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Research paper

A comparison between wastewater-based drug data and an illicit drug use survey in a selected community

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ABSTRACT

Background: Estimations of drug use are mostly based on population surveys that can suffer from response biases. The current study evaluates using wastewater-based epidemiology (WBE) for assessing illicit drug use by comparing wastewater data with that from a population survey.
Methods: Introductory letters (29,083) were sent to inhabitants of Lier, Belgium, asking them to participate in an online survey study. Participants were asked to indicate their drug use in the past week for a 12-week period (September–November 2014). Concomitant wastewater samples were collected from the associated wastewater treatment plant in four bi-weekly periods. Samples were analyzed using solid-phase extraction and liquid chromatography coupled to tandem mass spectrometry (LC–MS/MS).
Results: On average, 263 (1%) inhabitants filled out the questionnaire each week. According to the survey results, cannabis was the most used drug, followed by amphetamine, cocaine and methylenedioxymethamphetamine (MDMA). Wastewater data corroborated these results. Cocaine, amphetamine and MDMA showed a significant difference between days of the week. The four sampling periods differed significantly from each other for cocaine, amphetamine and methadone.
Conclusion: Observed drug consumption patterns from survey and wastewater data match national and international data. Wastewater analyses confirm that WBE can be reliably used to confirm patterns and trends in drug use. Future studies should focus on identifying the most opportune sampling period giving the most reliable estimates of drug use and use smaller, contained communities such as festivals or prisons if methodology allows.

Introduction

Based on survey studies an estimated 5.3% of European adults have used cannabis in the past year (EMCDDA, 2014). However, it has been questioned how reliable these results are since survey studies suffer from a number of methodological issues. Firstly, drug users are in general a challenging population to work with when it comes to survey research. The overall low number of current drug users decreases the chances of including them in a general population survey, thereby gathering too little data to make a reliable statement about drug use in that population. Also, drug users as a population may be less likely to fill out the surveys, for example because they are afraid of judicial consequences or because they live in a situation where they cannot be reached (i.e. not having a postal address). Furthermore, due to the work-intensive nature of population surveys, it can take several weeks to months from the starting point of a survey study until the results of a survey can be communicated. Considering the dynamic character of the drug market, use patterns could have changed during that time and new drugs and trends may have emerged, thereby decreasing the validity of the survey (Griffiths & Mounteney, 2010). However, one of the greatest issues with survey research is the possibility of reporting errors on a certain topic due to its sensitive nature, as is the case with questions on drug use (Tourangeau & Yan, 2007). This makes population surveys vulnerable to response biases since users may either under- or over-report their drug use.

There are a number of options to either circumvent these issues concerning collecting data on drug use or to supplement the

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information collected from survey research. These include extrapolating from registered traffic accidents, hospital admissions or admission to addiction clinics as well as looking at police data on drug seizures and trafficking. However, none of these methods can give the full picture of actual drug consumption. Thus, there is a lack of data on current drug use in the general population and methods complementary to traditional studies are necessary. These methods should not only complement current measures of drug use in the population, but may also make it possible to combine both subjective and objective measures of drug use and thereby increase the accuracy of drug use epidemiology significantly.

One of these potentially useful new approaches is analyzing wastewater to assess the use of illicit drugs in an area served by a wastewater treatment plant (WWTP). Hereby, wastewater is analyzed for the presence of drug target residues (DTRs): parent compounds and/or metabolites. DTRs end up in wastewater after drug use, metabolism and subsequent excretion. In the past 10–15 years, the field of wastewater-based epidemiology (WBE) has seen important improvements. Since its first application in 2005 (Zuccato et al., 2005), wastewater analysis techniques for DTRs have continued to be refined and extended and protocols for the correct handling and storage of wastewater samples have been developed (Castiglioni et al., 2013a). WBE has a number of advantages over traditional survey methods of estimating drug use. The presence of DTRs can be measured in near real-time as time from sampling to data reporting takes approximately two weeks (anecdotal evidence). Thus, trends and changes in drug use can be detected faster and more accurately than with traditional survey-based techniques. Furthermore, since WBE is performed on the combined wastewater from a large number of households (i.e. the catchment area of a WWTP), none of DTRs in the wastewater can be traced back to a certain individual. This makes the method truly anonymous and, if done in large enough samples, without major ethical issues (Hall et al., 2012; Prichard, Hall, de Voogt, & Zuccato, 2014). Finally, the use of DTRs as objective indicators of drug use could eliminate the need for subjective reporting from the population if the goal is performing a quantitative measurement of drug use. However, as mentioned by Castiglioni, Thomas, Kasprzyk-Hordern, Vandam, and Griffiths (2013), research making a direct comparison between WBE data and traditional epidemiological indicators has been scarce. This is necessary in order to promote the use of WBE either as the sole or as an additional method for monitoring drug use in the general population. Previous research on combining WBE with other epidemiological methods has highlighted the need for using comparable populations while performing these studies (e.g. a WWTP and survey covering the same population) (Reid et al., 2012). This would require a rigorous approach whereby WBE and population surveys are conducted simultaneously. Therefore, in the study described here the aim was to compare the usefulness of WBE for assessing illicit drug use in a community by comparing the results of wastewater analysis with those from a concomitantly administered population survey.

