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Drug testing after use: what insights can be gained from a harm reduction perspective on visitors of the drugs information and monitoring system (DIMS) in the Netherlands?

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Abstract

Background Interventions aimed to mitigate drug-related harm include drug checking, which invloves a chemical analysis of a drug sample alongside personalized harm reduction advise. The Drug Information and Monitoring System (DIMS) represents a network of Drug Checking Services (DCS) in the Netherlands, which people who use drugs (PWUD) may visit before consumption, though not consistently. This paper describes the characteristics and experienced effects of PWUD who have their drugs tested after use, in relation to the analysis results of the submitted drug sample and the setting of use.

Methods Data was collected between 2018 until 2022 encompassing a range of characteristics provided by the visitors. Statistical analyses were performed to find associations between the type of effects the visitor experienced and the (mis)match with the expected content of the drug sample or setting in which the sample was used.

Results 14% ($N=9472$) of all samples submitted to DIMS ($N=66150$) were used prior to attending a DCS. The majority of samples were sold as ecstasy (41%, $N=3460$) and cocaine (17%, $N=1407$). Most visitors were male (75%, $N=6359$), purchased their drugs offline (96%, $N=8081$), and reported having used the sample at a party/festival (43%, $N=3614$), while 27% ($N=2320$) used it in a home setting. Half of the visitors (49%, $N=4109$) declared not having used the sample in combination with other psychoactive substances. Positive mental effects were less likely to be experienced when the detected drug content did not match the expected content, while negative mental effects were more likely. Moreover, visitors consuming their sample at a party/festival were more likely to experience positive

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mental and physical effects and less likely to experience negative mental and physical effects compared to people consuming their sample at home.

Conclusions By identifying the characteristics of PWUD who have their drugs tested after use and by demonstrating that not only a (mis)match with the expected drug content, but also the setting in which the substance was used was associated with the drug experience, improved strategies can be developed to encourage individuals to visit a DCS before consumption, thereby reducing drug-related harm.

Keywords Drug checking service, Drug information and monitoring system, Harm reduction, People who use drugs, Setting, Mental effects, Physical effects, Preventive strategies

Introduction

In 2022, nearly 292 million people worldwide had used an illicit drug in the past year. Among them, the most used synthetic drug was cocaine (23.5 million), followed by ecstasy (20 million). In both cases, men were the most represented group [1].

The use of illicit drugs such as cocaine is associated with several acute and long-term health risks and has a serious impact on both an individual as well as societal level [2]. Over the years, various preventive strategies have been developed to reduce drug-related harm with a range of objectives. These strategies include disseminating information about drug market developments to a wide audience, as well as delivering targeted messages and warnings to people who use drugs (PWUD) about the risks associated with the substances they use. Especially, a more personalized harm reduction approach, such as drug checking, may increase the awareness about the health risks associated with the specific drugs that are used [3]. Drug checking is a harm reduction strategy that involves chemically analyzing drug samples submitted by PWUD and providing the test results directly to the service user, along with personalized harm reduction advise, without judgement regarding their decision to consume drugs. The aim is to encourage individuals to make more informed decisions and to reduce potential risks associated with drug use [4, 5]. An example is the Trans European Drug Information network (TEDI) project, which consists of a network of Drug Checking Services (DCS) that share the same goal and collaborate to improve strategies for reducing drug-related harm [6].

The Drug Information and Monitoring System (DIMS) in the Netherlands represents the oldest and largest still operational DCS in the world. DIMS was commissioned by the ministry of Health Welfare and Sports in 1992 to monitor the Dutch illicit drug market and to prevent serious adverse health effects associated with the exposure to extra hazardous substances [7]. Nowadays, DIMS consists of a network of 32 office-based DCS which are usually hosted by institutions for addiction care and drug prevention. To staff each location and to provide tailored harm reduction advise to PWUD, who would otherwise remain invisible for institutions for addiction care, DIMS is additionally funded by local municipalities [7]. According to Koning et al. [8], the typical visitors of a DIMS DCS are predominantly highly educated males in their twenties with no migration background, who visit a dance party or festival on a regular basis. This profile of the typical DCS visitor has also been confirmed by other similar studies [9, 10].

A key advantage of monitoring the illicit drug market through drug checking is that trends in drug markets and use can be identified, but also that results can be used by policy makers to develop more effective public health strategies aimed at reducing harm [7].

Moreover, there is growing evidence that the tailored harm reduction advise typically provided alongside the test results, influences behavioural intentions and actions of PWUD, especially when the analysis results provided by a DCS do not align with their expectations [11]. However, more in-depth research is necessary to understand these mechanisms [12].

To achieve the greatest health benefits, PWUD should visit a DCS and submit a drug sample before use. However, in some cases PWUD either never visit a DCS or choose to submit a drug sample for analysis after use on a particular occasion. The profile of the visitors and reasons to visit a DCS after use can vary as well as the experienced effects after consumption of a specific drug sample in a certain setting. Information gathered from this subset of visitors can be used to evaluate what substances were actually taken and what the experienced effects were under various circumstances among other characteristics.

The present study focuses on the data collected by DIMS over a five-year period (2018–2022) from PWUD who had their drug tested after use. The aim is to identify specific characteristics of PWUD who have their drugs tested after use, and to find out whether either a (mis) match with the expected content of the analysed drug sample or the setting in which the substance was used is associated with the outcome of the drug experience.

Table 1 Reasons for sample testing

First time drug use
First time use of this specific type of drug
Warned or asked to test by other people
Used to always test the substance
New dealer
Weird smell/colour/shape
Want to know what's in it
Experienced an unpleasant effect
Curious about test service
Last time disappointing result, now new sample
New pill/batch
Not Available

Materials and methods

Drug samples submitted to DIMS

Samples were submitted in person by PWUD to one of the 32 DCS of DIMS in a voluntary and anonymous way, with the aim to obtain details about their actual content. For this study, samples submitted to DIMS during 2018–2022 were considered.

