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**A Multivariable Analysis Delineating Hair Color, Hair Dyeing, and Hat Wearing as Predictors of
Level of Cocaine and MDMA Detection in Human Hair Samples**

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Abstract

Research suggests that hair color, hair dyeing, and perspiration can bias hair test results regarding drug exposure, but research is needed to examine such associations in a multivariable manner. In this epidemiology study, adults were surveyed entering nightclubs and dance festivals in New York City, and 328 provided hair samples which were analyzed using ultra-high-performance liquid chromatography–tandem mass spectrometry to determine level of detection of cocaine and 3,4-methylenedioxymethamphetamine (MDMA). Reporting use was not an inclusion criterion for analysis. We used two-part multivariable models to delineate associations of hair color, past-year hair dyeing, and frequency of past-month hat wearing (which may increase perspiration) in relation to any vs. no detection of cocaine and MDMA as well as level of detection, controlling for hair length, self-reported past-year cocaine/ecstasy/MDMA use, and age, sex, and race/ethnicity. Those reporting having dyed their hair were at increased odds of having any level of cocaine detected (adjusted odds ratio [aOR]=3.75, 95% CI confidence interval [CI]: 1.85-6.70), and compared to those with brown hair, those with blond(e) hair on average had lower levels of cocaine (ng/mg) detected (beta=-7.97, p=0.025). Those reporting having dyed their hair were at increased odds for having any level of MDMA detected (aOR=3.05, 95% CI: 1.44-6.48), and compared to those who reported never wearing a hat, those who reported wearing a hat daily or almost daily on average had lower levels of MDMA (ng/mg) detected (beta=-6.61, p=0.025). This study demonstrates the importance for use of multivariable models to delineate predictors of drug detection.

Keywords: cocaine; MDMA; hair testing; hair color

1. Introduction

Hair testing has become a valuable addition to drug use epidemiology studies in that it allows for detection of underreported use on surveys.¹⁻³ Hair testing is particularly valuable in such studies, especially when outdoor point-of-recruitment biospecimen collection is conducted. While hair testing can allow us to test for drug use months post-exposure, there are factors such as hair color, dyed hair, and amount one perspires, which can affect our ability to detect level of drug exposure.⁴

Many previous studies have examined hair color bias with respect to drug testing hair samples. While some studies have not detected differences in uptake of cocaine or other drugs according to hair color,^{5,6} various studies (with both between and within subject designs) have determined that darker hair tends to contain higher levels of cocaine and amphetamines than lighter, less pigmented hair.⁶⁻¹³ It is also possible that darker hair better retains level of drug exposure over time compared to lighter hair colors.¹² Relatedly, results of older studies have suggested that this leads to increased probability of detection of cocaine use among people of color,^{11,14} although other studies have not detected such race differences.^{6,15} Hair color effects may occur because eumelanin (melanin) content tends to be highest in darker hair¹⁶ and this can facilitate drug binding. However, since binding to melanin may only account for a small part in the complex process of drug accumulation, hair color may have only minimal effects in differences in drug detection.¹⁷

Cosmetic treatments such as hair dyeing can also affect drug detection in hair. Most studies focusing on effects of such treatments have found that dyeing and particularly decoloring (e.g., bleaching) one's hair tends to reduce the amount of drugs such as cocaine,

amphetamine, and 3,4-methylenedioxymethamphetamine (MDMA) detected in hair samples.^{11,18-22} Although one study found that amphetamines, particularly MDMA, tend to be more highly detected in dyed or bleached hair.²³ Given mixed results of past studies, continued research on the potential effects of both natural hair color and of dyed hair are needed.

Perspiration (e.g., sweating) is another possible important factor that can bias hair test results because drugs can be incorporated into hair through sweat and sebum.^{4,24,25} As such, excessive sweating can lead to higher levels of drug detection via external contamination. Further, sweating has been found to spread MDMA to older regions of hair.²⁶ Given that MDMA use in particular is prevalent among people who attend dance parties (where individuals often engage in high-intensity dancing in hot spaces),^{27,28} increased sweating may affect levels of such drugs in the hair. We further theorize that high frequency of hat wearing may also affect detection in a similar manner through excessive perspiration of the head.⁴ Although, while sweat may increase drug detection in hair (e.g., through external contamination), related hygienic practices such as frequent hair washing (e.g., shampooing) has been found to be linked to lower levels of detection of cocaine and amphetamines in hair.^{19,22} However, with respect to external contamination from sweat, it should be noted that laboratory washing procedures before hair analysis are not always successful in removing external contamination from sweat/perspiration if absorbed into the hair^{4,29} (or from other sources such as exposure to vapor³⁰). As such, excessive perspiration remains viewed as a complicated factor requiring more research.

