An analysis of ethical issues in using wastewater analysis to monitor illicit drug use

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Abstract

Aims To discuss ethical issues that may arise in using WWA to monitor illicit drug use in the general population and in entertainment precincts, prisons, schools and work-places.

Method Review current applications of WWA and identify ethical and social issues that may be raised with current and projected future uses of this method.

Results Wastewater analysis (WWA) of drug residues is a promising method of monitoring illicit drug use that may overcome some limitations of other monitoring methods. When used for monitoring purposes in large populations, WWA does not raise major ethical concerns because individuals are not identified and the prospects of harming residents of catchment areas are remote. When WWA is used in smaller catchment areas (entertainment venues, prisons, schools or work-places) their results could, possibly, indirectly affect the occupants adversely. Researchers will need to take care in reporting their results to reduce media misreporting. Fears about possible use of WWA for mass individual surveillance by drug law enforcement officials are unlikely to be realized, but will need to be addressed because they may affect public support adversely for this type of research.

Conclusions Using wastewater analysis to monitor illicit drug use in large populations does not raise major ethical concerns, but researchers need to minimize possible adverse consequences in studying smaller populations, such as workers, prisoners and students.

INTRODUCTION

It is difficult to monitor population use of drugs such as the amphetamine-type stimulants, cannabis, cocaine and heroin, whose use is prohibited by law [1]. Lack of information on their use makes it challenging to evaluate the effectiveness of policies implemented to reduce the harm that these drugs cause [1–4]. Traditional methods of monitoring such as household surveys of illicit drug use in the population have major limitations. Illicit drug users are likely to be under-represented in such surveys; if included, they may under-report their drug use, especially of stigmatized drugs such as heroin; and they often do not know the composition of the drugs that they report using [1,5,6]. Surveys are also expensive to conduct, are rarely carried out more often than annually and there are substantial delays in publishing their results [2,7,8]. The use of most illicit drugs (except for cannabis) is reported by fewer than 5% of household survey respondents, so very large samples are needed to estimate trends in their use [3,4].

Indirect indicators of drug use, such as numbers of drug arrests and people seeking treatment for drug dependence [8], have different limitations. Police arrest data, for example, are affected by the allocation of law enforcement resources; health-related harms may not be recognized by illicit drug users, may not be treated by the health-care system, may not be recognized as drug-related by health professionals and may not be recorded as drug-related [8]. Unique indicators of harm among illicit drug users [e.g. fatal and non-fatal drug overdoses; treatment for withdrawal, dependence; and blood-borne virus (BBV) infections] only occur typically after years of illicit drug use [7,8], which makes them poor indicators of current drug use trends.

Wastewater analysis (WWA) is a novel approach that promises to overcome these limitations by estimating levels of population illicit drug use from concentrations of excreted drug residues and metabolites in wastewater [9–11]. WWA promises to be more objective than survey data because it does not depend on self-reported drug use, it is not affected by low response rates [11,12] and it can potentially provide objective, continuous, near real-time estimates of drug use in the population [9,11].

The concept of WWA can provoke strong adverse reactions from civil rights advocates, who fear its possible misuse by law enforcement officials [13,14]. Hering [14], for example, has raised the spectre of the US government monitoring the illicit drug use of individual citizens via sensors in their wastewater pipes and toilets. Some US city governments have refused to allow sampling from their wastewater treatment systems for fear that the findings will affect the cities' reputations adversely [13,15]. These concerns and the issues underlying them need to be addressed if WWA is to be used routinely in monitoring illicit drug use.

Ethical issues raised by WWA research and its potential future applications have been noted, but not discussed in any depth in the literature (for an exception see [10]). Analyses of ethical issues in epidemiology in general (e.g. [16]) and drug use epidemiology in particular (e.g. [17]), public health surveillance (e.g. [18,19]) and environmental health research [20] provide little guidance. These analyses deal with ethical issues that arise in research that collects data from individuals (e.g. on self-reported drug use, infectious disease serostatus and biological samples). These ethical issues include: the capacity of drug users to consent to study participation [17]; the circumstances in which de-identified data may be used without subject consent [18]; and ensuring the confidentiality of sensitive information about drug use which

could seriously disadvantage individuals if disclosed to third parties [17]. None of these ethical concerns are relevant to WWA studies. Waste samples are collected from individuals without their consent, but these are collected as a composite sample which has been contributed to by a very large number of people, and so individuals are not identifiable.