Characteristics in relation to the submitted drug samples

Additional information related to the submitted drug sample was collected and registered using an online form during an in-person conversation (lasting about 10 min and following a structured format) between the visitor attending the DCS and a prevention worker.

The following data were used:

- *Whether the sample was already used*: YES/NO.
- *As what substance was the sample sold*: reported orally by the user.
- *Gender of the visitor*: Male/Female/Not Available. Visitors were not asked to declare to which gender they felt to belong but this was visually attributed by the prevention worker.
- *Origin of the sample*: Offline (i.e. the different Dutch provinces)/Online.
- *Setting of sample use*: The description of the setting of sample use was collected in an open text box (one or multiple settings of sample use could be described by the visitors). For data analysis, the responses were screened and clustered into the following categories: Party/Festival, Home, Nightlife (excluding parties and festivals) and Other. The "Other" category encompassed the least frequently selected options compared to the other categories, i.e. "Daily", "Everywhere", "Holiday", "For sex", "Squatter/Homeless", "Medication", "Sport", "Study/work", "Various" (this included visitors indicating multiple overlapping settings for substance use), "With friends" and "Not specified") and Not Available (NA).

Table 2 Pre-set list of self-reported mental and physical effects

Mental effects	Physical effects
Aggressive (N)	Dehydration and dry throat (N)
Alert (N)	Dizziness and faintness (N)
Anxious and paranoic (N)	Exhaustion and less energy (N)
Blissful/happy (P)	Headache (N)
Communicative and talkative (P)	Hyperthermia (N)
Cuddly and tender (P)	Itching (N)
Depressive (N)	Jaw clenching (N)
Dream images (P)	Lightness of arms and legs (N)
Excitement (P or N *)	More energy (P)
Nervous (N)	Muscle pain (N)
Peaceful and calm (P)	Nausea (N)
Psychotic (N)	Relaxation (P)
Tendency to take more (N)	Sweating (N)
Unpleasant hallucinations (N)	Tremors (N)
	Vomiting (N)

N = negative effect; P = positive effect * excitement was classified either P or N depending on whether the effect aligned with the type of substance used

- *Reasons for sample testing*: One single option from a pre-set list (Table 1) could be chosen by the visitors. For data analysis, the options, "Last time disappointing result, now new sample" and "New pill/batch" were considered as similar reasons for sample testing. The option "Curious about test service" was considered unrelated to whether a visitor would visit a DCS before or after consumption. For our analysis, these three categories were therefore grouped together under "Other".

- *Self-reported mental and physical effects*: visitors were asked to describe the mental and the physical effects they experienced after use of the submitted sample choosing among some options included in a pre-set list (Table 2). One or multiple options could be chosen by the visitors.

If visitors were not able to describe the experienced mental or physical effects by using the above-mentioned pre-set list, they could provide their own description about their mental and physical experiences. For this study, these specific descriptions were redefined in such a way that they would match the pre-set list.

All self-reported effects were divided into "Positive" and "Negative" effects (Table 2). For visitors who reported to have experienced both positive and negative effects, a third category "Mixed" effects was created. Visitors that declared not to have noticed any mental or physical effects following the use of the sample were attributed to the category "No effects noticed" and were not included in the data analysis about the self-reported effects.

- *Combination with other substances*: Data was collected about the possible use of samples in combination with other psychoactive substances (YES/NO), including alcohol/tobacco/medication. To avoid any bias potentially induced by the effects of other psychoactive substances, all analyses were conducted on data of which visitors reported that they did not use the sample in combination with other psychoactive substances ($n = 4109$).

(Mis)match between the detected content and expected content of the submitted drug sample

The content of the drug sample was analysed as previously described [13]. Briefly, a combination of laboratory analysis techniques, including gas chromatography–mass spectrometry (GC–MS) and liquid chromatography-diode array detection (LC-DAD), were used in order to identify all psychoactive compounds present, and for quantification of substances of which a reference standard was available, as well as the presence of adulterants, at varying sensitivities and specificities. When the detected psychoactive substances in the analyzed samples did not correspond to what the visitor expected to be present in the purchased sample, the sample was scored as a mismatch. The presence of any by-product or unknown substance in addition to the psychoactive substance present was not considered as a mismatch.

Statistical analysis

Descriptive statistics, expressed as percentage or absolute numbers, were used to report the obtained results. Statistical analysis was performed by using IBM SPSS® Statistics software, version 25 and MedCalc statistical software (online version, available at MedCalc Software Ltd. Odds ratio calculator. https://www.medcalc.org/calc/odds_ratio.php). Pearson's Chi-square tests were used to evaluate: [1] the association between the type of self-reported mental and physical effects (positive/negative/mixed) and either a match or mismatch with the actual drug content in relation to the expected drug content (yes/no) and [2] the association between the type of self-reported mental and physical effects (positive/negative/mixed) and the setting in which the substance was used (home/party-festival, being the most reported categories regarding the setting of substance use). When the Pearson's Chi-square tests were statistically signifiant, several Odds Ratio's (OR's) were calculated to evaluate: [1] whether visitors consuming a sample with a mismatch in drug content were more or less likely to have positive (versus negative and mixed) or negative (versus positive and mixed) mental or physical effects compared to visitors consuming a sample without a mismatch in drug content and [2] whether visitors consuming their sample at a party-festival were more or less likely to have positive (versus negative and mixed) or negative (versus positive and mixed) mental or physical effects compared to visitors consuming their sample at home. A two-tailed p-value < 0.05 was considered statistically significant.

Results

Amount and description of drug samples submitted to DIMS

In total, 66,150 drug samples have been submitted to DIMS between 2018 and 2022. A flowchart showing the initial total amount of drug samples registered and number of samples excluded from the analysis in the current study is provided in Fig. 1. 14% of the total samples submitted to DIMS ($N = 9472$) were already used before submission according to the visitor (Fig. 2A). Of them, 89% ($N = 8419$) were submitted for laboratory analysis and received a result about their content (Fig. 2B), whereas 11% ($N = 1053$) did not receive any result about their content, mainly due to limited laboratory capacity, and were therefore excluded. An overview per year is shown in Supplementary Fig. 1A-B. In 2020 and 2021, the total number of samples submitted to DIMS was lower than other years, because of restrictive measures due to the COVID-19 pandemic (Supplementary Fig. 1A-B).