Continued studies are needed to examine these factors in relation to our ability to accurately detect 1) any drug exposure, and 2) level of drug exposure. Many previous analyses

have relied on small sample sizes, and many have only focused on people reporting drug use. Further, many studies have utilized parametric statistical tests (e.g., t-test, ANOVA) despite highly skewed distributions which violate the assumptions of such tests.³¹ In addition, most studies have largely relied on bivariable statistical tests and have not utilized multivariable models which adjust for potential confounding factors. For example, some studies have found age, sex, and racial/ethnic differences in level of drug detection,^{11,32} so it is important to control for such factors when possible. This study focuses on both self-report and biospecimen analysis from data collected from a large-scale epidemiology study with an aim to detect underreporting of drug use. In this analysis, we focus on hair color, hair dyeing, and frequency of hat wearing as predictors of any detection of cocaine and MDMA as well as level of detection.

2. Materials and Methods

2.1. Study Sample

Participants were recruited from a drug use epidemiology study in New York City. Adults (age ≥ 18) were surveyed before they entered randomly selected nightclubs and dance festivals. They were administered an anonymous survey asking about past-year use of various drugs including cocaine and ecstasy/MDMA/Molly. Molly was included as this is the name of a prevalent powder (or crystalline) form of ecstasy in the US.³³ The survey also asked about demographic characteristics, and it asked whether participants were willing to provide an anonymous hair sample to be analyzed at a later date. Reporting use was not an inclusion criterion for providing a hair sample or for hair analysis. Those checking that they were interested in providing a hair sample were further asked by the survey about their natural and

current hair color, whether they have dyed their hair in the past year (and if so, what color), and they were asked about their frequency of hat wearing in the past month. A total of 1,953 participants were surveyed between 2019 and 2022, 486 (24.9%) provided a hair sample, and of these, 328 samples were large enough to analyze (67.5% of samples submitted). Hair analysis was conducted in March 2023. All methods were approved by the first author's institutional review board (ethnics committee).

2.2. *Collection of Specimens*

When a participant agreed to provide a hair sample, using clean scissors, study staff cut a lock of hair as close to the participant's scalp as possible. Short hair (e.g., <2cm) did not preclude hair submission eligibility and hair was analyzed in its full length up to 12 cm, which roughly corresponds to a 12-month period. Among those providing analyzable samples, most provided head hair (n=314, 95.7%), nine (2.7%) provided armpit hair, two (0.6%) provided chest hair, two provided beard hair (0.6%), and one provided leg hair (0.3%). Hair samples were folded into a small sheet of tin foil and sealed in an envelope labeled with the participant's study ID number which was later linked to the participant's survey data. Hair samples were stored in a locked drawer at room temperature until shipped to the toxicology lab for analysis.

2.3. *Reagents and Standards*

All chemicals, including methanol, formic acid, and acetonitrile, were purchased from Sigma-Aldrich (Milan, Italy) while ultra-pure water was obtained using a Milli-Q® UF-Plus apparatus (Millipore, Bedford, MA, USA).

2.4. *Sample Preparation*

Hair samples were treated with a procedure developed on-purpose for the keratin matrix. About 50 mg of hair was decontaminated by an initial wash with 1-mL dichloromethane, followed by a second wash with 1-mL methanol, each performed under 3 min of stirring. The dried hair was pulverized using six steel balls stirring in a Precellys® homogenizer. The pulverized samples were extracted by keeping them immersed in 0.5-mL methanol added with 2.5 µL of an internal standards mixture (final concentration of 0.01 ng/mg) at $+55 \pm 5^\circ\text{C}$ for 15 h. Lastly, the organic phase was collected and an aliquot of 5 µL was directly injected into the ultra-high-performance liquid chromatography (UHPLC) system.

2.5. *Instrumentation*

We used a targeted screening using published methods.^{34,35} The procedure is described as follows. Ultra-high-performance liquid chromatography (UHPLC) separation was performed via the SCIEX ExionLC™ AC system (Sciex, Darmstadt, Germany) using a Phenomenex Kinetex C18 column (100 x 2.1 mm, 1.7 µm) maintained at 45°C. The mobile phase was a mixture of water (A) and acetonitrile (B), both with formic acid 5 mM. The LC flow rate was set at 0.5 mL/min and the mobile phase eluted under the following linear gradient conditions: (A:B, v:v) isocratic elution at 97:3 for 0.5 min, from 97:3 to 30:70 in 3.5 min, isocratic elution at 30:70 for 0.5 min and final re-equilibration for 2.0 min to the initial condition. The total run time for each sample was 6.5 min. Mass spectrometry acquisition was performed with an API 5500 triple quadrupole mass spectrometer (Applied Biosystem/Sciex, Darmstadt, Germany) equipped with an electrospray Turbo Ion source operating in positive-ion mode. The mass analyzers were

operated in the selected reaction monitoring (SRM) mode. In order to establish appropriate SRM conditions, optimization of the mass spectrometer was conducted by direct infusion of the analytes into the electrospray ionization capillary and the declustering potential (DP) was adjusted to maximize the intensity of the protonated molecular species. The ESI source was held at 550 ° C.