None the less, we think it essential to consider ethical concerns that may be raised by specific applications of WWA in public health and law enforcement. Before doing so we describe briefly the rationale of WWA and summarize the evidence on its strengths and limitations. We then outline our approach to ethical analysis and consider ethical issues that could potentially arise in using WWA in various settings. We begin by discussing the use of WWA to monitor patterns of illicit drug use in the general population, and then consider ethical issues that may arise if it is used in settings where smaller populations contribute to wastewater samples, such as entertainment areas, prisons, schools and work-places. We conclude with a brief discussion of civil rights issues raised by possible future uses of WWA by law enforcement officials.

THE PROMISE OF WASTEWATER ANALYSES IN ESTIMATING ILLICIT DRUG USE

Illicit drugs and their metabolites are excreted in faeces and urine at levels (nanograms per litre) that can be measured in the influent to wastewater plants using chromatography and mass spectrometry [9,12]. Daughton [9] first suggested that methods used to measure pharmaceutical drugs in waterways could be used to measure illicit drug use in the population. Zuccato and colleagues published the first such study of cocaine in wastewater in Milan [21]. Since then, studies have been conducted of drug residues and metabolites of amphetamine-type stimulants, cannabis, cocaine and heroin and other opioids [21–23] in Australia [24,25], Belgium [26], Canada [27], Croatia [28], France [29], Norway [30], Spain [31] and the United States [32] (see recent reviews [11,12]).

WWA is a new and developing technology, so there are methodological differences between studies that make it difficult to compare directly findings by different investigators [12]. These include variations: in wastewater sampling methods (e.g. timing, frequency and duration of sampling) [33]; in the metabolites and drug residues tested for and the analytical methods used to quantify these substances [11,12]); and in how population drug consumption is back-calculated from drug residues [11].

None the less, the published studies provide promising qualitative support for the validity of WWA in monitoring trends in illicit drug use in the population. First, the rank order in which traces of illicit drugs have been detected in WWA corresponds broadly to the rank ordering of their self-reported use in population surveys [11,12,22]. Secondly, temporal variations in detection of drug traces correspond to variations in self-reported patterns of use. Levels of cocaine use, for example, are higher at weekends than on weekdays, whereas estimated levels of heroin use are more consistent throughout the week. Zuccato *et al*. [34] reported declines in rates of cocaine and heroin use and increases in rates of cannabis and amphetamines that paralleled changes in the reported use of these drugs in epidemiological surveys in Europe between 2007 and 2009 [34]. Thirdly, WWA studies also report geographic variations in levels of illicit drug use that correspond broadly with those in epidemiological surveys; within countries, higher levels of illicit drug use are estimated in larger than smaller cities and rural areas [22]; and higher rates were estimated in London than in Milan and Lugano [22].

We predict that WWA will not be used as a stand-alone method of monitoring illicit drug use, because epidemiological studies of drug use in wastewater catchment areas will be needed to understand WWA findings and vice versa [2,10,35]. WWA can, none the less, provide a useful additional indicator of illicit drug use in the population [2,10], with the very substantial advantages of providing cheaper, objective near real-time data on drug use in whole populations.

Our approach to ethical analysis

We consider uses of WWA by using a set of influential ethical principles that have often been used in assessing the ethics of biomedical and epidemiological research; namely, the principles of respect for autonomy, non-maleficence, beneficence and distributive justice [17,36,37].

Respect for autonomy

Respect for autonomy is usually taken to mean that we should respect and not interfere with the actions of rational persons (who in most cultures are usually taken to be adults). In biomedical and epidemiological research, the principle of respect for autonomy is generally taken to require: that research participants give informed and voluntary consent to participate in research; that the confidentiality and privacy of personal information will be respected; and that researchers will be truthful about any risks that may arise from study participation [17,36].

Non-maleficence

The principle of non-maleficence requires researchers to avoid causing harm, or placing participants at risk of harm. In biomedical research, the principle requires researchers to minimize the risks of direct harm to research participation [37].

Beneficence

The principle of beneficence requires that research studies have a reasonable chance of producing benefits, and that the benefits of research outweigh any burdens or risks of participation [36].

Distributive justice

The principle of distributive justice requires a fair and equitable distribution of the burdens and the benefits of research participation [37]. A fair and just research policy would aim to ensure: that the risks of research participation were not unfairly distributed (e.g. confined to the poor and indigent); and that any benefits of research participation (e.g. access to promising new treatments) were shared fairly by all who may potentially benefit [36].

The assessment of whether a research proposal satisfies these requirements is usually undertaken by an independent ethics review body or Institutional Review Board [37,38].

