples). These unanalyzable samples could have biased results although we did not detect differences in participant characteristics between those who provided analyzable versus unanalyzable hair samples. Indeed, males were more likely to provide body hair for analysis, but we do not believe this biased results as it was males that typically had shorter head hair than females and body hair was only used as a fallback. Beard and armpit hair also grow at a slower rate than head hair so we might have been be less likely to detect very recent use in such samples [45]. Specific styles of haircuts can also be indicators of social patterns, and possibly bias if this limits our ability to collect hair samples. Future research could examine whether hair styles affect willingness to provide hair samples and detection of specific drugs.

Use of hair products can affect ability to detect drug exposure and it should be noted that people of different races or ethnicities could have different hair composition which can affect test results [45]. Hair testing cannot always reliably detect infrequent cannabis consumption or LSD use [33,57,58], and we could not distinguish between medical and nonmedical use of amphetamine and prescription opioids. Although we have demonstrated our ability to detect fentanyl and its analogs in other high-risk populations [43], it is possible that very small exposures went undetected in this sample (who reported very low prevalence of heroin use). While our analytic sample was similar to the full survey sample, those providing an analyzable hair sample were more likely to report past-year cocaine use. We also assumed that over-reporting was uncommon, as in adult samples, over-reporting is rare [3,59]. Results also may not be generalizable to individuals beyond those who attend EDM parties in NYC. Limited recall of drug use is also a limitation as participants may not completely recall if and when they used specific drugs in the past year, especially if they had used drugs earlier in the day of the survey. Finally, the present study provides statistics regarding EDM parties in NYC, and may not apply to each individual party as there is likely heterogeneity within the city regarding demographic characteristics of attendees and drugs used.

Conclusions

We detected underreporting of drug use among EDM party attendees, with underreporting of cocaine and ketamine in particular. More research is needed to determine whether this is driven by intentional underreporting or unknown exposure. Continued testing for unknown exposure to fentanyl, its analogs, and other opioid NPS in particular, is of the utmost importance as such data are needed to inform prevention efforts for those at risk for exposure. We believe more epidemiology surveys should include biological testing to continue to inform surveillance efforts regarding use of common drugs and NPS.

Disclosure statement

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Funding

Research reported in this publication was supported by the National Institute on Drug Abuse of the National Institutes of Health under Award Numbers R01DA044207 and K01DA038800.

ORCID

Joseph J. Palamar http://orcid.org/0000-0002-8565-9415

References

[1] Fendrich M, Mackesy-Amiti ME, Johnson TP. Validity of self-reported substance use in men who have sex with men: comparisons with a general population sample. Ann Epidemiol. 2008; 18(10):752–759.

[2] Fendrich M, Rosenbaum DP. Recanting of substance use reports in a longitudinal prevention study. Drug Alcohol Depend. 2003; 70(3):241–253.

[3] Fendrich M, Johnson TP, Wislar JS, et al. The utility of drug testing in epidemiological research: results from a general population survey. Addiction. 2004;99(2):197–208.

[4] Palamar JJ. Barriers to accurately assessing prescription opioid misuse on surveys. Am J Drug Alcohol Abuse. 2019;45(2): 117–123.

[5] Johnson T, Fendrich M. Modeling sources of self-report bias in a survey of drug use epidemiology. Ann Epidemiol. 2005;15(5): 381–389.

[6] Oliver CF, Palamar JJ, Salomone A, et al. Synthetic cathinone adulteration of illegal drugs. Psychopharmacology (Berl.). 2019; 236(3):869–879.

[7] Palamar JJ, Salomone A, Vincenti M, et al. Detection of "bath salts" and other novel psychoactive substances in hair samples of ecstasy/MDMA/"Molly" users. Drug Alcohol Depend. 2016;161: 200–205.

[8] Palamar JJ, Salomone A, Gerace E, et al. Hair testing to assess both known and unknown use of drugs amongst ecstasy users in the electronic dance music scene. Int J Drug Policy. 2017;48: 91–98.

[9] Johnson TP, Bowman PJ. Cross-cultural sources of measurement error in substance use surveys. Subst Use Misuse. 2003;38(10): 1447–1490.

[10] Tanner-Smith EE. Pharmacological content of tablets sold as "ecstasy": results from an online testing service. Drug Alcohol Depend. 2006;83(3):247–254.

[11] Parrott AC. Is ecstasy MDMA? A review of the proportion of ecstasy tablets containing MDMA, their dosage levels, and the changing perceptions of purity. Psychopharmacology (Berl.). 2004;173(3-4):234–241.

[12] Caudevilla-Gálligo F, Ventura M, Ruiz BII, et al. Presence and composition of cathinone derivatives in drug samples taken from a drug test service in Spain (2010-2012). Hum Psychopharmacol. 2013;28(4):341–344.