We deemed any detection based on the lower limit of quantitation (LLOQ) in this analysis for two reasons. First, this was done because a main focus of the parent study was unintentional exposure to various drugs as contaminants or adulterants, and unintentional exposures can lead to very small amounts of exposure. Second, since we focused on exposure in relation to hair color, hair dyeing, and hat wearing, we believe it is important to focus on drug incorporation in general, regardless of whether this resulted from intake or contamination.

2.6. *Statistical Analysis*

Univariable statistics were first computed to examine the distribution of detected level of cocaine and MDMA exposure. We described the distributions of cocaine and MDMA detection overall, and by each level of each independent variable of interest—hair color, hair dyeing, frequency of hat wearing, and self-reported past-year use. It should be noted that for hair color, we used a recoded variable based on participant self-reported natural hair color, current hair color (if dyed), and analyst interpretation of hair color. As such, in our final variable for the main analysis, if a participant (for example) reported a natural hair color of brown that was dyed blond(e), hair color was coded as blond(e). However, given that overall hair color (especially if dyed) does not always best represent the color of the hair sample submitted, in the

last third of samples collected (in 2021-2022), if the analyst determined the hair sample to be a different color (e.g., brown, and not blond[e]), then the sample was coded as being brown. As described below, we also conducted sensitivity tests in which we used the variables based only on self-reported hair color without the analyst's correction.

Figure 1 presents a breakdown of our bivariable and multivariable models. We examined bivariable associations via a set of different tests. First, using chi-square, we determined whether there were differences in categories within each independent variable according to whether the participant tested positive or negative for any exposure. We then compared distributions of detection for each independent variable. Given the highly positively skewed distributions, we used nonparametric statistics to test for potential bivariable differences in exposure. Specifically, we used Kruskal-Wallis tests for comparisons of variables with 3-4 categories and Mann-Whitney-Wilcoxon tests for comparisons of variables with two categories. These tests are robust to highly skewed distributions (which violate the assumptions of common parametric tests like t-test and analysis of variance). These tests were first computed focusing only on distributions among positive cases, and then these tests were repeated for all cases (including 0s for non-detection). To further visualize distributions, we created kernel density plots focusing on cases testing positive using data transformed via a common logarithm (\log_{10}). Finally, to examine independent variables in a multivariable manner, we used two-part models that accounted for a large number of 0s, and a highly positively skewed continuous distribution.³⁶ Two-part models generate three outputs with the first representing a logistic regression model (which generates adjusted odds ratios [aORs] of any detection vs. no detection). The second part focuses on the distribution among positive cases (thus, it is

conditional on any detection); in this study, we deemed a linear model (a Gaussian model with identity link) to be adequate for this part. Finally, the model produces a margins output combining differences in detection (any vs. none) with differences in level of exposure. We computed a separate model for cocaine exposure and for MDMA exposure with each controlling for participant age, sex, race/ethnicity, and hair length. To prevent casewise deletion of participants with missing data, for variables with missing data we included missing data indicators.³⁷ We also conducted sensitivity tests in which we included uncorrected hair color (based solely on participant self-report) in the multivariable models and sensitivity tests also tested model results excluding participants who provided hair from a body part other than the head. All statistics were computed using Stata 17 SE³⁸ and graphics were constructed using R 4.2.2 software.³⁹

3. Results

As shown in Table 1, the majority of the sample identified as male (52.4%) and white (51.8%), and 46.7% reported past-year cocaine use and 43.0% reported past-year ecstasy/MDMA use. The majority of participants had brown hair (57.8%) and did not report having dyed their hair in the past year (82.9%). The distributions of cocaine and MDMA detection in the full sample (regardless of any detection) were both highly positively skewed (skewness >7.5). The mean level of cocaine detection was 5.2 ± 21.0 ng/mg (median = 0.2, range = 0.0–230.0) and the mean level of MDMA detection was 2.0 ± 9.0 ng/mg (median = 0.0, range = 0.0–118.0). When focusing specifically on cases testing positive, the mean level of

cocaine detection was 8.4 ± 26.3 ng/mg (median = 0.9, range = 0.05–230.0) and the mean level of MDMA detection was 6.0 ± 14.8 ng/mg (median = 1.5, range = 0.03–118.0).