Overall, the majority of samples submitted to DIMS between 2018 and 2022 were sold as ecstasy tablets (59%, $N = 38916$), followed by cocaine (8%, $N = 5307$), amphetamine (6%, $N = 4092$), MDMA powder (6% $N = 4225$), 2C-B (6% $N = 4275$) and other illicit drugs (6%, $N = 3735$) (Fig. 3). However, when only the drug samples that were used prior to submission between 2018 and 2022, and for which an analysis result was available, are taken into account, this distribution differs (Fig. 3). For instance, the proportion of samples sold as ecstasy submitted and used before submission is lower (41%, $N = 3460$) than the overall proportion of ecstasy samples submitted. Conversely, the proportion of cocaine samples used prior to submission is higher (17%, $N = 1407$) than the overall proportion of cocaine samples submitted. A similar shift is observed for amphetamine (13%, $N = 1110$). An overview per year is shown in Supplementary Fig. 2.

Characteristics in relation to the drug samples submitted by PWUD after use

For all further results only the proportion of drug samples that were already used before submission and that have received a result about the content were considered ($N = 8419$).

Gender

The majority of people who visited the DCS were male (on average male 75%, $N = 6359$; female 24%, $N = 1998$; not available 1%, $N = 62$). An overview per year is shown in Supplementary Fig. 3.

