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Drug testing in Europe: monitoring results of the Trans European Drug Information (TEDI) project

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Drug testing is a harm reduction strategy that has been adopted by certain countries in Europe. Drug users are able to hand in their drugs voluntarily for chemical analysis of composition and dose. Drug users will be alerted about dangerous test results by the drug testing systems directly and through warning campaigns. An international collaborative effort was launched to combine data of drug testing systems, called the Trans European Drug Information (TEDI) project. Drug testing systems of Spain, Switzerland, Belgium, Austria, Portugal, and the Netherlands participated in this project. This study presents results of some of the main illicit drugs encountered: cocaine, ecstasy and amphetamine and also comments on new psychoactive substances (NPS) detected between 2008 and 2013. A total of 45 859 different drug samples were analyzed by TEDI. The drug markets of the distinct European areas showed similarities, but also some interesting differences. For instance, purity of cocaine and amphetamine powders was generally low in Austria, whilst high in Spain and the Netherlands. And the market for ecstasy showed a contrast: whereas in the Netherlands and Switzerland there was predominantly a market for ecstasy tablets, in Portugal and Spain MDMA (3,4-methylenedioxymethamphetamine) crystals were much more prevalent. Also, some NPS appearing in ecstasy seemed more specific for one country than another. In general, prevalence of NPS clearly increased between 2008 and 2013. Drug testing can be used to generate a global picture of drug markets and provides information about the pharmacological contents of drugs for the population at risk. Copyright © 2016 John Wiley & Sons, Ltd.

Keywords: new psychoactive substances; drug testing; amphetamine; cocaine; ecstasy; purity; adulterants

Introduction

Drug use touches on political, legal, economic, and health issues in society. Drug use may be of a compulsive and addictive nature or it can be a way to intensify the nightlife experience.[1] Nightlife experience and drug use have changed considerably since the early 1990s as new drugs, drug users, and drug use patterns came to light.[2] In Western Europe, nightlife has extended far beyond the midnight curfew since the 1990s and excesses in hedonistic or sexual behaviour have become more accepted. This coincided with an increased popularity of many (illicit) drugs for their effects of additional energy and increased self-confidence.[3] Alongside traditional psychotropic drugs, new synthetic drugs have emerged in the nightlife scene with unknown effects and risks.

Most recreational substance users could be considered as relatively unproblematic[4] and in some ways, they might not differ much from non-substance users, with the exception of a higher propensity for novelty seeking and impulsivity.[5,6] For instance, one recent survey described recreational substance users as young, highly educated users with excellent employment opportunities, who mainly use substances for expansion of their own experiences.[7]

The prevalence numbers for illicit substance use between EU countries differ considerably, from tenths of percentages to more than 10% lifetime prevalence.[8] To capture recreational drug use specifically, targeted surveys among nightlife visitors are considered more informative. For instance, in an online drug survey done in 2011, 39% of almost 8000 UK respondents reported to have used ecstasy pills in the last year and this was 57% among the regular UK clubbers.[9] For cocaine, these figures were 42% and 54%, respectively. Another online survey from 2013 among 3335 Dutch clubbers revealed that 61% used ecstasy (MDMA; 3,4-methylenedioxymethamphetamine) in the last year, for cocaine this was 27% and for amphetamine 33%, respectively.[10] These surveys showed that drug use is an important factor in the recreational nightlife settings.

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Whereas the main focus of addressing chronic compulsive drug use is treatment of dependence and withdrawal symptoms, the focus of addressing recreational patterns of drug use is more associated with acute toxicity. This has led to harm reduction initiatives all over the world, such as provision of good ventilation, accessible drinking water, chill-out spots and the presence of first aid teams to prevent acute problems caused by drug use at dance parties and clubs.[11] In addition, because of a new generation of drugs, often synthetic, which emerged in the wake of new nightlife scenes, there was a large gap in knowledge about the effects and risks of harms linked to these substances.[12,13] Special concern was raised about misrepresentation, adulteration, and exposure to unexpected contents or dose.[14,15]

Consequently, the concept of drug testing was introduced as a new harm reduction strategy aimed at these recreational drug users across Europe and the United States. The first country to utilize drug testing for this purpose was the Netherlands, where the government adopted the drug information and monitoring system (DIMS) in the early 1990s to monitor these new and existing drug markets with respect to dose, composition, adulterants, and availability.[13,16] Through this nationwide system of stationary testing facilities, users are able to hand in their drugs voluntarily for chemical analysis of composition and dose. In this way, it is possible to track the market situation and rapidly implement harm reduction strategies in cases where acutely hazardous substances appear on the drug market.[17] For instance, drug users are alerted through the framework of the testing facilities that are imbedded within prevention institutes and flyers are distributed at clubs or warnings are published in the media.[18]

In the following years, drug testing was adopted by other nations in Western Europe. The first mobile drug testing service in the nightlife setting was set up in Vienna, Austria, in 1997.[19,20] A similar system was introduced in Zürich, Switzerland, in 2001.[21] In 1997, a Spanish initiative started by testing drugs with reagent colourimetric drug testing at parties.[22] That quickly evolved into a stationary testing facility with more advanced analysis techniques. In 2001, a Portuguese service of colourimetric analysis started working at festivals and nightlife events and in 2009 this drug testing project was partly funded by the government.[23] Other examples are SINTES in France and Modus Vivendi in Brussels.[24] In the United States, a small-scale system has existed since 2001 where analysis results from submitted pills are published on the Internet.[25]

Some important insights have been gained from drug testing systems. For instance, specific adulterants have been identified by Dutch and French drug testing systems, such as levamisole or atropine, and this has been communicated back to cocaine users.[26,27] In addition, it was shown that pills sold on the street market as ecstasy did not merely contain MDMA-like substances, but also a variety of unexpected substances, like PMA (*para*-methoxyamphetamine), PMMA (para-methoxymethamphetamine), piperazines, mephedrone, 4-fluoroamphetamine, and others.[15,27–31] Similar to the rise of new synthetic substances in the 1990s and early 2000s, drug testing systems have been able to follow the appearance of a new wave of synthetic psychoactive substances that have appeared recently on the drug markets of various countries.[15,31–33] Most chemical and analytical data is obtained from drug seizures reported by forensic laboratories around the world,[34–36] including those from countries that also have drug testing facilities.[37,38] However, the drug testing systems are unique in assembling drug user-derived information, such as street retail composition of samples, prices and effects.[15,26,28,30]