Comparisons of cocaine and MDMA exposure by each independent variable are presented in Table 2. Those who dyed their hair were more likely to have any cocaine detected in their hair (31.9% vs. 18.5%, $p=0.012$), and a similar difference emerged regarding MDMA which approached significance (34.0% vs. 23.5%, $p=0.052$). Further, those reporting cocaine use were more likely to test positive for any cocaine exposure (60.6% vs. 24.0%, $p<0.001$) and those reporting ecstasy use were more likely to test positive for MDMA exposure (80.2% vs. 24.0%, $p<0.001$). Despite some visibly large differences in means (particularly with respect to level of cocaine detection), our nonparametric tests which compared medians within distributions did not yield significant differences regarding hair color, hair dyeing, or hat wearing frequency. However, level of detection of cocaine and MDMA were significantly higher among participants reporting past-year use in tests focusing only on positive cases ($p<0.05$) and when focusing on all cases (including 0s; $p<0.001$). Figure 2 presents distributions of level of detection (transformed) among cases testing positive.

Results of our multivariable models are presented in Table 3. With respect to cocaine detection, those reporting having dyed their hair in the past year were at increased odds for having any level of cocaine detected (aOR=3.75, 95% confidence interval [CI]: 1.85-6.70, $p<0.001$), and those reporting past-year cocaine use were also at higher odds for any detection (aOR=7.36, 95% CI: 4.11-13.18, $p<0.001$). Regarding predictors of level of detection (among cases testing positive), compared to those with brown hair, those with blond(e) hair on average had about an 8 ng/mg decrease in detection (beta [b]=-7.97, standard error [SE]=3.56, $p=0.025$),

and those reporting past-year cocaine use on average had over 7 ng/mg detected compared to those not reporting use ($b=7.44$, $SE=3.58$, $p=0.038$). With regard to the combination of any detection and level of detection, results were similar with blond(e) participants tending to have lower levels of detection ($b=-5.02$, $SE=2.11$, $p=0.017$) and those reporting cocaine use tending to have higher levels of detected cocaine exposure ($b=6.94$, $SE=2.35$, $p=0.003$).

With respect to predictors of level of ecstasy detection (Table 3 continued), those reporting having dyed their hair in the past year were at increased odds for having any level of MDMA detected (aOR=3.05, 95% CI: 1.44-6.48, $p=0.004$), and those reporting past-year ecstasy use were also at higher odds for any detection (aOR=15.51, 95% CI: 8.44-28.50, $p<0.001$). Regarding predictors of level of detection (among cases testing positive), compared to those who reported never wearing a hat, those who reported wearing a hat daily or almost daily on average had lower levels (of about 6 ng/mg less than those with brown hair) detected ($b=-6.61$, $SE=2.94$, $p=0.025$). With regard to the combination of any detection and level of detection, results were similar with those wearing a hat daily or almost daily on average having lower levels of detection ($b=-2.26$, $SE=1.01$, $p=0.026$) and for those reporting ecstasy use tending to have higher levels of detected MDMA exposure ($b=3.43$, $SE=1.01$, $p<0.001$).

With respect to the sensitivity tests conducted in which we used the uncorrected hair color variable based solely on self-report, both cocaine and MDMA multivariable models yielded similar results with all of the same predictors significant and in the same direction. In addition, models not including participants who provided a hair sample from a body part other than the head also yielded similar results.

4. Discussion

While hair testing has become a valuable addition to drug epidemiology studies as it allows us to test for drug use months post-exposure, research suggests that there are factors such as hair color, dyed hair, and amount one perspires, which can affect our ability to detect level of drug exposure.⁴ We investigated these factors in this study using multivariable models to help address potential demographic confounds.

A main finding was that compared to participants with brown hair, those with blond(e) hair tended to have lower detectable levels of cocaine exposure. Hair color was not related to detection of any exposure vs. no exposure, suggesting that while hair color does not appear to affect whether someone who was exposed may test positive or negative, those with blond(e) hair typically have lower detectable levels. In fact, the mean level of cocaine detected among those who were blond(e) was less than a third of the level detected in brown hair. While it is certainly possible that blond(e) individuals simply used less cocaine (a limitation of this between subject design), we did control for various factors including hair length to help address potential confounding. However, many previous studies (with both between and within subject designs) have determined that darker hair tends to contain higher levels of cocaine (and amphetamines) than less pigmented hair.⁶⁻¹³ Indeed, effects of hair color may be deemed minimal¹⁷ considering that color did not affect any overall detection vs. no detection, but in some cases of minimal exposure, hair color may in fact make a difference between positive vs. negative detection, especially when standard detection cutoffs are utilized.^{40,41}