[13] Vidal Gine C, Vilamala MV, Espinosa IF, et al. Crystals and tablets in the Spanish ecstasy market 2000-2014: are they the same or different in terms of purity and adulteration?. Forensic Sci Int. 2016;263:164–168.

[14] Brunt TM, Nagy C, Bucheli A, et al. Drug testing in Europe: monitoring results of the Trans European Drug Information (TEDI) Project. Drug Test Anal. 2017;9(2):188–198.

[15] Tupper W, McCrae K, Garber I, et al. Initial results of a drug checking pilot program to detect fentanyl adulteration in a Canadian setting. Drug Alcohol Depend. 2018; 190:242–245.

[16] US Drug Enforcement Administration. Counterfeit prescription pills containing fentanyls: a global threat [DEA Intelligence Brief; DEA-DCT-DIB-021-16]. 2016. [cited 17 March 2020]. Available from: http://www.dea.gov/docs/Counterfeit%20Prescription%20Pills.pdf.

[17] Arens AM, van Wijk XMR, Vo KT, et al. Adverse effects from counterfeit alprazolam tablets. JAMA Intern Med. 2016;176(10): 1554–1555.

[18] New York City Department of Health and Mental Hygiene. Presence of fentanyl in cocaine contributing to increase in drug overdose deaths in 2017. Advisory # 10; 2017. [cited 17 March 2020]. Available from: https://ndews.umd.edu/sites/ndews.umd.edu/files/fentanyl-han-advisory.pdf.

[19] Ciccarone D. Fentanyl in the US heroin supply: a rapidly changing risk environment. Int J Drug Policy. 2017; 46:107–111.

[20] O'Donnell JK, Gladden RM, Seth P. Trends in deaths involving heroin and synthetic opioids excluding methadone, and law enforcement drug product reports, by census region - United States, 2006-2015. MMWR Morb Mortal Wkly Rep. 2017;66(34): 897–903.

[21] Young-Wolff KC, Tucker L, Alexeeff S, et al. Trends in self-reported and biochemically tested marijuana use among pregnant females in California from 2009-2016. JAMA. 2017;318(24):2490–2491.

[22] Krotulski AJ, Mohr ALA, Fogarty MF, et al. The detection of novel stimulants in oral fluid from users reporting ecstasy, Molly and MDMA ingestion. J Anal Toxicol. 2018;42(8):544–553.

[23] Palamar JJ, Salomone A, Bigiarini R, et al. Testing hair for fentanyl exposure: a method to inform harm reduction behavior among individuals who use heroin. Am J Drug Alcohol Abuse. 2019; 45(1):90–96.

[24] Li DH, Janulis P, Mustanski B. Predictors of correspondence between self-reported substance use and urinalysis screening among a racially diverse cohort of young men who have sex with men and transgender women. Addict Behav. 2019;88:6–14.

[25] Fendrich M, Johnson TP, Sudman S, et al. Validity of drug use reporting in a high-risk community sample: a comparison of cocaine and heroin survey reports with hair tests. Am J Epidemiol. 1999;149(10):955–962.

[26] Darke S. Self-report among injecting drug users: a review. Drug Alcohol Depend. 1998;51(3):253–263.

[27] Bone C, Gelberg L, Vahidi M, et al. Under-reporting of risky drug use among primary care patients in federally qualified health centers. J Addict Med. 2016; 10:387–394.

[28] Verstraete AG. Detection times of drugs of abuse in blood, urine, and oral fluid. Ther Drug Monit. 2004;26(2):200–205.

[29] Garcia-Bournissen F, Moller M, Nesterenko M, et al. Pharmacokinetics of disappearance of cocaine from hair after discontinuation of drug use. Forensic Sci Int. 2009;189(1-3):24–27.

[30] Suwannachom N, Thananchai T, Junkuy A, et al. Duration of detection of methamphetamine in hair after abstinence. Forensic Sci Int. 2015;254:80–86.

[31] Shen M, Xiang P, Sun Y, et al. Disappearance of 6-acetylmorphine, morphine and codeine from human scalp hair after discontinuation of opiate abuse. Forensic Sci Int. 2013;227(1-3): 64–68.

[32] Fendrich M, Johnson TP, Wislar JS, et al. Drug test feasibility in a general population household survey. Drug Alcohol Depend. 2004;73(3):237–250.

[33] Palamar JJ, Le A, Guarino H, et al. A comparison of the utility of urine- and hair testing in detecting self-reported drug use among young adult opioid users. Drug Alcohol Depend. 2019;200: 161–167.

[34] Hedegaard H, Bastian BA, Trinidad JP, et al. Drugs most frequently involved in drug overdose deaths: United States, 2011–2016. Natl Vital Stat Rep. 2018;67(9):1–14.

