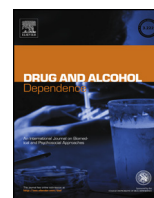




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Assessing geographical differences in illicit drug consumption—A comparison of results from epidemiological and wastewater data in Germany and Switzerland

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ABSTRACT

Background: Wastewater analysis is an innovative approach that allows monitoring illicit drug use at the community level. This study focused on investigating geographical differences in drug consumption by comparing epidemiological, crime and wastewater data.

Methods: Wastewater samples were collected in 19 cities across Germany and Switzerland during one week, covering a population of approximately 8.1 million people. Self-report data and consumption offences for the investigated areas were used for comparison and to investigate differences between the indicators.

Results: Good agreement between data sources was observed for cannabis and amphetamine-type stimulants, whereas substantial discrepancies were observed for cocaine. In Germany, an important distinction could be made between Berlin, Dortmund and Munich, where cocaine and particularly amphetamine were more prevalent, and Dresden, where methamphetamine consumption was clearly predominant. Cocaine consumption was relatively homogenous in the larger urban areas of Switzerland, although prevalence and offences data suggested a more heterogeneous picture. Conversely, marked regional differences in amphetamine and methamphetamine consumption could be highlighted.

Conclusions: Combining the available data allowed for a better understanding of the geographical differences regarding prevalence, typology and amounts of substances consumed. For cannabis and amphetamine-type stimulants, the complementarity of survey, police and wastewater data could be highlighted, although notable differences could be identified when considering more stigmatised drugs (i.e. cocaine and heroin). Understanding illicit drug consumption at the national scale remains a difficult task, yet this research illustrates the added value of combining complementary data sources to obtain a more comprehensive and accurate picture of the situation.

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1. Introduction

The consumption of illicit drugs in a given population or community remains a partially hidden activity that cannot be directly

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measured nor totally unveiled. Traditionally, the nature, versatility and extent of this phenomenon are assessed through the use of indicators such as consumption surveys or descriptive statistics. The last decade has seen the emergence and refinement of wastewater-based epidemiology (WBE), which relies on quantitative measurement of specific biomarkers of illicit drug use in wastewater. Presented as a complementary approach to current surveillance methods (Amundsen and Reid, 2014; Been et al., 2015; Bramness et al., 2014; Reid et al., 2012, 2011), WBE has received much attention. Although further developments will most probably refine it in the near future, WBE already enables the gathering of unique spatio-temporal information about consumption (Ort et al., 2014). Nevertheless, information about consumers (e.g. age, sex, socio-economical status and history of drug use), crucial for policy makers, cannot be gathered by this approach, but requires the use of classical monitoring tools. Yet, these are also affected by some limitations such as the difficulty to obtain representative estimates, long study times, high costs and difficulties in reaching specific groups of regular users (Banta-Green and Field, 2011; Ort et al., 2014).

In general, estimating and monitoring drug use relies on direct and indirect methods (European Monitoring Centre for Drugs and Drug Addiction; EMCDDA, 2015a). The former are mainly based on general population surveys (GPS), where a representative sample of the population is questioned about illicit drug use. The latter rely on extrapolating information about drug use from other sources indirectly related to drug use such as police statistics, treatment data as well as WBE. Despite suffering from the abovementioned limitations, these methods provide a partial, yet informative perspective of the phenomenon. By bringing together different and complementary data sources, it is expected to obtain a more precise understanding of the dynamics of illicit drug use at the national level.

In this study, samples collected from different wastewater treatment plants (WWTP) in Germany and Switzerland (including Liechtenstein) were analysed. Estimates of the average daily consumption of illicit drugs were computed based on these measurements and pharmacokinetics data available in the literature. Results obtained from wastewater analysis were compared to data derived from GPS and consumption offences registered by police forces. The aim of this study was to evaluate geographical differences and formulate hypotheses explaining divergences in the data sets. The cities investigated in the context of this study are shown in Fig. 1. Focus was set on the use of cocaine, cannabis, heroin, amphetamine, methamphetamine, and 3,4-methylenedioxymethamphetamine (MDMA or ecstasy).