Between 2011 and 2013, a collaborative effort was launched to combine the consumer-targeted drug testing systems of the European Union, called the Trans European Drug Information (TEDI) project (www.tediproject.org). This project aimed at assembling the drug testing information into a central database for analysis and monitoring of the European drug market. The drug testing systems of Spain (including the Basque country and Catalonia), Switzerland, Austria, and the Netherlands participated in this project. In addition, two small-scale testing initiatives also participated: the municipality of Brussels and Portugal. This article presents the results related to the key illicit drugs encountered on the European drug markets, i.e., cocaine, ecstasy, and amphetamine. Briefly, results of the emerging market of new psychoactive substances will also be presented, such as their appearance as adulterants and their appearance as purposely sold substances.

Materials and methods

Participants

The drug testing services in this study obtained drug samples from drug users directly and there was face-to-face contact with these users, which meant that information about the drug users was also available. The most recent Dutch study among 386 testing drug users at the Amsterdam testing facility between 2008 and 2011 showed more males (73%), that testing drug users had a relatively high education and were of Dutch ethnicity.[39] Earlier research showed a high similarity between Dutch and Austrian drug users which compared testing with non-testing drug using peers.[20] Most users were male (~70%), well-educated and predominantly of Western-European ethnicity. Finally, in both studies, most testing drug users displayed a typical recreational drug use pattern, i.e., drug use during the weekends and at nightlife events, and a preference for electronic dance music. A survey of the Swiss drug testing service (among 1376 visitors between 2003 and 2010; 78.1% male, 27.8 years) showed that the majority of interviewees (81.1%) reported polydrug use during a typical party night.[40] In most aspects, the surveyed drug users at testing services seemed to largely reflect non-testing drug users in Europe.[9,10]

Colourimetric drug tests

Drug samples were handed in either at a stationary or mobile drug testing facility to undergo presumptive colourimetric testing. The most frequently used reagent for the colourimetric test was the Marquis reagent that facilitated differentiation between some very common drugs on the market, such as heroin (purple), (meth)amphetamine (orange), 3,4-methylenedioxymethamphetamine (MDMA) (blue/ black), 2,5-dimethoxy-4-bromophenethylamine (2C-B), and (4-Bromo-2,5-dimethoxy-amphetamine) DOB (green). If the sample was a tablet, characteristic features such as logo, diameter, thickness, weight, colour, and absence/presence of a groove were recorded. If a tablet from a certain batch had been previously analyzed by gas chromatography coupled to mass spectrometry (GC-MS) at least three times, the colourimetric test result, together with the characteristics of the tablet, were considered to provide sufficient identification of that tablet. The testing facilities were then able to provide the average tablet content and range to the drug user. In the Netherlands, this recognition of tablets has been proven to be very reliable.[17,28] But in the case of new tablets or powders, liquids, capsules, and miscellaneous forms, the drug samples were analyzed using a variety of instrumental techniques.

Instrumentation

The DIMS laboratory (DSM Resolve, Geleen, the Netherlands) utilized liquid chromatography with diode array detection (LC-DAD) and GC-MS for identification and quantitative analysis of the drug samples. GC–MS was performed on an Agilent 6890 N GC (Agilent, Santa Clara, CA, USA) system and a Leco Pegasus III MS (Leco, St Joseph, MI, USA) system. Samples (10–15 mg) were dissolved, alkalized, and extracted into an organic solvent followed by analysis by GC-MS. Compounds were separated using a nonpolar GC column (Sigma-Aldrich, Darmstadt, Germany). The GC-MS method was suitable for detecting analytes at a concentration equal to or larger than 1% (*w/w*). For LC-DAD analysis, the samples (10–15 mg) were dissolved and extracted into methanol, centrifuged, and directly analyzed by LC-DAD (Agilent, 1290 Infinity II). In light of laboratory costs, only the ten most prevalent target analytes of the Dutch drug market (amphetamine, methamphetamine, ketamine, cocaine, MDMA, 2C-B, 4-fluoroamphetamine, caffeine, levamisole, phenacetin) were calibrated (9-point calibration series) for routine quantitative analyses. Reference standards were ordered at LGC (LGC Standards, Middlesex, Teddington, UK).

Identification of drug samples by Energy Control at Barcelona (Spain), the mobile testing services of Ailaket in the Basque region (Spain) and Check!n (Portugal) was performed with by thin layer chromatography (TLC). Energy Control also analyzed all samples by GC-MS and ultraviolet spectrophotometry. The TLC plates were developed using three different solvent systems: (1) methanol/25% ammonia solution, (2) methanol, and (3) acetone. Pure methanol was used for detection of ketamine and levamisole in cocaine. Visualizations were obtained from application of the Marquis test and *p*–dimethylaminobenzaldehyde (DMAB). Reference standards were supplied by the Municipal Institute for Medical Research in Barcelona (IMIM – Hospital del Mar).

GC-MS for Energy Control was performed at IMIM to confirm TLC results. This was performed in an Agilent 5890 series II gas chromatograph coupled to a 5971A quadrupole mass spectrometer detector (Agilent). The oven temperature was initially maintained at 90 °C for 2 min. and programmed to reach 300 °C at 20 °C per min. It was finally maintained at 300 °C for 4 min, with a total run time of 14.5 min. Helium was used as carrier gas at a flow rate of 0.48 mL/min. The 2007 Wiley-VCH Verlag GmbH & Co. KgaA., Weinheim (Germany) reference library was used for spectral comparison. To determine the purity of the samples, ultraviolet spectrophotometry was performed in a Jenyway 6405 apparatus. The absorbance with the spectrophotometer was measured for each solution at different wavelengths (480, 526, and 580 nm). The fit of absorbance against concentration at the wavelength of maximum absorption provided the calibration curve and a standard linear calibration curve was run to obtain the linear range of samples, the correlation factors were within accepted value (=0.996) and the standard calibration curves were all linear.