With respect to hair dyeing, unlike some other studies that have detected lower levels of cocaine, amphetamine, and MDMA among those with dyed hair,^{11,18-22} we did not find that dyed

hair was significantly related to level of cocaine and MDMA detection with all else being equal. Although bivariable differences in distribution did not yield significance, it may be noteworthy that those who dyed their hair had levels of cocaine detection on average three times lower than those who did not dye their hair. Further, we did estimate that those having dyed their hair in the past year were at more than three times the odds of testing positive overall for any exposure to cocaine or MDMA. While it is unknown why hair dyeing was associated with increased odds of overall (any) detection, the lower (although non-significant) levels of detection build upon previous findings which have demonstrated that cosmetic treatments like bleaching or dyeing may damage the cuticle or decompose incorporated drugs, leading to a decrease of drug hair content.^{42,43} Results of one study suggest that hair samples contaminated after dyeing and bleaching treatments retain a higher amount of cocaine.⁴² Since these treatments are generally water-based, it is likely that water can open the cuticles making hair more sensitive to incorporation. Other studies have found that amphetamines, particularly MDMA, tend to be more highly detected in dyed or bleached hair,²³ but more research is needed to further investigate the potential nuance regarding effects of hair dye on any detection vs. level of detection with respect to use of various stimulants.

In this study, we queried frequency of hat wearing as a possible indicator of sweating. We focused on this because excessive hat wearing can increase perspiration and can become a source of self-contamination.⁴ Importantly, laboratory washing procedures are not always successful in removing such external contamination from sweat/perspiration if absorbed into the hair.^{4,29} Results from our multivariable model suggest that compared to those who never wear a hat, those who wear a hat daily or almost daily tend to have lower levels of MDMA

detected in their hair. Although, hygienic practices such as washing and shampooing can indeed lower levels of detection of various amphetamines in hair.^{19,22} It is possible that excessive sweating helped some participants to “sweat out” the MDMA, assuming frequent hygienic practices (e.g., showering). MDMA use in particular has been linked to bouts of (sometimes profuse) sweating,⁴⁴ but more investigation into the cause is needed. Given that to our knowledge this is among the first studies to query level of hat-wearing, we believe these findings can inform future studies. More research is not only needed to determine the effects of excessive sweating in non-laboratory settings, but more information is needed regarding how often and to what extent people sweat. With respect to hat-wearing specifically, more information is needed on hat type(s) worn, when they are worn (e.g., time of day, season), and whether and to what extent participants report noticing sweat while wearing them.

Finally, those reporting past-year use of cocaine and ecstasy/MDMA tended to have any detection as well as higher levels of the drug detected for cocaine and MDMA, respectively. This may not be a fully surprising result, but nonetheless it is an important result because individuals in nightclub scenes are often unknowingly exposed to adulterants or contaminants present in other drugs. Other individuals simply deny known use on surveys. In fact, a recent study comparing self-reported use and hair test results in this population found that when compared to self-report on its own, prevalence based on self-report plus hair test results were 28.8% and 14.9% higher for cocaine and ecstasy/MDMA, respectively.³ We cannot deduce whether underreported use in particular is due to unknown exposure (e.g., cocaine as an adulterant in drugs like ecstasy or ketamine), but we believe it is important to monitor both self-report and drug detection to inform prevention and harm reduction.

4.1. *Limitations*

Unlike many of such studies conducted in clinical or laboratory settings, this was an epidemiology study in which people were surveyed entering dance venues at the point of recruitment. As such, much of the study was conducted in a somewhat uncontrolled environment. We largely relied on self-reported hair color on the survey, but self-report is not always accurate, at least with regard to the small portion of hair provided to study staff. For example, if someone has natural brown hair and dyes his or her hair blond(e), this does not necessarily mean that the sample (or the full sample) provided was indeed (fully) blond(e). A between subject design could have better deduced differences in hair colors within the same participants. Frequency of hat wearing was used as an indicator of possible excessive sweating, but there are plenty of other factors that can lead to excessive sweating—factors related to both lifestyle and season. Hair was analyzed in its full length, but segmental analysis focusing on smaller, more specific timepoints could likely have provided more specific information regarding exposure and how our variables of interest affected detection. We considered any detection (based on the LLOQ) as positive, rather than detection above specified cutoffs. Relatedly, we did not consider benzoylecgonine detection a criterion for very low levels of cocaine detection. As such, external contamination was possible in some cases. Given these limitations, these results should be viewed largely as being correlational.

