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Wastewater testing compared to random urinalyses for the surveillance of illicit drug use in prisons

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Abstract

Introduction and Aims—Illicit drug use is known to occur among inmate populations of correctional (prison) facilities. Conventional approaches to monitor illicit drug use in prisons include random urinalyses (RUAs). Conventional approaches are expected to be prone to bias because prisoners may be aware of which days of the week RUAs are conducted. Therefore, we wanted to compare wastewater loads for methamphetamine and cocaine during days with RUA testing and without.

Design and Methods—We collected daily 24-hour composite samples of wastewater by continuous sampling, computed daily loads for one month and compared the frequency of illicit drug detection to the number of positive RUAs. Diurnal data also were collected for three days in order to determine within-day patterns of illicit drugs excretion.

Results—Methamphetamine was observed in each sample of prison wastewater with no significant difference in daily mass loads between RUA testing and non-testing days. Cocaine and its major metabolite, benzoylecgonine, were observed only at levels below quantification in prison wastewater. Six RUAs were positive for methamphetamine during the month while none were positive for cocaine out of the 243 RUAs conducted.

Discussion and Conclusions—Wastewater analyses offer data regarding the frequency of illicit drug excretion inside the prison that RUAs alone could not detect.

INTRODUCTION

Control of illicit drug availability and use is a cause of concern for inmate safety.[1] Because a majority of the people entering prisons are in need of substance-abuse treatment, [2-4] intake assessment[5] and random urinalyses (RUAs) are used for illicit drug use surveillance.[6,7] Subjects are selected for urinalyses either randomly or based upon suspicion.(Bellatty P, 2011, personal communication) The temporal frequency of RUAs can

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also be random or on a schedule of convenience (e.g., Monday-Thursday), which are assumed to be well known to inmates. Therefore, RUAs capture only a small percent of the inmate population on any given day, which may be biased due to prisoner knowledge and consequently largely negative tests. (Bellatty P, 2011, personal communication)

Sewage-based drug epidemiology may be a more objective approach facilitated by the fact that correctional (prison) facilities contain a relatively small, well-defined population that typically discharge wastewater via prison-specific sewer lines. However, to date, only a single report documents illicit drug use in a prison using a sewage-based drug epidemiology approach.[8] While this study reported quantifiable loads of illicit drugs and estimated the number of doses over time, no comparisons of measured loads to conventional indicators of drug use (e.g., RUAs) were made. A sewage-based approach has the potential of providing more representative information on illicit drug use within the prison system that is complementary to RUA data. Such population data may support a public health orientation that considers total population health rather than just individual behaviors, in this instance WWTP testing may be an attractive alternative or complement to RUA. Because wastewater sampling can be performed without prisoners' knowledge, it was used to test our hypothesis that illicit drug loads in sewage on RUA testing days are lower than on non-RUA testing days due to prisoner knowledge and avoidance of drug use. A range of indirect measures, or indicators, of drug use are used in other settings such as surveys, but these measurement approaches may be practically difficult to implement in prisons and also subject to substantial self-report biases given the setting.[9]

Single, 24-h wastewater composite samples were created by continuously sampling a prison's wastewater effluent during a single month (August, 2011) along with hourly samples for three days (n=72). The mass loads of methamphetamine, cocaine, and benzoylecgonine were then compared to the numbers of positive RUAs on RUA-days (n=28 days) over the same one-month time period.

EXPERIMENTAL METHODS

Information regarding the prison, chemical analyses, and analyte stability during sample collection is provided in the supplemental information (SI). Permission for the study was obtained from prison administrators and the activities were deemed exempt from Institutional Review Board (IRB) oversight. The IRB-exemption is consistent with the analysis by Hall et al. who found ethical issues related to using wastewater analysis to monitor drug use in prisons could be mitigated if i) the prison name and location is kept anonymous and ii) individual or collective punishments are unlikely to occur as a consequence of the wastewater study.[10]

Wastewater Sampling

Representatively sampling wastewater in close proximity to a single source such as a prison, requires high-frequency sampling in order to capture all urine pulses potentially containing illicit drugs.[11,12] Daily 24-hour composite samples were collected starting from 23:05 July 30 to 23:05 August 26 (28 days), 2011. For the collection of daily samples, a Masterflex peristaltic pump was used (3.2 mm inner diameter Norprene® tubing × 7.62 m)

to deliver wastewater at a flow rate of 8 mL/min. A total volume of 12 L was collected in a closed container (HDPE) located inside a refrigerator (4 °C) on site.

Hourly composite samples were collected on August 13-15th, 2011. An ISCO 2900 was set to collect hourly composites and fitted with the same type of tubing/pump as described above. The peristaltic pump was operated continuously at 8 mL/min for a total collected volume of 480 mL per hour in 500 mL HDPE bottles. Fifty mL from each daily and hourly sample were transferred to 50 mL centrifuge tubes every night and transported at 4 °C to the laboratory (Oregon State University) and directly frozen until analyses (supplemental information, SI).