ETHICAL ISSUES IN WWA IN THE GENERAL POPULATION

The use of WWA to study trends in illicit drug use in large catchment areas does not raise any major ethical issues when evaluated using the principles of respect for autonomy (consent and

confidentiality) and non-maleficence (direct harm to participants). It is impossible to identify any individual because wastewater samples come from an environmental source, so confidential information is protected. Because individuals cannot be identified they cannot be harmed *directly* by such studies. There is a possibility of indirect harm—such as stigmatization of residents in a wastewater catchment area—but this is remote because the catchment areas used for population monitoring purposes typically include 10 000 or more people (often several hundred thousand), and the estimated rates of illicit drug use in these catchment areas are likely to be much lower than 10%. Given the negligible risk of harm, consent is not required. It would, in any event, not be possible to seek informed consent of all individuals—residents and visitors—who contributed to a wastewater sample.

WWA satisfies the principle of beneficence because it potentially provides non-intrusive monitoring of temporal trends in illicit drugs use within the population of a large catchment area. It can also identify new illicit drugs that may be used and it can be used to evaluate the effectiveness of policies that aim to reduce the supply of or demand for drugs. Its findings can also potentially be used to inform drug users of the identity of the substances that they may, perhaps unknowingly, be using [39]. The results of WWA studies can therefore potentially improve public health, the health of illicit drug users and the evaluation of law enforcement efforts to reduce illicit drug supply.

Distributive justice is also well served by WWA studies. No social groups are singled out or even potentially identifiable in such studies, because the whole population of the catchment area contributes to its findings and drug users may benefit from such studies.

For all these reasons, we argue that WWA studies of large populations do not raise major ethical issues. This was also the conclusion of an Australian research ethics committee that ruled that ethical approval was not required for wastewater studies undertaken by the authors.

ETHICAL ISSUES IN WWA STUDIES IN SPECIAL VENUES

Entertainment venues

WWA methods could potentially be used to monitor illicit drug use in entertainment venues, rock concerts or festivals, dance parties or pubs and nightclubs. There may be legal obstacles in obtaining such wastewater samples if venue operators refuse to allow their collection. However, it is unlikely that operators could prevent sampling from wastewater that came from multiple premises, and did not occur at an outlet on their property. Issues of consent and privacy also do not arise if the catchment area is an entertainment precinct because individuals cannot be identified.

WWA studies could possibly have negative effects such as economic losses for businesses (e.g. pubs, clubs and hotels) within the catchment area, but this seems unlikely. The patrons of entertainment precincts in large cities are well known to have higher rates of illicit drug use than the general population. It is also unlikely that WWA studies will produce more economic harm to such operators than media reports of arrests or epidemiological studies of drug use or drug-related harms (e.g. overdoses attended by ambulances) within these areas. Any such hypothetical adverse social effects are likely to be outweighed by the potential public health benefits of improved knowledge about levels of illicit drug use in the community. Patrons of these precincts could also benefit from such studies if warnings were issued about the risks of

using the illicit drugs identified in wastewater samples. Researchers should, none the less, take care in reporting the results of such studies to avoid causing unintended harm to residents of catchment areas.

WWA studies in prisons

There is a good case for conducting WWA studies in prisons. High proportions of prisoners are drug offenders and drug use occurs in prisons, albeit at a lower level than in the general population [40–42]. Drug use in prisons endangers the health and safety of prisoners and prison staff [40,42]. Drug smuggling in prisons can lead to violence and drug use may cause fatal overdoses and BBV infections in prisoners [42]. For these reasons, prisons make considerable efforts to detect drug use by prisoners, e.g. by conducting urinalyses and cell searches and searching prison visitors. One prison WWA study has been conducted; Postigo *et al*. [43] measured illicit drug traces in wastewater from one prison in 2009. They found that cannabis and cocaine were used more consistently over time than heroin and amphetamines, and that levels of illicit drug use in the prison were much lower than those in a nearby city.

Prison WWA studies measure drug use in ways that do not identify individuals using methods that are much less intrusive than urinalysis and cell searches. The major ethical concerns about prison WWA studies arise from possible policy responses to their findings that could affect all inmates adversely, including those who do not use illicit drugs. Prison authorities could, for example, respond to WWA indications of illicit drug use by eliminating contact visits with families to reduce drug smuggling. This would, arguably, be a form of collective punishment.

Such punitive responses are NOT unique to WWA studies; they could also be triggered by seizures of drugs, overdose deaths or positive results from urinalyses of individual prisoners. Researchers will, none the less, need to discuss carefully possible policy responses to their findings with prison officials before conducting these studies. They may want to reconsider their involvement if punitive sanctions are likely; and they should think carefully about the way in which the results of these studies are reported in the media. We recommend that researchers avoid identifying particular prisons to reduce the risk that the media will stigmatize an entire inmate population, prompting punitive policy responses.