5. **Conclusions**

Results add to previous findings that hair color, hair dyeing, and perspiration can affect any detection and level of detection of cocaine and MDMA in hair samples. To our knowledge,

this is among the first studies to focus on a large epidemiology study to examine such associations and to utilize more advanced multivariable modeling to delineate results of predictors. Many previous studies have not been large and have examined such factors individually—in a bivariable manner. Given that these factors have complex associations with our ability to detect drug exposure, we believe that it is important to not only consider multiple concepts within the same models but to also control for potential confounding variables such as demographic characteristics. This epidemiology study helped add much needed nuance to previous studies which were largely based on research conducted solely in clinics and laboratories, although continued research—particularly research controlling for potential confounding factors—is needed.

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Predictors

- Hair Color
- Dyed Hair
- Hat-wearing
- Reported Past Year Use

Control Variables

- Hair Length
- Age
- Sex
- Race

Bivariable Tests (predictors one at a time, no control variables)

MDMA

- Any Detection
- Level of Detection (Full Sample)
- Level of Detection (Only Positive Cases)

Cocaine

- Any Detection
- Level of Detection (Full Sample)
- Level of Detection (Only Positive Cases)

Multivariable Models (all predictors and control variables together)

MDMA

- Any Detection
- Level of Detection (Full Sample)
- Combined Any Detection & Level of Detection

Cocaine

- Any Detection
- Level of Detection (Full Sample)
- Combined Any Detection & Level of Detection

Figure 1 Breakdown of bivariable and multivariable models.

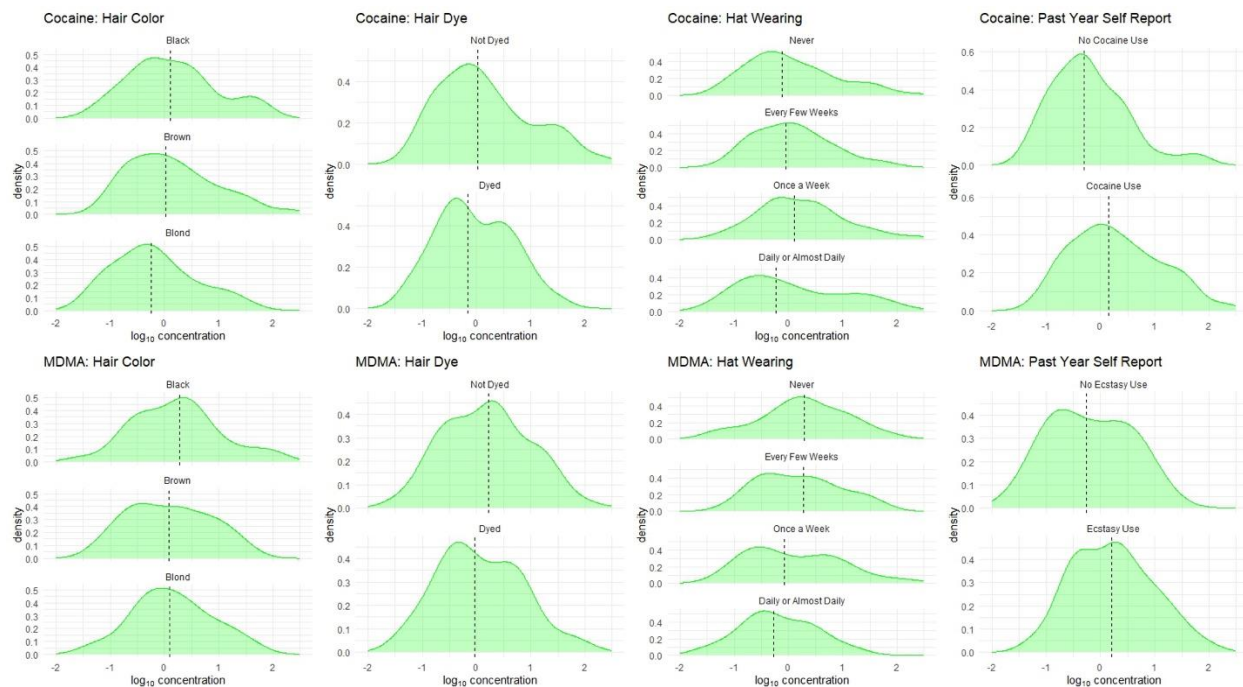


Figure 2 Distributions of the level of detection (transformed) among cases testing positive for cocaine and MDMA.