The Austrian (Checkit) and Swiss (Saferparty) mobile drug testing services at dance events and festivals used mobile high performance liquid chromatography (HPLC) devices, that are equipped with DAD/UV-Vis Spectrometers and autosamplers. In brief, three to ten milligrams of drug sample was pulverized and then dissolved in 1 mL of methanol and vortexed for 1 min. Ten μL of the supernatant was diluted with 400 μL of internal standard solution (Trazodone 25 μg/mL dissolved in 10 mM aqueous ammoniumformate buffer) ready to be injected into the liquid chromatography MS (LC–MS) system. Separation was performed on a 2.1 × 150 mm Luna PFP column (Phenomenex, Torrance, CA, USA) using fast gradient elution with 10 mM aqueous ammonium formate buffer (pH 4.5) and acetonitrile (ACN) with a total run time of 7.5 min. The flow rate was set to 300 μL/min. For the identification of the compounds, retention time, UV spectra, and mass spectra were obtained and compared to those of reference substances previously measured. The quantitation was achieved by UV-detection at a wavelength of 254 nm. A database that is coupled to this device warrants positive identification of the samples. However, if an unknown psychoactive compound was encountered in the HPLC, the sample would be analyzed with more advanced techniques, like GC-MS and to identify the chemical structure.[41]

Statistics

Descriptive statistics (mean and percentage) were used to report the different compounds measured. Percentages of drug samples containing the main labelled psychoactive compound relative to drug samples that did not contain this compound were calculated. The latter category is referred to in the Results section as misrepresented samples.

Results

Between 2008 and 2013, 45 859 different drug samples were analyzed by the TEDI drug testing services in total. The DIMS of the Netherlands received approximately 30 000 samples for analysis (Figure 1). There was a difference in the type of drug samples that were submitted to the different drug testing services, with the Netherlands mostly receiving ecstasy pills, whereas the Basque country (Ailaket) and Portugal (Check!n) did not receive any ecstasy pills for analysis between 2008 and 2013. Also, Spain (Energy Control) and Austria (Checkit) revealed a higher prevalence of MDMA crystal powders over ecstasy pills, while this was opposite for the Netherlands (DIMS), Belgium (Modus Fiesta), and Switzerland (Saferparty). The data presented from Portugal (Checki!n) represent testing results of samples submitted during three editions (2008, 2010, and 2012) of a big biennial international electronic music festival (Boom).

Cocaine

Between 2008 and 2013, the cocaine markets of the European drug testing systems showed differences in terms of purity and composition. Percentages of samples containing cocaine were relatively high, with Austria showing the highest number of misrepresented cocaine powders, whereas the Basque country, Switzerland, and the Netherlands generally showed the highest submission rates of cocaine powders that contained cocaine (Figure 2). Likewise, the average purity of powders that contained cocaine was lowest for Austria (on average 42% across 2008–2013), whereas the purities of the Basque country, the Netherlands, and Switzerland were around 60% in 2013 (Figure 3).

Many different adulterants were detected on the cocaine market by six different drug testing systems and most of them were comparable (Table 1). Clearly, levamisole was the most commonly detected adulterant in cocaine in 2013, followed by phenacetin, and caffeine. Also, the local anaesthetics appearing in cocaine seemed to appear in all countries. Levamisole was only systematically quantified in cocaine powders by the DIMS in the Netherlands, which revealed that the average content rose from 7.5% in 2010 to 8.7% in 2013.

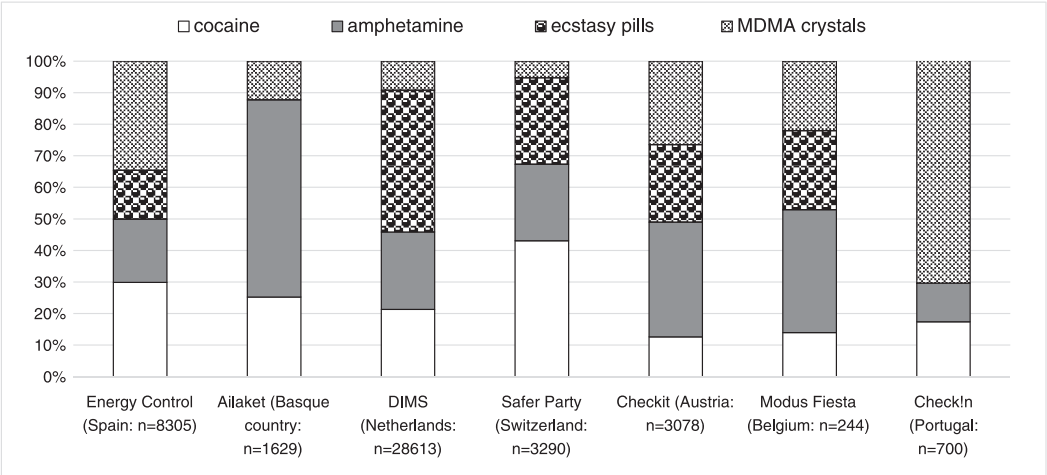

Figure 1. The number and type of drug samples that were handed in between 2008 and 2013 across seven drug testing services. *Modus Fiesta assembled data from 2011, Check!n assembled data biennially from 2008.

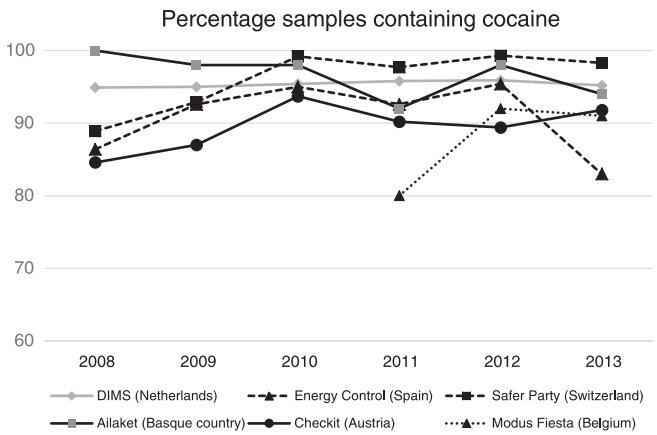

Figure 2. Prevalence of cocaine detected in samples that were sold as cocaine in six drug testing services across 2008–2013.*
*Modus Fiesta only assembled data from 2011. Check!n did not systematically classify cocaine powders.