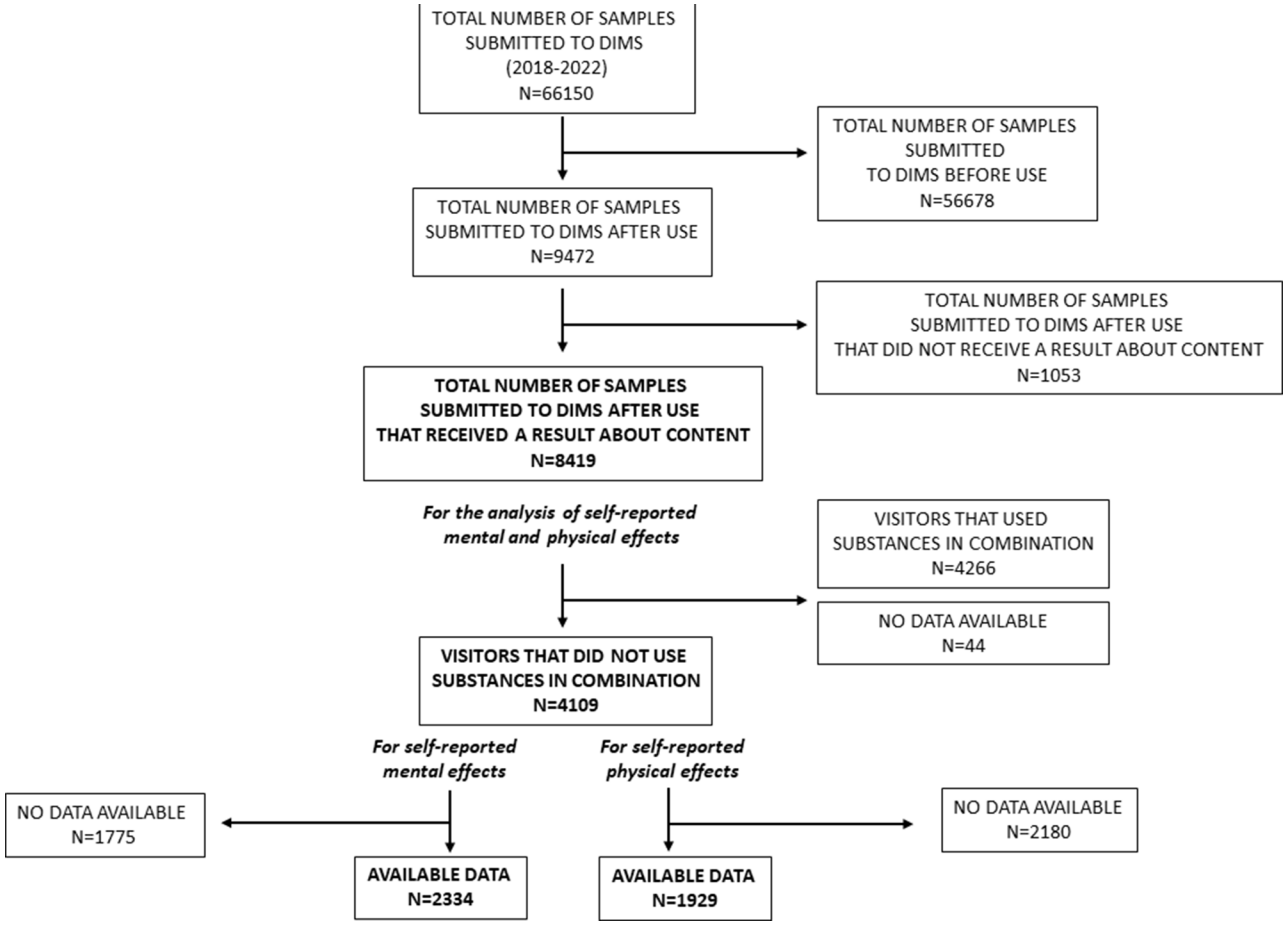

Fig. 1 Flow chart of the sample size

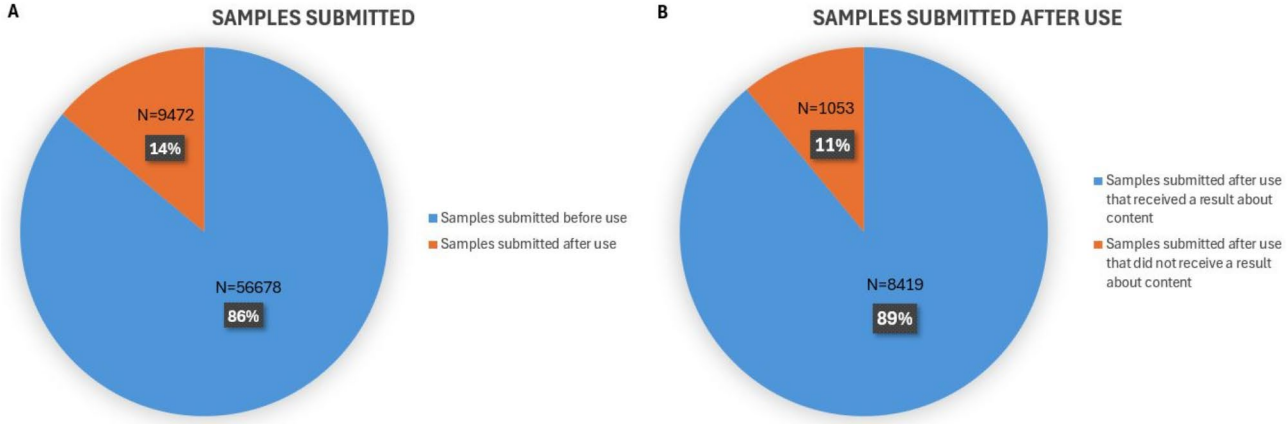

Fig. 2 (**A**) Samples submitted before and after use (percentage and absolute number). (**B**) Samples submitted after use that received or did not receive a result about the content (percentage and absolute number)

Online vs. offline

The vast majority of drug samples submitted to DIMS were purchased through offline sources (on average 96%, $N = 8081$), primarily from dealers or friends. On average, 4% ($N = 306$) were purchased online. For less than 1% ($N = 32$) of them, the origin was not defined. An overview per year is shown in Supplementary Fig. 4.

Combination use

On average, half of the visitors (49%, $N = 4109$) declared not to have used the sample in combination with any

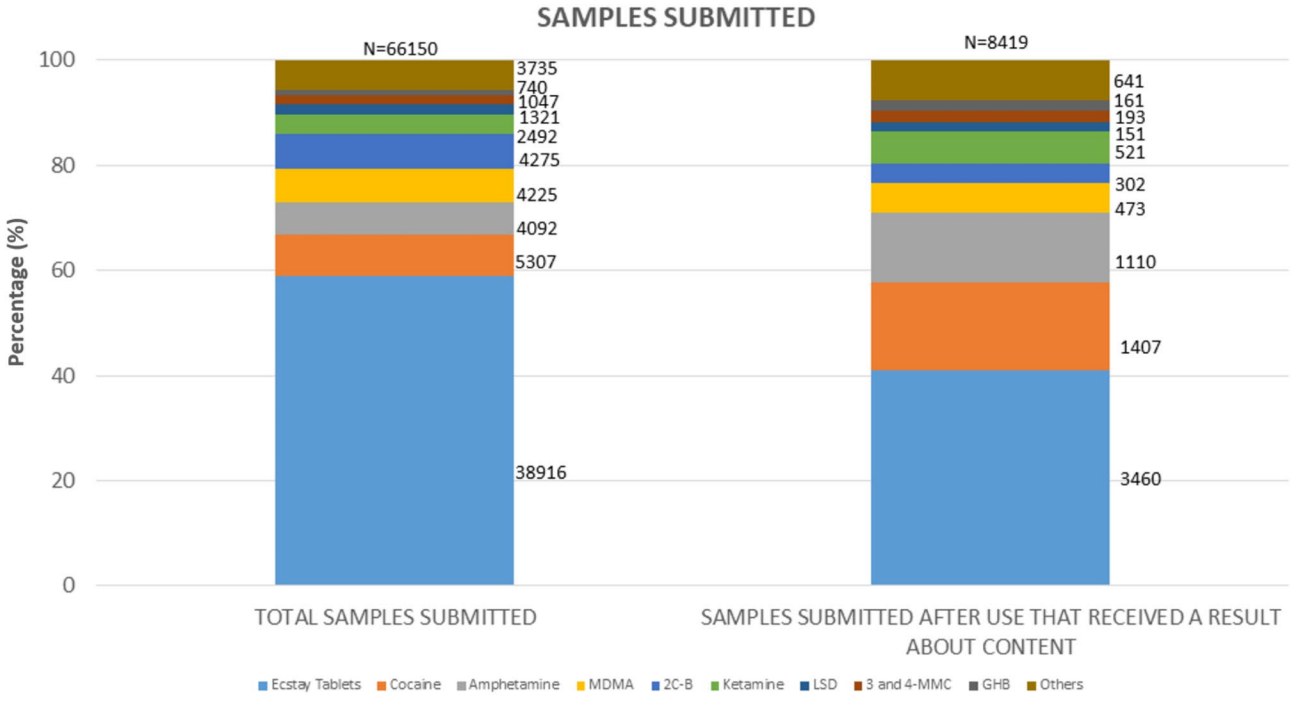

Fig. 3 Percentage and absolute number of ecstasy tablets, cocaine, amphetamine, MDMA powder, 2C-B, ketamine, LSD, 3-MMC and 4-MMC, GHB and other illicit drugs relative to the total samples submitted and the samples submitted after use that received a result about the content

other psychoactive substances. An overview per year is shown in Supplementary Fig. 5.

Setting in which the drug sample was used

Most of the samples submitted afer use (43%, $N=3614$) were consumed at a party or festival, followed by a home setting (27%, $N=2320$) (Fig. 4). The overview per year shows a temporary decrease in samples used at a party or festival setting because of restrictive measures due to the COVID-19 pandemic (Supplementary Fig. 6).

Reasons for testing after use

The main reason for submitting a sample to DIMS after use was because visitors wanted to know the content of the sample (57%, $N=4790$), followed by experienced unpleasant effects (27%, $N=2264$) or other reasons (4%, $N=371$) (Fig. 5). An overview per year is shown in Supplementary Fig. 7.