2. Materials and methods

2.1. Epidemiological data and police statistics

General population survey data included the reported prevalence of use during the 12-months prior to questioning with a focus on the investigated areas (see Fig. 1 and Table 1; Kraus et al., 2015, 2014, 2010a,b, 2001; Social and Market Research Institute and Addiction Suisse, 2015). Reported substances were: cocaine, cannabis, amphetamine and amphetamine-type stimulants (ATS)—such as methamphetamine and MDMA (for Germany only) and heroin (for Switzerland only). For Germany, available data was representative of the Federal States (Bundesland; Kraus et al., 2010a,b, 2001), except for Berlin, where capture/recapture methods were used to derive the estimates (Kraus et al., 2015, 2014). For Switzerland, survey data included responses provided by participants living within the catchments of the considered WWTP

(Social and Market Research Institute and Addiction Suisse, 2015). See Supplementary material for more details about GPS data used.

Police statistics consisted of the number of offences for illicit drug use registered in the investigated areas during 2013 (Switzerland) and 2014 (Germany). Data were expressed as number of offences per year per thousand inhabitants. Epidemiological data and police statistics were not available for Liechtenstein.

2.2. Wastewater data

Amphetamine, methamphetamine and MDMA were quantified in wastewater samples together with the specific urinary metabolites of cocaine (i.e. benzoylecgonine), cannabis (i.e. 9-carboxy-delta-9-tetrahydrocannabinol, THC-COOH) and heroin (6-monoacetylmorphine, 6-MAM).

Daily 24-h composite raw wastewater samples were collected over 7 consecutive days in March, 2014, from 19 cities (in total 22 WWTPs) across Germany and Switzerland (including Liechtenstein), as shown in Fig. 1 and Table 1. Wastewater samples were analysed using validated liquid-chromatographic tandem mass spectrometric methods. Details on the analytical procedures can be found in Bijlsma et al. (2014) (samples from Germany), Castiglioni et al. (2006) (Lugano), Been et al. (2015) (Chur, Lausanne, Lucerne, Neuchatel and Sion) and Berset et al. (2010) (Basel, Bern, Geneva, St. Gallen, Zurich, Winterthur and Liechtenstein (Bendern)). All laboratories are involved in the multi-city study published by the EMCDDA (2015b) and the analytical performance of methods used were assured by the participation in external inter-laboratory exercises.

Average daily population normalised loads (concentrations multiplied by daily wastewater flows and divided by the number of inhabitants), back-calculations (daily consumption of parent compound based on estimated loads and excretion data) and the associated errors were estimated for each city using Monte Carlo simulations, following existing procedures (Been et al., 2015; Jones et al., 2014). The parameters used are reported in Tables 2 and 3. For Berlin, the results from the four WWTPs were merged to be representative of the catchment area covering the entire city.

Nationwide estimates of illicit drug use were computed using a series of ordinary least squares and mixed effect models. The back-calculated amount of parent compound consumed in each city per day of the week was used as response variable. The number of inhabitants was used as predictor variable in ordinary regression analysis, while for mixed effect models, the day of the week was also included as (random) predictor variable. Additional information about wastewater data can be found in Supplementary material.

3. Results

3.1. Population surveys

Estimates of last-year prevalence of cocaine, cannabis and ATS in the investigated cities are shown in Figs. 2 and 3 and Table 4.

The highest prevalence for cocaine (2.8%) was measured for Berlin, with much lower levels in the other Federal States (0.4–0.8%). In Switzerland, Lausanne was highest (2.3%), followed by Lucerne (1.2), Geneva (1.0%), Zurich (0.9%) and Winterthur (0.9%). For cannabis, the highest prevalence in Germany were reported for Berlin (11%) and Dortmund/Dülmen (7.3%), with lower figures for Dresden (4.0%) and Munich (3.5%). In Switzerland, prevalence of cannabis use was far more homogeneous (average $7.0 \pm 2.2\%$), except for Sion and Lugano with very low levels (1.6% and 3.7%, respectively). Last-year prevalence data for amphetamine and ATS was available only for Germany, with the highest figures reported for Berlin and Dresden (see Fig. S1).

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