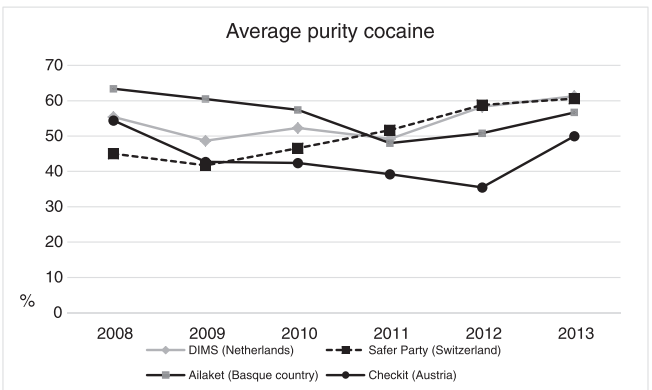

Figure 3. Average purity (in %) of cocaine powders in four drug testing services across 2008–2013.*
*Energy Control and Modus Fiesta performed no systematic quantifications of cocaine. Check!n did not measure cocaine purity.

Amphetamine

Percentages of samples believed to be amphetamine powder and then confirmed to contain this substance were relatively high and this fluctuated between 82 and 99% for most drug testing systems, except for Austria that showed 10% more misrepresented amphetamine powders than the other countries (Figure 4). Austria also showed by far the lowest purity of amphetamine with an average of around 15%. The highest purity values were found in the Netherlands (Figure 5). Overall, the purity of amphetamine samples seemed to have increased across the European countries with an average purity of 39% in 2013. The majority of amphetamine powders detected in all the European partner countries between 2008 and 2013 were also observed to contain caffeine (Figure 6). Another psychoactive substance detected in amphetamine powders was 4-methylamphetamine (4-MA), which was increasingly prevalent across all countries between 2008 and 2013.

Ecstasy pills and MDMA crystal powders

The ecstasy tablet market across the different European countries showed some interesting similarities. The percentage of ecstasy tablets containing MDMA plummeted around 2009 (Figure 7). The ecstasy tablet market recovered within a year and from 2010 onwards there was a noticeable increase in percentage ecstasy tablets containing MDMA with the Netherlands and Switzerland far exceeding 90% in 2013. This was also reflected in terms of MDMA dose per tablet. Whereas this was at a low in 2009 (an average of 60–70 mg/tablet for four European countries), doses rapidly increased from 2010 (Figure 8). In 2013, the single dose per tablet approximately doubled in the corresponding European country since 2009 to an average of 107–114 mg/ tablet.

In general, the MDMA crystal powder market revealed relatively low adulteration in the years 2008-2013 and most crystal powders contained MDMA (Figure 9). Crystal powders that contained MDMA (ranging between 75% and 97% across all countries) were generally of high purity (Figure 10), showing an average across all countries of 73.5%.

Table 1. Percentages cocaine powders containing adulterants detected in 2008-2013 by six European drug testing systems

	Levamisole	Phenacetin	Caffeine	Lidocaine	Procaine	Tetracaine	Hydroxyzine	Diltiazem
2008								
Austria	-	30.8	23.1	15.4	-	-	-	-
Ailaket (Spain)	-	53.7	25.8	2.7	-	-	-	-
Energy Control (Spain)	-	37.8	24.4	5.7	10.9	2.3	-	-
Switzerland	-	45.8	37.5	8.3	-	-	-	-
The Netherlands	31.6	32.9	16.7	8.4	3.8	-	2.0	5.7
2009								
Austria	-	-	-	4.4	-	-	-	-
Ailaket (Spain)	-	35.0	32.4	8.8	3.1	-	-	-
Energy Control (Spain)	10.8	34.7	23.7	6.1	7.4	5.8	-	-
Switzerland	23.3	43.3	15.0	13.3	-	-	-	-
The Netherlands	50.5	38.8	18.5	11.2	5.6	-	-	2.0
2010								
Austria	55.6	17.5	17.5	17.5	1.6	-	-	-
Ailaket (Spain)	-	37.0	33.0	-	-	2.4	-	-
Energy Control (Spain)	29.2	26.0	16.7	7.2	6.2	9.1	-	-
Switzerland	44.0	38.6	9.6	7.2	-	-	-	-
The Netherlands	67.4	25.4	18.1	12.7	4.0	0.3	16.2	3.0
2011								
Austria	64.6	28.1	29.3	24.4	6.1	-	-	-
Ailaket (Spain)	12.6	17.9	21.4	24.5	13.4	6.0	-	-
Energy Control (Spain)	21.9	27.0	22.2	3.4	5.3	15.1	-	-
Switzerland	40.0	25.1	12.7	8.3	2.8	2.6	-	-
The Netherlands	61.3	31.3	23.5	9.0	4.4	1.2	15.5	2.3
Belgium	-	33.3	33.3	-	-	40.0	-	-
2012								
Austria	56.7	28.9	30.8	12.5	2.9	1.0	-	-
Basque (Spain)	27.7	16.8	28.3	10.9	3.4	8.1	-	-
Catalonia (Spain)	26.3	22.5	21.1	4.4	5.2	16.4	-	-
Switzerland	42.1	19.5	16.2	12.2	1.3	0.9	-	-
The Netherlands	65.2	18.4	14.2	9.3	3.2	0.3	9.6	1.2
Belgium	-	16.7	33.3	8.3	8.3	8.3	-	-
2013								
Austria	59.1	40.0	27.3	13.6	2.7	-	-	-
Basque (Spain)	27.5	19.9	22.4	12.0	7.2	6.6	-	-
Catalonia (Spain)	27.5	22.2	25.4	4.9	4.3	10.3	-	-
Switzerland	42.0	16.9	16.3	11.4	-	1.1	-	-
The Netherlands	66.7	14.8	16.7	7.8	1.9	0.2	7.8	1.7
Belgium	-	-	9.0	9.0	-	-	-	-

Adulterants of the ecstasy market

The ecstasy market (tablets and crystal powders) showed resemblance across all European drug testing services in the type of adulterants detected. For example, many new psychoactive substances (NPS) were detected in tablets sold as ecstasy tablets or powders sold as MDMA. The term NPS refers to substances with a psychoactive effect that were recently offered on the consumer drug market, although they could be synthesized much longer ago. Table 2 shows a summary of some of the most frequently detected NPS in ecstasy across five European drug testing services. Some substances seemed unique to certain countries. 4-Fluoroamphetamine (4-FA) and its analogues only appeared in the Netherlands, as did 4-APB, 5-APB, 6-APB, PMMA and PMA. On the other hand, 4-methylethcathinone (4-MEC) did not appear on the ecstasy market in the Netherlands but it was present on the ecstasy markets of Switzerland, Spain and Austria. As a whole, the types of different substances detected on the ecstasy market increased throughout the years (Table 2).