Self-reported experienced mental and physical effects

For the description of the self-reported mental and physical effects experienced after consumption of the submitted drug sample, only visitors who did not use the submitted drug sample in combination with other substances were taken into account ($N=4109$), in order to avoid any possible bias related to substance interactions.

Mental effects

In total, 57% ($N=2334$) of the 4109 visitors who did not use the sample in combination with other substances provided a description of the experienced mental effects. Half (50%, $N=1157$) of the visitors from this subset of data reported positive mental effects related to the use of the submitted drug sample, 34% ($N=805$) experienced negative effects, 9% ($N=218$) reported mixed effects, whereas 7% ($N=154$) did not notice any mental effects after consumption. An overview is shown in Supplementary Fig. 8A.

Physical effects

In total, 47% ($N=1929$) of the visitors provided a description of the experienced physical effects. After classification of the available reports, 35% ($N=664$) reported positive effects, 48% ($N=929$) experienced negative effects, 10% ($N=197$) reported mixed effects, while 7% ($N=139$) did not notice any physical effects (Fig. 6). An overview per year is shown in Supplementary Fig. 8B.

Association between self-reported effects and (mis)match with the expected drug content

For 90% ($N=3711$) of the 4109 visitors who did not use the submitted drug sample in combination with other substances, the content of the drug sample after analysis matched with their expectations. In 9% ($N=373$) of cases there was a mismatch between the detected content and

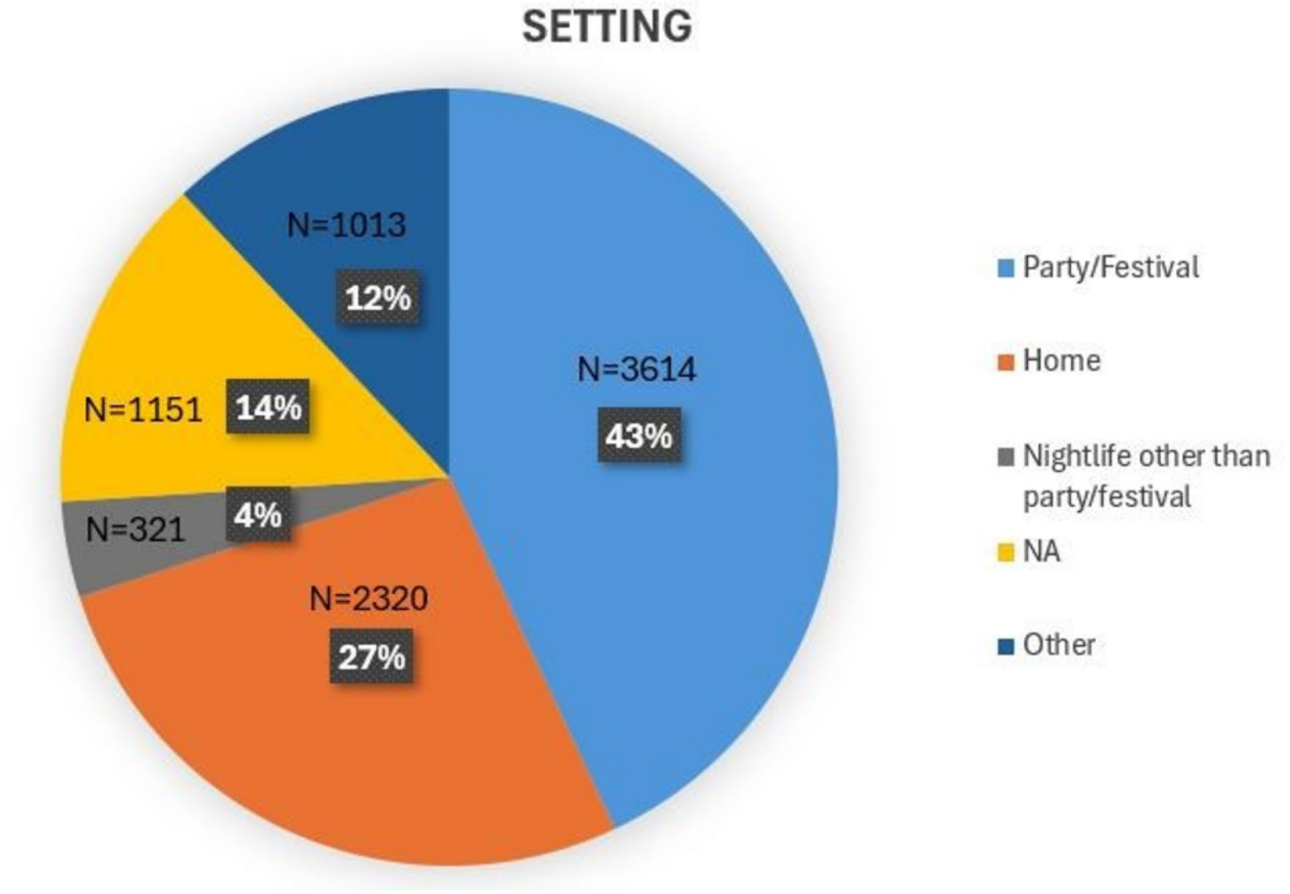

Fig. 4 Settings for the use of samples submitted after use that received a result about the content (percentage and absolute number)