Table 1. Sample characteristics (n=328)

	n (%)
Age, years (mean \pm SD)	26.1 \pm 5.9
Sex	
Male	172 (52.4)
Female	156 (47.6)
Race/Ethnicity	
White	170 (51.8)
Black	15 (4.6)
Hispanic	70 (21.3)
Asian	39 (11.9)
Mixed/Other	34 (10.4)
Self-Reported Past Year Cocaine Use	
No	175 (53.4)
Yes	153 (46.7)
Self-Reported Past Year Ecstasy Use	
No	187 (57.0)
Yes	141 (43.0)
Current Hair Color	
Brown	180 (57.8)
Black	84 (26.9)
Blond(e)	48 (15.4)
Dyed Hair in Past Year	
No	218 (82.9)
Yes	81 (27.1)
Past-Month Hat Wearing Frequency	
Never	96 (32.1)
About Once Every Few Weeks	92 (30.8)
About Once a Week	55 (18.4)
Daily or Almost Daily	56 (18.7)

Note. SD = standard deviation. Percentages for hair color, hair dyeing, and hat wearing reflect case-complete data; these variables were missing 4.9% (n=16), 8.8% (n=29), and 8.8% (n=29) of data, respectively.

Table 2. Bivariable comparisons of any detection and level of detection of cocaine and ecstasy exposure according to hair color, and past-year use of hair dye, hat wearing, and use of cocaine and ecstasy

	Any Cocaine Detection			Cocaine (ng/mg) – Only Positive Cases			Cocaine (ng/mg) – All Cases		
	No, n (%)	Yes, n (%)	p	Mean ± SD	Median (range)	p	Mean ± SD	Median (range)	p
Hair Color			0.706			0.163			0.678
Brown	71 (60.7)	109 (55.9)		10.8 ± 33.7	1.1 (0.5 – 230.0)		6.5 ± 26.7	0.2 (0.0 – 230.0)	
Black	29 (24.8)	55 (28.2)		6.6 ± 14.9	0.9 (0.5 – 70.8)		4.4 ± 12.4	0.4 (0.0 – 70.8)	
Blond(e)	17 (14.5)	31 (15.9)		3.0 ± 6.1	0.6 (0.5 – 28.3)		1.9 ± 5.1	0.2 (0.0 – 28.3)	
Dyed Hair in Past Year			0.012			0.224			0.144
No	88 (81.5)	130 (68.1)		11.1 ± 32.0	1.0 (0.5 – 230.0)		6.6 ± 25.3	0.2 (0.0 – 230.0)	
Yes	20 (18.5)	61 (31.9)		2.9 ± 5.6	0.7 (0.5 – 30.2)		2.2 ± 5.0	0.5 (0.0 – 30.2)	
Past-Year Hat Wearing			0.159			0.574			0.233
Never	28 (25.9)	68 (35.6)		8.0 ± 26.7	0.8 (0.6 – 207.0)		5.7 ± 22.7	0.4 (0.0 – 207.0)	
Every Few Weeks	41 (38.0)	51 (26.7)		4.9 ± 12.0	0.9 (0.6 – 70.8)		2.7 ± 9.2	0.2 (0.0 – 70.8)	
Once a Week	18 (16.7)	37 (19.4)		11.7 ± 38.7	1.3 (0.5 – 230.0)		7.9 ± 32.1	0.5 (0.0 – 230.0)	
Daily/Almost Daily	21 (19.4)	35 (18.3)		11.2 ± 28.0	0.6 (0.5 – 155.0)		7.0 ± 22.7	0.2 (0.0 – 155.0)	
Reported Past-Year Cocaine Use			<0.001			<0.001			<0.001
No	95 (76.0)	80 (39.4)		3.6 ± 11.8	0.5 (0.5 – 70.8)		1.7 ± 8.2	0.0 (0.0 – 70.8)	
Yes	30 (24.0)	123 (60.6)		11.4 ± 32.0	1.4 (0.6 – 230.0)		9.2 ± 29.1	0.9 (0.0 – 230.0)	
	Any MDMA Detection			MDMA (ng/mg) – Only Positive Cases			MDMA (ng/mg) – All Cases		
	No, n (%)	Yes, n (%)	p	Mean ± SD	Median (range)	p	Mean ± SD	Median (range)	p
Hair Color			0.458			0.975			0.490
Brown	120 (58.5)	60 (56.1)		4.2 ± 6.1	1.7 (0.1 – 26.2)		1.4 ± 4.0	0.0 (0.0 – 26.2)	
Black	51 (24.9)	33 (30.8)		9.5 ± 24.3	1.4 (0.0 – 118.0)		3.7 ± 15.8	0.0 (0.0 – 118.0)	
Blond(e)	34 (16.6)	14 (13.1)		7.2 ± 12.9	1.7 (0.1 – 40.0)		2.1 ± 7.5	0.0 (0.0 – 40.0)	
Dyed Hair in Past Year			0.052			0.495			0.090
No	150 (76.5)	68 (66.0)		6.8 ± 16.1	1.7 (0.0 – 118.0)		2.1 ± 9.5	0.0 (0.0 – 118.0)	
Yes	46 (23.5)	35 (34.0)		5.5 ± 13.8	0.9 (0.1 – 74.0)		2.4 ± 9.4	0.0 (0.0 – 74.0)	
Past-Year Hat Wearing			0.682			0.232			0.527
Never	60 (30.6)	36 (35.0)		7.3 ± 14.3	2.0 (0.1 – 74.0)		2.7 ± 9.4	0.0 (0.0 – 74.0)	
Every Few Weeks	63 (32.1)	29 (28.2)		5.9 ± 10.2	1.9 (0.1 – 40.0)		1.9 ± 6.3	0.0 (0.0 – 40.0)	
Once a Week	34 (17.4)	21 (20.4)		8.8 ± 25.6	0.9 (0.1 – 118.0)		3.4 ± 16.2	0.0 (0.0 – 118.0)	
Daily/Almost Daily	39 (19.9)	17 (16.5)		2.0 ± 3.7	0.5 (0.0 – 15.3)		0.6 ± 2.2	0.0 (0.0 – 15.3)	
Reported Past-Year Ecstasy Use			<0.001			0.027			<0.001
No	165 (76.0)	22 (19.8)		2.2 ± 3.5	0.5 (0.0 – 15.3)		0.3 ± 1.4	0.0 (0.0 – 15.3)	
Yes	52 (24.0)	89 (80.2)		7.0 ± 16.3	1.6 (0.1 -118.0)		4.4 ± 13.4	0.0 (0.0 -118.0)	