New psychoactive substances (NPS)

Figure 11 shows the numbers of NPS samples that were detected by Austria, Switzerland, Spain, and the Netherlands across 2008–2013. These numbers clearly showed an increase. A large number of NPS were detected in samples that were not purposely sold as a NPS. The different types of NPS detected in drug samples also increased during the years, especially from 2011 onward (Figure 12). In Spain, the most new types of NPS were detected, whereas the Basque country and Switzerland generally encountered fewer types of NPS per year.

Discussion

Whereas drug markets are being monitored on a continuous basis by intergovernmental and global organizations, such as the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA)

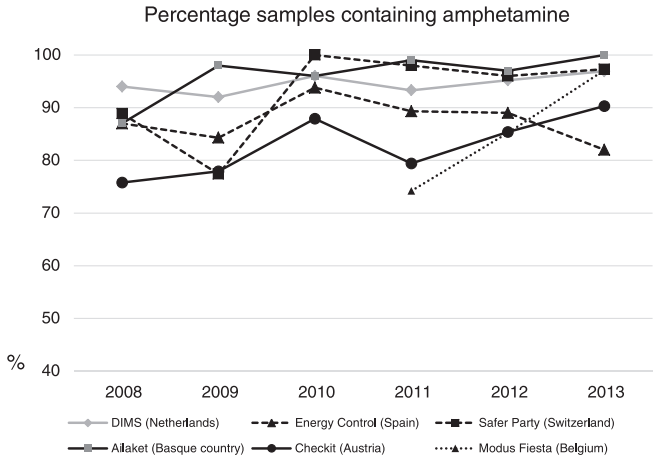

Figure 4. Prevalence of amphetamine detected in samples that were sold as amphetamine in six drug testing services across 2008–2013.
*Modus Fiesta only assembled data from 2011. Check!n did not systematically classify amphetamine powders.

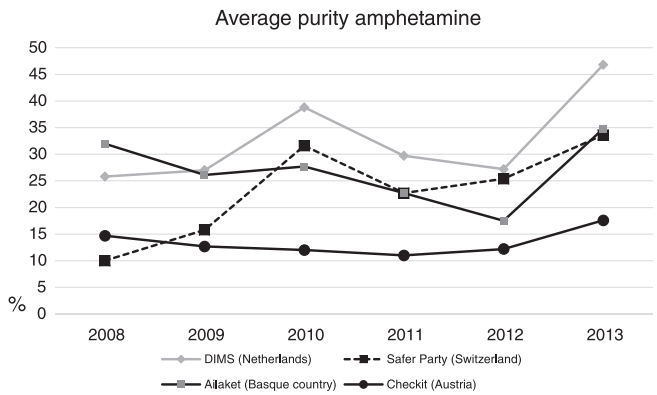

Figure 5. Average purity (in %) of amphetamine powders in four drug testing services across 2008–2013.
*Energy Control and Modus Fiesta performed no systematic quantifications of amphetamine. Check!n did not measure amphetamine purity.

and the United Nations Office on Drugs and Crime (UNODC), respectively, the sources offering drug market information to those organizations usually differ considerably from the consumer-targeted drug testing systems.[16,17,42] Most of the drug testing systems that were described in this study actually offer drug testing analysis results to the EMCDDA, but in the rest of the European countries, drug market information is based on police seizures only, which do not necessarily reflect the situation on the street retail level.[30] Consumer-derived drug testing systems reflect the street retail level more closely, since consumers hand in drugs they bought via dealers and other drug traders which makes it possible to accurately follow the domestic drug market in time. Forensic seizures do not merely reflect domestic, but also international drug trade and do not have the goal to monitor these market processes through time.[17] In addition, forensic seizure data often do not discriminate between large batches or small ones,[30,36,37] which raises questions at the representative value of these data for the domestic market, since some batches are much more widely distributed than others.

Results of this study demonstrated that the illicit drug markets from seven distinct European areas showed some important similarities, but also some interesting differences. In the case of some substances this might be due to the fact that the source of production and dispersion are the same. For instance, ecstasy pills were produced for a large part in the Netherlands during 2008–2013.[42] For this reason, it is not surprising that many other drug testing services found similar trends in the ecstasy market and that adulterants and substitute substances (NPS) were comparable following detection on the Dutch drug market first. Examples are the substances methylone, mephedrone and mCPP.[32,43,44] On the other hand, some NPS primarily occur in just one country, such 4-FA in the Netherlands. This might be due to specific desirable effects that are preferred more by a particular subpopulation.[45]

In addition, some substances are not controlled in one European country, while controlled in another. Since their proliferative rise in the late 2000s, there has been an ongoing worldwide debate about NPS and their legislation.[46–48] Another issue which may explain the striking prevalence of 4-FA in the Netherlands might have been associated with the control status of certain chemical precursors.[49]