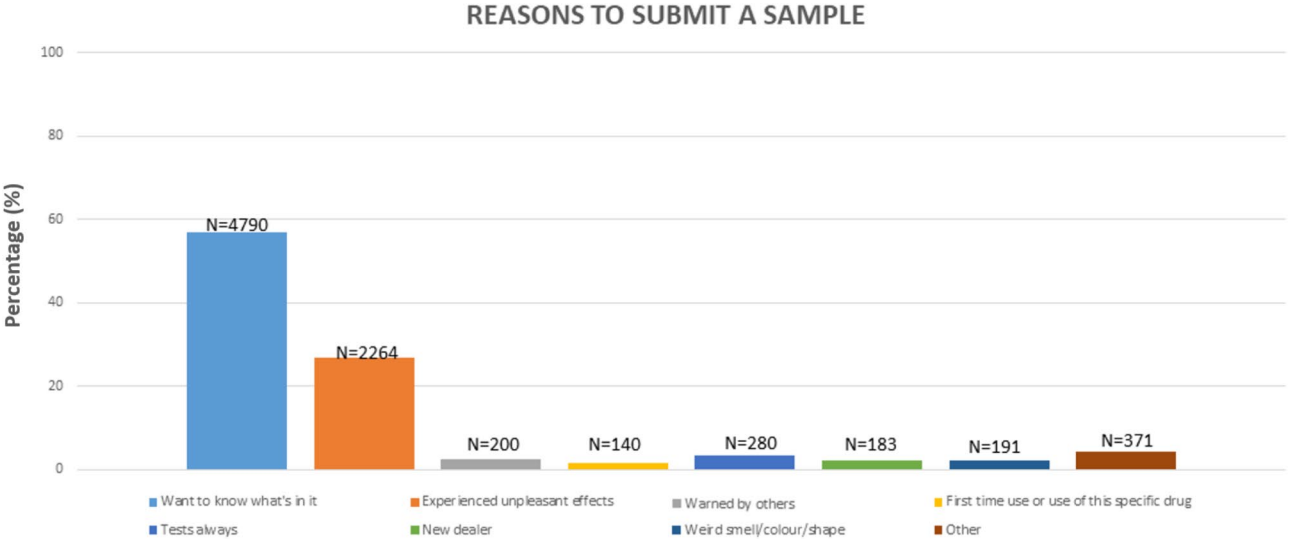

Fig. 5 Reasons for testing samples submitted to DIMS that received a result about the content (percentage and absolute number)

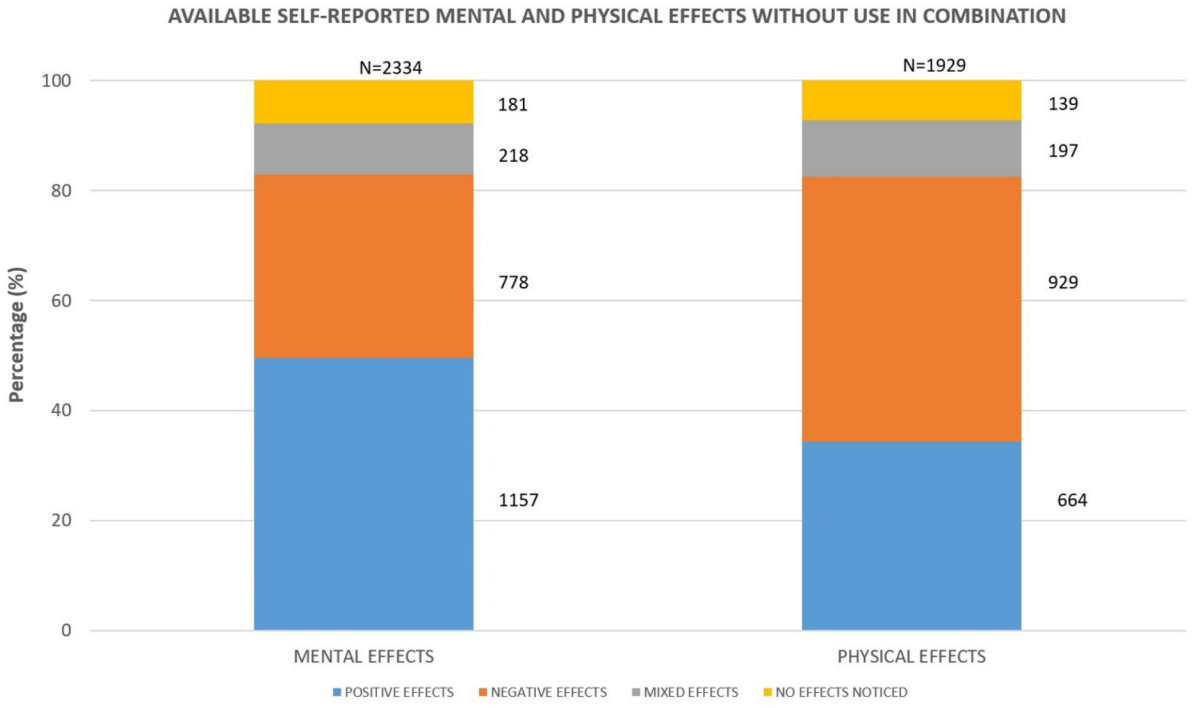

Fig. 6 Mental and physical effects self-reported by visitors that received a result about the content and did not use the sample in combination with other substances (percentage and absolute number)

Table 3 Absolute number of visitors reporting positive, negative and mixed mental effects categorized by whether the actual drug content either matched or mismatched the expected content

Mental effects	Match	Mismatch
Positive	1088	65
Negative	684	84
Mixed	191	27
Total	**1963**	**176**

Table 4 Absolute number of visitors reporting positive, negative and mixed physical effects categorized by whether the actual content either matched or mismatched the expected content

Physical effects	Match	Mismatch
Positive	612	49
Negative	829	92
Mixed	173	24
Total	**1614**	**165**

expected content, whereas for 1% ($N = 25$) information about the expected content was not available.

Mental effects

Interestingly, a significant association was found between the self-reported mental effects and the (mis)match with the drug content ($x^2_{(2)} = 22{,}70$; $p < 0.01$). Subsequent analyses revealed that visitors consuming a sample of which the actual drug content did not match the expected content were less likely to experience positive mental effects (OR = 0.47, $p < 0.01$) and more likely to experience negative mental effects (OR = 1.70, $p < 0.01$) compared to visitors consuming a sample of which the actual content matched with their expectation. The absolute number of visitors who reported positive, negative and mixed mental effects categorized by whether the actual content either matched or mismatched the expected content at the time of purchase is reported in Table 3.