[35] Palamar JJ, Griffin-Tomas M, Ompad DC. Illicit drug use among rave attendees in a nationally representative sample of US high school seniors. Drug Alcohol Depend. 2015;152:24–31.
[36] Hughes CE, Moxham-Hall V, Ritter A, et al. The deterrent effects of Australian street-level drug law enforcement on illicit drug offending at outdoor music festivals. Int J Drug Policy. 2017;41: 91–100.
[37] Palamar JJ, Acosta P, Le A, et al. Adverse drug-related effects among electronic dance music party attendees. Int J Drug Policy. 2019;73:81–87.
[38] MacKellar DA, Gallagher KM, Finlayson T, et al. 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 Rep. 2007;122(1_suppl):39–47.
[39] Palamar JJ, Le A, Acosta P, et al. Consistency of self-reported drug use among electronic dance music party attendees. Drug Alcohol Rev. 2019;38(7):798–806.
[40] Kintz P. Issues about axial diffusion during segmental hair analysis. Ther Drug Monit. 2013;35(3):408–410.
[41] Di Corcia D, D'Urso F, Gerace E, et al. Simultaneous determination in hair of multiclass drugs of abuse (including THC) by ultra-high performance liquid chromatography-tandem mass spectrometry. J Chromatogr B Analyt Technol Biomed Life Sci. 2012;899: 154–159.
[42] Salomone A, Gazzilli G, Di Corcia D, et al. Determination of cathinones and other stimulant, psychedelic, and dissociative designer drugs in real hair samples. Anal Bioanal Chem. 2016;408(8): 2035–2042.
[43] Salomone A, Palamar JJ, Bigiarini R, et al. Detection of fentanyl analogs and synthetic opioids in real hair samples. J Anal Toxicol. 2019;43(4):259–265.
[44] Vincenti M, Salomone A, Gerace E, et al. Application of mass spectrometry to hair analysis for forensic toxicological investigations. Mass Spectrom Rev. 2013;32(4):312–332.
[45] Kintz P, Salomone A, Vincenti M. Hair analysis in clinical and forensic toxicology. San Diego, CA: Academic Press; 2015.
[46] Cooper GA, Kronstrand R, Kintz P, Society of Hair Testing. Society of Hair Testing guidelines for drug testing in hair. Forensic Sci Int. 2012;218(1-3):20–24.
[47] Heeringa SG, West BT, Berglund PA. Applied survey data analysis. London: Chapman and Hall: CRC Press; 2010.
[48] Palamar JJ, Barratt MJ. Prevalence of reagent test-kit use and perceptions of purity among ecstasy users in an electronic dance music scene in New York City. Drug Alcohol Rev. 2019;38(1): 42–49.
[49] Colon-Berezin C, Nolan ML, Blachman-Forshay J, et al. Overdose deaths involving fentanyl and fentanyl analogs - New York City, 2000-2017. MMWR Morb Mortal Wkly Rep. 2019;68(2):37–40.
[50] Han BH, Tuazon E, Kunins HV, et al. Unintentional drug overdose deaths involving cocaine among middle-aged and older adults in New York City. Drug Alcohol Depend. 2019;198:121–125.
[51] Ledgerwood DM, Goldberger BA, Risk NK, et al. Comparison between self-report and hair analysis of illicit drug use in a community sample of middle-aged men. Addict Behav. 2008;33(9): 1131–1139.
[52] Staff J, Schulenberg JE, Maslowsky J, et al. Substance use changes and social role transitions: proximal developmental effects on ongoing trajectories from late adolescence through early adulthood. Dev Psychopathol. 2010;22(4):917–932.
[53] White D, Rosenberg ES, Cooper HLF, et al. Racial differences in the validity of self-reported drug use among men who have sex with men in Atlanta, GA. Drug Alcohol Depend. 2014;138: 146–153.
[54] American Civil Liberties Union. Report: the war on marijuana in black and white. 2013. [cited 17 March 2020]. Available from: https://www.aclu.org/report/report-war-marijuana-black-and-white.
[55] Hamby T, Taylor W. Survey satisficing inflates reliability and validity measures: an experimental comparison of college and amazon mechanical Turk samples. Educ Psychol Meas. 2016;76(6):912–932.
[56] Tourangeau R, Rips LJ, Rasinski K. The psychology of survey response. 6th ed. New York, NY: Cambridge University Press; 2006.
[57] Taylor M, Lees R, Henderson G, et al. Comparison of cannabinoids in hair with self-reported cannabis consumption in heavy, light and non-cannabis users. Drug Alcohol Rev. 2017;36(2):220–226.
[58] Richeval C, Allorge D, Vanhoye X, et al. LSD detection and interpretation in hair. Curr Pharm Des. 2017;23(36):5496–5501.
[59] Norwood MS, Hughes JP, Amico KR. The validity of self-reported behaviors: methods for estimating underreporting of risk behaviors. Ann Epidemiol. 2016;26(9):612–618.e2.