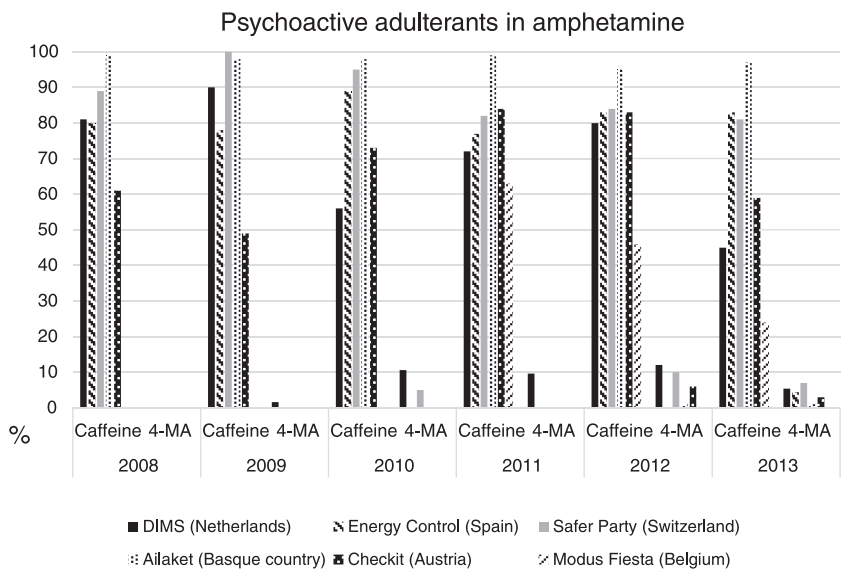

Figure 6. Prevalence of caffeine and 4-methylamphetamine (4-MA) in amphetamine powders across six drug testing services between 2008 and 2013.
*Modus Fiesta only assembled data from 2011. Check!n did not systematically detect these adulterants in amphetamine.

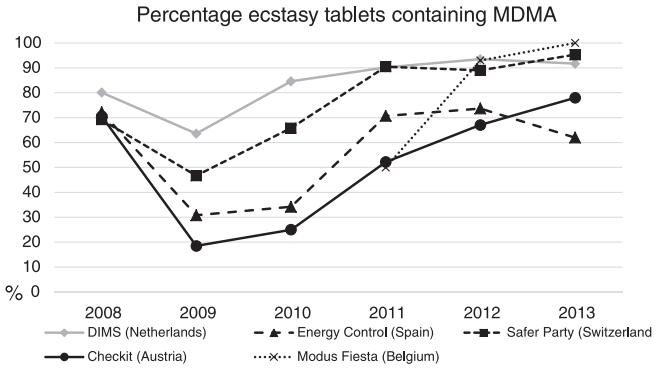

Figure 7. Prevalence of MDMA detected in tablets sold as ecstasy in five drug testing services across 2008–2013.*
*Modus Fiesta only assembled data from 2011. Check!n did not systematically classify ecstasy tablets.

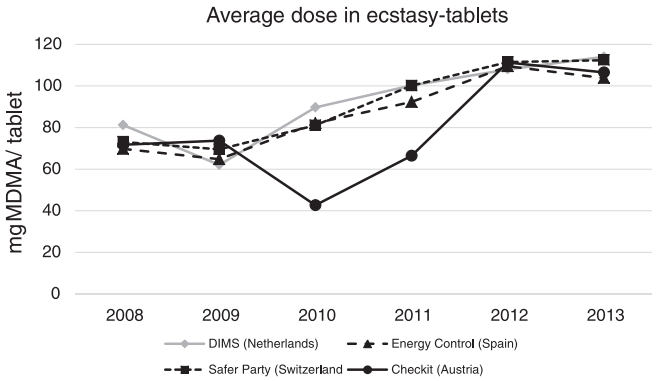

Figure 8. Average purity (in mg MDMA/tablet) of ecstasy tablets in four drug testing services across 2008–2013.*
*Modus Fiesta and Check!n performed no quantifications of ecstasy tablets.

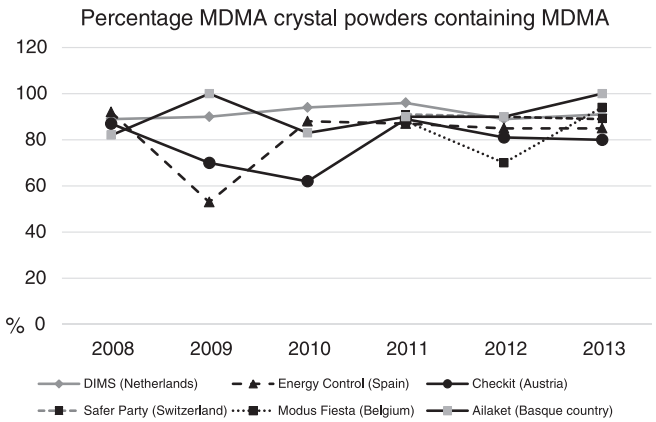

Figure 9. Prevalence of MDMA detected in MDMA crystal powders sold as MDMA in 6 drug testing services across 2008–2013.*
*Modus Fiesta only assembled data from 2011. Check!n did not systematically classify MDMA crystal powders.

For example, piperonyl methylketone (PMK) is a known internationally controlled precursor used in the manufacture of amphetamine, but 4-fluoro-PMK is not controlled. This might be one of the reasons why clandestine drug manufacturers have shifted to using this precursor in times where access to PMK proved difficult.[50]

Another interesting trend that was seen on the ecstasy market was the substantial increase in MDMA dose in ecstasy pills between 2008 and 2013 across all countries. There might be a number of

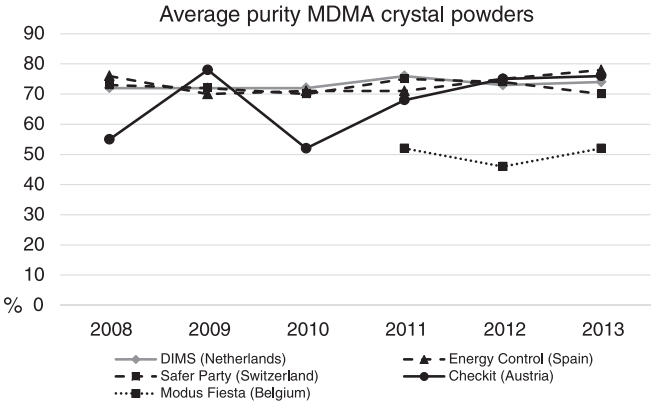

Figure 10. Average purity of MDMA crystal powders in five drug testing services across 2008–2013.*
*Check!n performed no quantifications of MDMA crystal powders.

reasons for this increase, but they all remain speculative. Perhaps the producers have increased their doses to regain consumer's trust and confidence in the ecstasy pill market again after the shortage of MDMA in 2009. Otherwise it could be speculated that the ecstasy producers are increasingly competing against the arrival of more and more NPS since 2009 and are improving their product to win the favour of consumers over the choice for other substances. In any case, this is a potentially worrying trend because the risks of adverse side effects and overdosing increase with higher dosed pills, especially when consumers do not anticipate this.