Methods

Wastewater samples

Sampling

During autumn 2014, a bi-weekly sampling campaign was set up in the WWTP of Lier, Belgium. The selected WWTP has a design capacity of 30,600 inhabitant equivalents (data from www.aquafin.be, accessed 23-01-2015) and serves around 35,000 inhabitants. The city of Lier was chosen for this study because the WWTP covered only the city of Lier, so that the data obtained from the wastewater study and the data from the survey study would cover the same population. Another advantage for choosing Lier is that it does not have a large commuter population, which again contributes to doing better comparisons.

The sampling campaign resulted in data from four two-week periods (called sampling sessions), spanning 01 September 2014 until 30 November 2014. For each two-week period, 24-h composite wastewater samples were collected daily. The composite sampling was done in a time-proportional manner with 10-min time intervals. All samples were collected in high-density polyethylene containers and stored at −20 °C until analysis.

Analytical methodology

Wastewater samples were analysed according to previously validated and published methods (Kinyua et al., 2015; van Nuijs et al., 2009a, 2013). Samples were first filtered through a glass filter (0.7 μm retention capacity) to remove solid particles. This was followed by a solid-phase extraction (SPE) procedure on Oasis MCX and Oasis HLB cartridges to concentrate analytes and remove interferences. Resulting extracts were analyzed by liquid chromatography coupled to tandem mass spectrometry. The DTRs of interest were cocaine, benzoylecgonine (BE, being the main human metabolite of cocaine (Jufer, Walsh, & Cone, 1998)), amphetamine, methamphetamine, methylenedioxymethamphetamine (MDMA), 2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine (EDDP, as the specific metabolite of methadone), ketamine, 6-monoacetylmorphine (6-MAM, as the specific human metabolite of heroin), and 11-*nor*-9-carboxy-delta-9-tetrahydrocannabinol (THC-COOH, as the specific metabolite of cannabis). Further details about sample preparation, analysis and quality control are described elsewhere (Kinyua et al., 2015; van Nuijs et al., 2009a, 2013).

Measured concentrations (in ng/L) were multiplied by the flow rate of the sample (in L/day) to obtain mass loads (expressed in mg/day) for all DTRs. Correction factors (Castiglioni et al., 2013a; Ort et al., 2014) were then applied to the mass loads for each DTR in order to calculate actual drug use and correct for differences in excretion patterns of illicit drugs (see Table SI-1). This results in a value referred to as 'drug consumption' (expressed in mg/day).

Surveys

In August 2014, 29,083 introductory letters were sent out to the inhabitants of Lier above the age of 15 to inform them about the study and how they could participate. In order to preserve the privacy of the participants, all the addresses were collected by employees of the city council and letters were sent using an external mailing company. At no point in data collection did the researchers have access to personal information about the participants, except that which they chose to divulge themselves.

In the introductory letter, it was explained that a web-based survey would be made available during the same period as the wastewater sampling campaign (i.e. September 2014–November 2014) and the addressee was asked to fill out this questionnaire. Furthermore, it was made clear that although the weekly completion of the survey was preferred, every type of participation was allowed (e.g. once, twice or more times). Participants could choose to leave their through which they would receive a reminder to fill out the questionnaire each week. While the focus of the survey was on the past-week use of illicit drugs (cannabis, cocaine, (meth)amphetamines, heroin, MDMA, ketamine, new psychoactive substances (NPS) or mephedrone), participants were also asked to indicate if they had used alcohol, tobacco or a number of pharmaceutical drugs such as codeine, methadone, dextroamphetamine (Dexedrine®) or methylphenidate (Concerta®, Ritalin®) in the past week. If the answer was "no" for all substances, they could click ahead to the end of the questionnaire. If the answer was "yes", a page opened with further questions on the use of the selected substance, such as the number of days they used, the