Physical effects

Regarding the physical effects, no significant association was found between the self-reported (positive, negative and mixed) physical and the (mis)match with the drug content ($x^2_{(2)} = 5.26$, $p = 0.07$). The absolute number of visitors who reported positive, negative and mixed physical categorized by whether the actual content either matched or mismatched the expected content at the time of purchase is reported in Table 4.

Association between self-reported effects and setting

For the analysis of a possible association between the setting and self-reported mental and physical effects, the two most reported settings home and party/festival were further investigated.

Mental effects

A significant association was found between the self-reported (positive, negative and mixed) mental effects and the reported setting of use (home or party/festival) ($x^2_{(2)} = 49{,}60$; $p < 0.01$). Subsequent analyses revealed that visitors consuming their samples at a party/festival setting were more likely to experience positive mental effects (OR = 2.07, $p < 0.01$) and less likely to experience negative mental effects (OR = 0.49, $p < 0.01$) compared to people consuming the sample at home. The absolute number of visitors who reported positive, negative and mixed mental effects at home or at a party/festival is reported in Table 5.

Physical effects

A significant association was found between the reported physical effects (positive, negative and mixed) and the reported setting of use (home or party/festival) ($x_{(2)} = 45.71$, $p < 0.01$). Visitors consuming their sample at a party/festival setting were more likely to experience positive physical effects (OR = 2.27, $p < 0.01$) and less likely to experience negative physical effects (OR = 0.53, $p < 0.01$) compared to people consuming the sample at home. The absolute number of visitors who reported positive, negative and mixed physical effects at home or at a party/festival is reported in Table 6.

Table 5 Absolute number of visitors reporting positive, negative and mixed mental effects at home or at a party/festival

Mental effects	Home	Party/Festival
Positive	253	623
Negative	253	283
Mixed	64	94
Total	**570**	**1000**

Table 6 Absolute number of visitors reporting positive, negative and mixed physical effects at home or at a party/festival

Physical effects	Home	Party/Festival
Positive	*N* = 152	*N* = 345
Negative	*N* = 297	*N* = 295
Mixed	*N* = 67	*N* = 69
Total	N = **516**	N = **709**

Discussion

The objective of the present study was to identify the characteristics of PWUD who have their drugs tested at one of the 32 DCS of DIMS in the Netherlands after use, and to investigate whether either a (mis)match with the expected content of the drug sample or the setting in which the substance was used was associated with the outcome of the drug experience. Between 2018 and 2022, 14% of the visitors submitted a drug sample after use. The majority of samples submitted were ecstasy, cocaine, and amphetamine. The majority of visitors were males who purchased the drug sample offline, for instance from a dealer. Submitted drugs were predominantly used at a party/festival setting, but also at home. Interestingly, half of the visitors reported that they did not use other substances in combination. The most reported reason to test after use was because visitors wanted to know the actual content of their drug sample or because they experienced negative mental or physical effects. In nine out of ten cases, the actual content of the drug sample after analysis matched the expected content. Furthermore, postive mental effects were less likely to be experienced when the detected drug content did not match the expected content, while negative mental effects were more likely. For physical effects, no significant association was found. Also, the setting in which a drug sample was consumed had an effect on the type of reported experience. Most of the postive mental and physical effects were experienced in a party or festival setting rather than a home setting.

A large proportion of the DCS visitors who had consumed the sample before submission, reported to have experienced negative mental effects (33%) and negative physical effects (48%), which in part could have been avoided when they would have visited the DCS prior to consumption. These negative effects can be explained by either the presence of an extra hazardous adulterant, or deviant content. However, the content of the majority of the samples that were analysed corresponded with the expected content at the time of purchase (90%), so other explanations for these experienced negative effects including exposure to a high dosage cannot be excluded. In this study, the strength of the drug sample was not taken into account, because no data was available about how much a visitor had used while experiencing the reported effects. Nevertheless, a previous study has described a strong association between the pharmacological content of samples sold as ecstasy and the subjective experiences reported by people using them, with the probability of experiencing adverse effects (most likely physical) in particular when doses were exceeding 120 mg MDMA [14].

However, when a drug sample does not contain an adulterant or a different substance than expected, or when the appropriate dosage was used, a negative experience can still take place. Not only because drug use is never safe, but also because the influence of set and setting are usually underestimated [15]. How set and setting can affect the outcome of an experience can be addressed

by the staff at the DCS during the tailored harm reduction advise [8]. Interestingly, the present results also showed the existence of a specific subset of visitors who already used a drug sample and experienced positive effects, but still had their drugs tested (50% for mental effects and 34% for physical effects). Although this group did not report any negative effects after use of the particular drug, this does not exclude the possibility that next time their experience is similar. Therefore, also these individuals should always be taken seriously and receive tailored harm reduction advise about the potential risks associated with drug use and the influence of drug, set and setting.

In relation to setting, it was observed that most of the positive mental and physical effects were experienced when consuming the drug at a party or festival, compared to consumption at home. Previous studies highlight that the effect of a specific drug, as well as the degree of control of its use, are not only due to the pharmacologic action of the substance itself. Also, other interacting crucial variables can play a role, such as the physical and social setting in which the substance was taken, together with the user's attitude at the time of consumption, including his/her personality [15, 16]. In particular, this has been reported for the use of hallucinogens and psychedelics for which, although the set was described as a crucial factor, the trip experience was more closely linked to specific aspects of the setting (a proper, secure and comfortable setting, experienced by the user as "a good place") [17]. The findings obtained from the PWUD included in the present study might be explained in the light of previous lines of evidence on people engaged in drug use during parties and festivals [18, 19]. The majority of this group associates drug use in this setting with pleasure and positive outcomes [20] and is often unaware of the possible consequences and risks of drug use. Therefore, having made the decision to use drugs, they can follow a number of harm reduction strategies for reducing risks and having an overall positive drug experience [21]. Moreover, a positive social context during parties and festivals, such as being with friends or acquaintances, can act as a key determinant of a positive drug experience [22]. This might be attributed to the effects of social interactions and emotions on the release of specific hormones, such as oxytocin [23], further reinforcing the positive feelings related to drug consumption during parties and festivals. Also music, which has been investigated for the musical genres of techno, reggae and rap, can significantly contribute to a positive drug use experience during parties and festivals [22, 24]. This may be due to an increase in the release of specific neurotransmitters, such as dopamine [25], that can further reinforce the association between drug consumption, the resulting pleasure, and the external stimuli contribution to the positive experience.