The cocaine market is a worldwide market and largely dependent on import from Latin American countries. The results in this study showed that there were some differences in the European countries concerning content and purity of cocaine, which might have reflected differences in import and trafficking. It is well-known that cocaine is being trafficked through various channels and via different countries.[42] It appeared that purity recorded in the Basque country was highest on average and lowest in Austria. This would be consistent with the fact that one of the import channels of cocaine is Northern Africa and Southern Europe.[42]

Another interesting finding was the fact that most adulterants detected were similar although there seemed to be an upward tendency of adulteration observed across the investigated time span. The local anaesthetics procaine and tetracaine were increasingly detected in cocaine powders. Another adulterant increasingly detected across all drug testing services was levamisole, which also seemed to have replaced phenacetin as major adulterant in most countries. Levamisole can cause serious effects following chronic exposure, including cytopenia which results in agranulocytosis and neutropenia.[51] It may also lead to vasculopathy, a ghastly looking skin condition.[52–54] While levamisole only causes these effects upon chronic exposure, it has to be noted that the average levamisole content in Dutch cocaine powders was 8.7% in 2013. In compulsive or chronic users, manifestations of neutropenia and vasculopathy might have to be considered.[55]

The amphetamine market showed some differences between the different European countries, especially in association with purity. In Austria, amphetamine purity was low in comparison to the Netherlands and Switzerland. There was a slight upward trend in purity across all countries. Although caffeine was the most common adulterant detected in amphetamine powders, there was an interesting incidence in 4-MA detection. In 2011 and 2012, several fatalities were ascribed to 4-MA in Belgium, the United Kingdom and the Netherlands.[56] In response, the substance was banned in 2012.

Table 2. New psychoactive substances most commonly encountered on the ecstasy market (tablets and powders) in 2008-2013 by five European drug testing systems

	Austria	Ailaket (Spain)	Energy Control (Spain)	Switzerland	The Netherlands
2008	mCPP	mCPP	Methylone, mCPP	2C-B, mCPP	mCPP, 2C-B, MBDB, BZP, DXM
2009	Methylone, mCPP	Methylone	Mephedrone, methylone, mCPP, DXM	mCPP, 2C-B	Mephedrone, methylone, 4-FA, 2C-B, mCPP, BZP
2010	Mephedrone, methylone	DXM	Mephedrone, methylone, mCPP, 2C-B, DXM	Mephedrone, mCPP, 2C-B	Mephedrone, methylone, MDDMA, 4-FA, 4-FMA, mCPP, pFPP, 2C-B, PMMA, PMA
2011	Mephedrone, methylone, mCPP, 2C-B, 4-MEC	-	Mephedrone, methylone, mCPP, 2C-B, DXM	Methylone, mCPP	Mephedrone, 4-FA, 4-FMA, mCPP, pFPP, 2C-B, PMMA, PMA, 6-APB
2012	Mephedrone, methylone, mCPP, 2C-B, 4-MEC	Mephedrone, DXM	Methylone, mCPP, 2C-B, DXM	Mephedrone, mCPP, 2C-B	Mephedrone, 4-FA, 4-FMA, mCPP, pFPP, TFMPP, 2C-B, 2C-I; PMMA, 4-APB, 5-APB, 6-APB
2013	Methylone, mCPP, 2C-B, 4-MEC	-	Mephedrone, methylone, mCPP, 2C-B, 4-MEC, DXM	mCPP, 4-MEC	Mephedrone, methylone, ethylone, 3-FMC, 4-FA, 2-FMA, 5-MeO-DiPT, mCPP, pFPP, TFMPP, 2C-B, DXM, PMMA, 4-APB, 5-APB, 6-APB

2-C-B, 2,5-dimethoxy-4-bromophenethylamine; 2C-I, 2,5-dimethoxy-4-iodophenethylamine; 3-FMC, 3-fluoromethcathinone; 4-MEC, 4-methylethcathinone; 4-FA, 4-fluoroamphetamine; 4-FMA, 4-fluoromethamphetamine; 5-MeO-DiPT, 5-methoxy-diisopropyltryptamine; 6-APB, 6-(2-aminopropyl)benzofuran; DXM, dextromethorphan; MBDB, N-methyl-1-(1,3-benzodioxol-5-yl)-2-butanamine; mCPP, *meta*-chlorophenylpiperazine; pFPP, *para*-fluorophenylpiperazine; TFMPP, 1-(3-trifluoromethylphenyl)-piperazine; BZP, benzylpiperazine; MDDMA, 3,4-methylenedioxydimethylamphetamine; PMA, *para*-methoxyamphetamine; PMMA, para-methoxymethamphetamine.

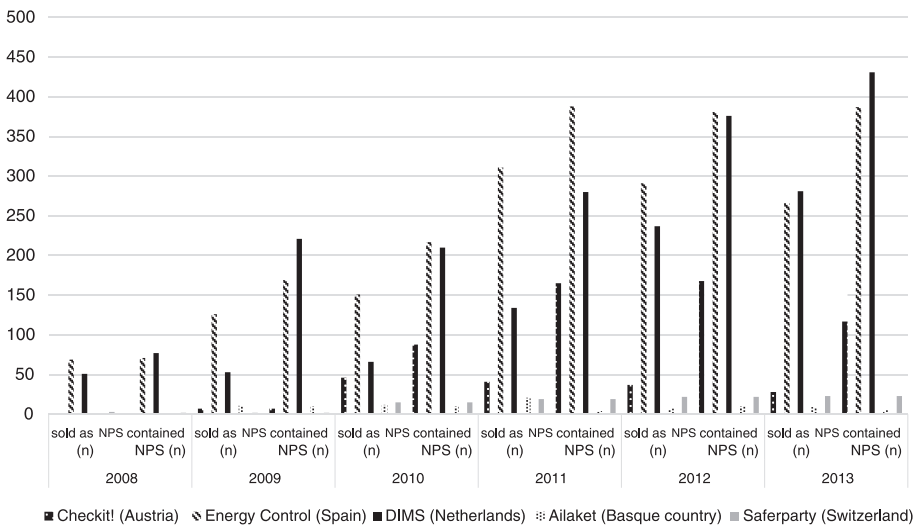

Figure 11. Numbers of drug samples that were sold as NPS and total numbers of samples wherein NPS were detected across five drug testing services across 2008–2013. NPS, new psychoactive substances; the term NPS refers to substances with a psychoactive effect that were recently offered on the consumer drug market, although they could be synthesized much longer ago.
*Check!n and Modus Fiesta did not systematically detect NPS or classify whether or not they were sold as such.