Note. Any detection means that any level was detected based on the lower limit of quantification. MDMA = 3,4-methylenedioxymethamphetamine; SD = standard deviation.

Table 3. Multivariable correlates of level of detected cocaine and ecstasy exposure based on two-part models.

	Level of Cocaine Detection (ng/mg)			Level of MDMA Detection (ng/mg)		
	Logit Model	GLM Model	Combined	Logit Model	GLM Model	Combined
	aOR (95% CI)	b (SE)	b (SE)	aOR (95% CI)	b (SE)	b (SE)
Hair Color						
Brown	Ref	Ref	Ref	Ref	Ref	Ref
Black	1.58 (0.81-3.05)	-5.84 (4.15)	-3.32 (2.74)	0.95 (0.48-1.91)	4.03 (3.50)	1.37 (1.26)
Blond(e)	0.67 (0.30-1.47)	-7.97 (3.56) ^a	-5.02 (2.11) ^a	0.67 (0.28-1.57)	4.24 (3.68)	1.06 (1.19)
Dyed Hair in Past Year						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	3.75 (1.85-6.70) ^c	-5.10 (4.05)	-5.01 (2.11)	3.05 (1.44-6.48) ^b	3.04 (4.18)	1.97 (1.66)
Past-Year Hat Wearing						
Never	Ref	Ref	Ref	Ref	Ref	Ref
Every Few Weeks	0.55 (0.28-1.11)	-1.47 (3.40)	-1.37 (2.13)	0.71 (0.35-1.44)	-1.66 (2.84)	-0.79 (0.94)
Once a Week	1.46 (0.63-3.34)	7.21 (8.00)	5.48 (5.69)	1.60 (0.65-3.98)	0.83 (4.71)	0.74 (1.91)
Daily/Almost Daily	0.50 (0.22-1.15)	2.84 (4.84)	0.84 (2.76)	0.94 (0.37-2.35)	-6.61 (2.94) ^a	-2.26 (1.01) ^a
Reported Past-Year Use						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	7.36 (4.11-13.18) ^c	7.44 (3.58) ^a	6.94 (2.35) ^b	15.51 (8.44-28.50) ^c	4.83 (2.66)	3.43 (1.01) ^c

Note. Any detection means that any level was detected based on the lower limit of quantification. GLM = generalized linear model; MDMA = 3,4-methylenedioxymethamphetamine; aOR = adjusted odds ratio; CI = confidence interval; b = beta; SE = standard error. Reported past-year use refers to past-year cocaine use in the cocaine model and past-year ecstasy/MDMA use in the MDMA model. ^a p < 0.05, ^b p < 0.01, ^c p < 0.001.

Figure 1. Breakdown of bivariable and multivariable models.

Figure 2. Distributions of level of detection (transformed) among cases testing positive for cocaine and MDMA.