In this context, a key challenge for prevention workers is to ensure that PWUD are adequately informed that, despite the positive mental and physical effects they may experience at a party or festival setting, drug use is never without risks. Drug-related incidents can always occur at these events as demonstrated by a study conducted in the Netherlands [26]. Thus, based on the findings of the present study, as well as previous observations [27], an important element of effictive preventive strategies is to adequately consider the role of setting in influencing drug-induced experiences. Additionally, PWUD should be informed about the various factors that can influence their drug experience and the potential discrepancies between their expectations and the actual outcome. This is most effective when explained to PWUD before drug use. Therefore, DCS should emphasize on carefully planning drug use and reducing the risks associated with it beforehand.

Another observation in this study was that during the years 2020 and 2021, the number of samples submitted to DIMS was reduced due to the restrictive measures during the COVID 19 pandemic. The pandemic in those years certainly had an impact on the use of recreational drugs. Because of the decreased number of parties and festivals, drugs were more consumed at home. As a result of the restrictive measures implemented by governments, feelings of isolation along with the exacerbation of pre-existing mental problems, such as depression and anxiety, were particularly observed in vulnerable groups, including PWUD [28–31]. However, no specific analyses were conducted in this study, as other factors may have played a significant role in shaping the outcome of a drug experience during the COVID-19 pandemic.

To increase the amount of PWUD visiting a DCS before using a drug at a party or festival or at home, different types of DCS, i.e. office-based and those operating directly in recreational settings, like large-scale festivals, can be implemented to target specific user populations. Previous studies on the impact of DCS in recreational settings, have shown that providing accurate and complete information about drug content allows festivalgoers to better manage their drug consumption and adopt health protecting behaviours [10, 32, 33].

Strengths and limitations

The results presented in this paper should be interpreted in the light of a number of strengths and limitations. This study was made possible only because visitors trust the staff of the DCS who are primarily prevention workers trained by DIMS. All DCS part of the DIMS network are office-based and can be visited anonyomously, allowing visitors to feel comfortable providing additional

information about their drug use, beyond just submitting the drug sample. This trust in DCS and their staff should be considered a critical asset of drug checking as a harm reduction intervention [6], and plays a key role in addressing the influence of set and setting on mental and physical effects associated with drug use. It also helps to develop tailored strategies to effectively inform visitors about these factors, in order to reduce drug-related harm. One limitation is the fact that at a DCS all information is collected while respecting anonymity and confidence. Therefore, visitors' sociodemographic background, except for gender (indeed, the majority of our visitors are male students and this certainly accounts for a gender unbalance), is not available and thus the impact of these factors in relation to their respective drug use experience could not be evaluated in the current study. Also, the in-person conversation visitors have with the prevention worker, during which they ask for information, typically lasts about 10 min and follows a structured format. However, the answers collected from the visitors remain inherently subjective. In light of this limitation, it is also clear why it was not possible to collect information on the actual amount of drugs used, which would have provided a better understanding of the experienced effects in relation to the actual dosage taken.

Another limitation that should be considered is that the consumption of the drug sample in combination with alcohol and/or tabacco may not have been reported accurately, as visitors may have seen this not as a "relevant" combination of psychoactive substances. However, these substances can have an influence on the experienced mental and physical effects. In particular, the use of drugs in combination with nicotine can result in an increased intake of one or both substances [34]. Moreover, the concomitant use of nicotine and cocaine results in an enhancement of positive ratings of the drugs [35]. Furthermore, nicotine and opiates are known to interact leading to an increase of the total drug intake [35–37]. Regarding the use of drugs in combination with alcohol, it is widely known that the extra hazardous compound cocaethylene is produced in individuals consuming cocaine which increases the risk associated with cocaine use [39]. Also, most deaths following opioid overdose involve significant alcohol levels [40–42]. Conversely, several life-threatening events described as "alcohol-related" often involve the use of other drugs [43]. Thus, future efforts are needed to adequately address the health risks of drug use in combination with alcohol and tabacco.

When focusing on drug-induced mental and physical effects, it is important to avoid lumping all substances together in the analysis, even if they share similar pharmacological effects, such as ecstasy and cocaine, both of which are considered stimulants. However, while ecstasy is the most submitted type of drug by visitors of DIMS in total, cocaine and to a lesser extent amphetamine are more often submitted for analysis after use. Several factos could explain this important difference, and therefore, additional research is needed to further investigate this observation and strengthen harm reduction strategies for specific drugs.

Lastly, no data is available on how frequently PWUD may visit a DCS. Indeed, it may be possible that certain people visit a DCS multiple times a year, other people come only once, while most of the PWUD may never visit a DCS for various reasons, including mistrust or not able to plan their drug use. Thus, a significant challenge lies in reaching PWUD who do not visit a DCS using alternative strategies.

Conclusion

Risks associated with drug use and negative mental and physical drug experiences can never be avoided. However, this study highlights the importance of providing tailored information about the content of a drug sample submitted for analysis at a DCS before use in order to reduce drug-related harm even without combining it with alcohol or tabacco. Additionally, the impact of set and setting on drug experiences, often overlooked, can be addressed during a DCS visit. In conclusion, to reduce negative effects and mitigate drug-related harm, a more diverse group of PWUD should be encouraged to visit a DCS before use for tailored harm reduction advice.

Supplementary Information

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Supplementary Material 1

Author contributions

SS analysed and interpreted the data, wrote the original draft of the paper and revised it. MB and MGM analysed the data and wrote the original draft of the paper. LT interpreted the data and revised the paper. NH and LSR interpreted the data and wrote the original draft of the manuscript and revised the paper. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare no competing interests.

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