In line with reports from the EMCDDA the number of NPS detected in drug samples submitted to the drug testing services increased substantially over the last years in this study.[57] Both the number of samples that contained NPS and the types of NPS increased. This phenomenon is also supported by the fact that, over time, more drug users indicated to have used these substances, as was reported by the Global Drug Survey.[9] As the present study results showed, NPS were detected on the drug market via two ways: either NPS had been purposely bought under their own names, or NPS were detected in drugs that were bought as ecstasy or amphetamine.[58,59] This might result in different health consequences, because the health risks of most NPS remain unknown.

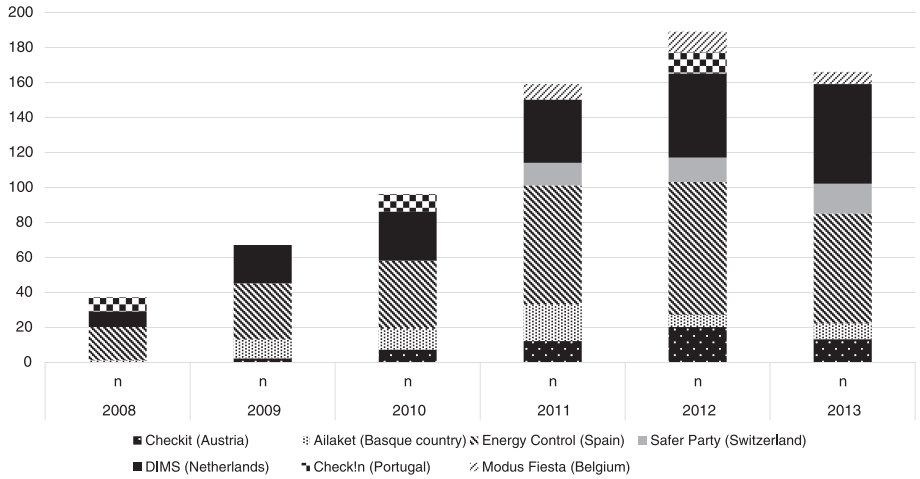

Figure 12. Number of different new psychoactive substances per year across seven drug testing services.
*Results of Check!n reflect the BOOM festival (Portugal), which is organized once every two years.

In fact, recent incidents and fatalities have urged the EMCDDA to do a number of risk assessments of substances, like 5-(2-aminopropyl) indole (5-IT), 4-methyl-5-(4-methylphenyl)-4,5-dihydrooxazol-2-amine (4,4′ DMAR), or 1-phenyl-2-(1-pyrrolidinyl)-1-pentanone (α-PVP).[60–62] This remains a matter of large concern to the drug testing services and this message is communicated to the drug using public continuously, as is the emergence of PMMA or 4-chloromethamphetamine in pills that were sold as ecstasy.[63,64]

One matter that needs to be addressed is the representativeness of these consumer-derived data. The drug users that engaged with the drug testing services during the study period did not necessarily represent all drug users.[17] A serious limitation in this respect was the fact that some drug testing services had a wide national reach and visited by large numbers of drug users weekly, whereas others (e.g. Belgium and Portugal) were much smaller in scale. This makes a stringent comparison difficult in some cases. Even with the larger drug testing services, these are still dependent on drug users that want to have their drugs analyzed. An unknown proportion of users may not be interested in drug analysis, which could introduce a selection bias in the type of drug users that visit the testing services. However, a comparison in a previous study, involving Austria and the Netherlands, it appeared that drug-testing users were broadly similar to non-testing users.[20] More recent studies also indicated that users who visited the drug testing service of Amsterdam were not that different from the general nightlife crowd commonly encountered in the Netherlands.[10,39]

Another issue that is important in interpreting the results in this study is the fact that it involved analysis results from different countries and laboratory techniques were different. This has complicated the comparability of the results. For instance, some laboratories analyzed their substances to the salt, whereas others analyzed them to the base. This was taken into account in the final calculations, but it might have impacted some of the purity results nonetheless. Also, the sensitivities of certain techniques were higher than others, making detection of small amounts of substance possible, whereas other techniques might have missed them. This could have impacted on the identification of NPS and adulterants that could have led to underreporting. Also, there could have been differences in the ability of laboratories to update their spectral databases. Newly emerging substances can easily be missed in the absence of spectral information. For future projects, it is strongly encouraged to have an inter-laboratory collaboration and exchange of information beforehand. For instance, a ring test could be used to compare performances of the different analytical systems used and to better characterize compounds.

Conclusion

The results of this study show that drug testing can be used to generate a global picture of various drug markets. It is important to spot the general trends and differences between various countries, especially from the perspective of risk assessment. Since drug testing services derive information directly from the drug users and aim their activities directly at this target group, they offer the opportunity to perform prevention policy in practice, for example by warning campaigns and direct communication which is fact-based. In addition to chemical analysis data, drug testing services are fed by information about the drugs given by the drug users themselves, such as effects of a substance and precise location of purchase. This creates a system of pharmacovigilance that can be used, and has been used, for further risk assessments of substances. Moreover, drug testing services can be an instrument to offer some control over a market that is otherwise unpredictable and treacherous. For example, drug dealers and manufacturers will be less inclined to trade in dangerous substances or adulterants if they know that there is a way for consumers to test their product. Also, if a dangerous substance can be identified and localized via a warning campaign, drug traders are more inclined to rapidly withdraw their products from the market.

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