WWA research in schools and work-places

WWA studies in high schools are likely to raise similar ethical objections on the part of teachers and schools, and parents of students to individual drug testing in this setting [44]; namely, that publication of research findings could stigmatize all children and young people at schools where WWA was performed. This would be a reasonable concern if particular schools were singled out for testing and named when WWA findings were made public. These concerns would be reduced if WWA sampling was performed in a similar manner to school surveys of drug use, e.g. if schools were selected randomly for sampling, if aggregate-only results of WWA studies in schools were reported, and if none of the participating schools were identified publicly.

We doubt that WWA research in the school setting should be a high priority, because studies in schools may be less useful than in other settings. The only published study to date, for example, found much lower levels of illicit drug use in the school than in the general population [45]. It may also not be clear if all residues are from illicit drugs, because school

children may be prescribed stimulant medication for attention deficit hyperactive disorder (ADHD), such as Dexedrine, which cannot be distinguished easily from the use of illicit amphetamine in WWA studies. Low levels of most illicit drug residues (apart possibly from cannabis) would also be expected in school wastewater because most illicit drug use in secondary school populations would be infrequent; regular illicit drug use is more likley to occur among early school leavers and in early adulthood, after students have left school [46].

Similar concerns are likely to be raised by WWA studies in work-places. There is considerable controversy about the value and acceptability of work-place illicit drug testing [47]. This controversy may also affect WWA studies, even though they could potentially reduce the need for individual drug testing, thereby affording greater privacy to workers. Moreover, it is not easy to conduct WWA studies in individual schools or work-places. The equipment for WWA studies is often in place in wastewater treatment plants, but this is not true of the effluent from individual buildings. Additionally, limited physical access to sewers on a premise, intermittent flows and highly fluctuating concentrations complicate the collection of representative samples. This challenges the reliable quantification of illicit drug loads and it may be more difficult to do so unobtrusively without stigmatizing individual work-places or schools.

For these reasons, there needs to be more debate about the ethical and social justification for conducting WWA studies in schools and work-places. We argue that WWA studies in these settings should be given low priority until WWA methods have been used extensively, and discussed publicly, in less contentious settings such as sampling from catchment areas with much larger populations or that include entertainment precincts.

POSSIBLE USES OF WWA IN DRUG LAW ENFORCEMENT

Civil libertarians' concerns about law enforcement officials using WWA for mass surveillance of individual citizens via sensors in wastewater pipes and toilets (e.g. [14]) are unlikely to be realized, for the following reasons. First, it may not be feasible to access a pipe leading from a residence (e.g. from a bungalow or apartment) before it mixes with sewage from other residences. Secondly, the usefulness of WWA in tracking individuals will depend upon how many people live at or visit a residence. Thirdly, sensors that could carry out this task are not available, and in order to install such hypothetical devices law enforcement agencies would probably require a warrant. Finally, WWA would be a very expensive way for law enforcement officials to prove a charge of drug use, an offence that usually carries a minimal penalty. Given the specialist expertise required to use WWA, we think that law enforcement officials are most likely to be interested in using population levels of illicit drug use to assess the effectiveness of supply control efforts and identify new drugs in the illicit market.

In serious criminal investigations law enforcement agencies might consider using WWA to: detect clandestine drug laboratories; and perhaps to support an application for a search warrant [48]. Many aspects of different countries' laws governing evidence and criminal procedure await research [48] because the legal status of wastewater is unclear, including who owns it [49]. These issues will require future ethical and legal scrutiny once effective methods have been developed and implemented for routine use. We do not think that these concerns about possible future uses of WWA by law enforcement officials are serious enough to prevent the development of WWA for population monitoring of illicit drug use.

CONCLUSIONS

Chemical analysis of illicit drug residues and metabolites in wastewater is a promising method of monitoring drug use trends in the population. It is most likely to be used in conjunction with population surveys, testing the purity of drug seizures and social surveys of regular drug users. However, it has considerable potential to serve the public good, and there is a strong prima facie case for developing these methods for routine use.

WWA does not raise major ethical concerns when used for public health purposes to monitor illicit drug use in large populations, because individuals are not identifiable. WWA will provide useful information on aggregate trends in illicit drug use in the wastewater catchment area that can be used to evaluate the effectiveness of drug policies.

Ethical issues may arise from concerns about possible indirect harms from using WWA in a prison or an entertainment venue, because the results of such studies may produce policy responses that could affect all occupants of these premises adversely, regardless of their drug use. Researchers could mitigate these risks by not identifying the location of study sites when publishing results. They should also consider the potential policy responses to their findings before conducting studies. Significant social concerns may make it difficult to conduct WWA studies in schools and work-place settings, and it may be advisable to give studies in these settings a lower priority until these methods are ready for routine use.

Fears about possible mass use of WWA for individual surveillance by drug law enforcement officials are unlikely to be realized. It is none the less important for researchers to address these concerns because they may reduce public support for this type of monitoring.

Declarations of interest

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