RUA Testing

During RUAs prisoners are monitored (watched) while urine is collected. The prison routinely collects six urine samples per day for RUAs only on Mondays through Thursdays. To examine the relationship between RUAs and wastewater estimates, urine samples for RUAs were collected every day over an entire week. A larger number (21 per day instead of 6 only) of samples were collected between August 1- 5 in order to sample a greater proportion of the prison population. Six RUA per day were then used for August 6-26.

A total of 243 RUA samples were collected over 28 days. The number captures 12% of the total inmate population (if no inmates were sampled twice), while the daily sampling rate of 6 and 21 per day corresponds to 0.3 and 1 % of the prison population. See SI for details regarding RUA screening and analysis.

RESULTS AND DISSCUSSION

Methamphetamine

Methamphetamine was quantifiable in every daily wastewater sample with corresponding mass loads ranging from 467 to 2,730 mg (Figure 1A). In contrast, methamphetamine was only infrequently detected (5/42 days) in a Spanish prison.[8] A range of 12-68 doses of methamphetamine per day, assuming 30 mg per dose and that none was directly discarded (e.g., dumped), was calculated for the prison's 2,083 inmates (and unspecified number of visitors and staff), which corresponds to a range of approximately 6-32 doses per 1,000 inmates per day. The United Nations Office on Drug Crimes Indicates that the United States had the second highest level of methamphetamine seizures internationally in 2011 while Spain appears to be neither a trafficking nor a country with substantial methamphetamine use.[13]

The methamphetamine loads in the sewer on the prison's routine RUA testing days (Monday-Thursday) was not significantly different from non-testing days (Friday-Sunday, Two-sided T-test $p<0.05$). The lack of a significant difference indicates that prisoner knowledge of testing days (Monday-Thursday) did not correspond to lower methamphetamine loads. However, contributions to daily measured loads by non-inmates (employees and/or visitors) cannot be excluded and could potentially obscure any patterns in inmate methamphetamine excretion/use by day of the week.

Of the 243 RUAs conducted during the one-month sampling period, only six (2.5%) were positive for methamphetamine (Figure 1B), which is consistent with the daily rate of 6-32 doses per 1,000 inmates (0.6 – 3.2%). The agreement between the measured loads and the number of positive RUAs indicate that measurements made on a few number of daily composite wastewater samples may be a cost-effective alternative to the analysis of hundreds of urine samples, most of which are blank, through the RUA program.

Additional information on methamphetamine use within the facility was obtained from the diurnal profiles compiled from the hourly composite samples collected over a three day period (August 13-15; Figure 2). Methamphetamine was present in every hourly sample with computed mass loads ranging from 11 to 151 mg and an average of 38 mg (Figure 2). Visitors are allowed in the prison every day and methamphetamine excretion is evident during each hour of each day during both visiting (7:15-10:15 and 12:30-15:45) and non-visiting hours. Because the prison did not provide employee numbers and the timing of shift changes, it is not possible to differentiate between inmate and employee contributions to the observed methamphetamine loads during non-visiting hours when no visitors are present. Use of methamphetamine can lessen the fatigue associated with work activities[14], night shift work[15] and increase alertness.[16] Alternative sampling locations inside the prison and more detailed records on the number and work shifts of employees would be needed to differentiate inmate from employee use and excretion of methamphetamine. Methamphetamine use has previously been documented in all 96 communities municipal wastewater in Oregon, which were tested in 2008. [17]

Cocaine and Benzoylecgonine

All cocaine and benzoylecgonine concentrations were below the limit of quantification (LOQ) of 10 and 40 ng/L (See SI), respectively, for each daily composite sample. Cocaine and benzoylecgonine were detected (>LOD but <LOQ) for ~50% of the days during the month although concentrations were below the LOQ (Table 1). In contrast, cocaine and benzoylecgonine were quantified in every daily sample at a Spanish prison.[8]

A Fisher's Exact Test, which does not assume normality, was used to test if there was any difference (two-sided, alpha<0.05) between samples that were above detection (LOD<X<LOQ) and the number of samples <LOD for days on which RUAs typically are collected (Monday-Thursday) and non-testing days (Friday-Sunday). A 2×2 contingency table (Table 1) was constructed[18] with no statistical difference between the routine RUA testing days (Monday-Thursday) and the non-testing days (Friday-Sunday) for both cocaine and benzoylecgonine.

No positive RUAs for cocaine (benzoylecgonine) were reported during the month. The lack of positive RUAs for cocaine is consistent with the low concentrations of cocaine and benzoylecgonine detected in wastewater. Wastewater measurements support the RUA test results with both sets of measures indicating that methamphetamine use is more prevalent among those in the prison than is cocaine use.

CONCLUSIONS

Illicit drug loads on RUA testing days were not statistically different from non-RUA testing days. RUAs given to inmates were only positive for the presence of methamphetamine six out of 243 samples within one month and not positive for cocaine. The analysis hourly and daily composites of wastewater revealed methamphetamine excretion every day and every hour, which is information that cannot be obtained from RUAs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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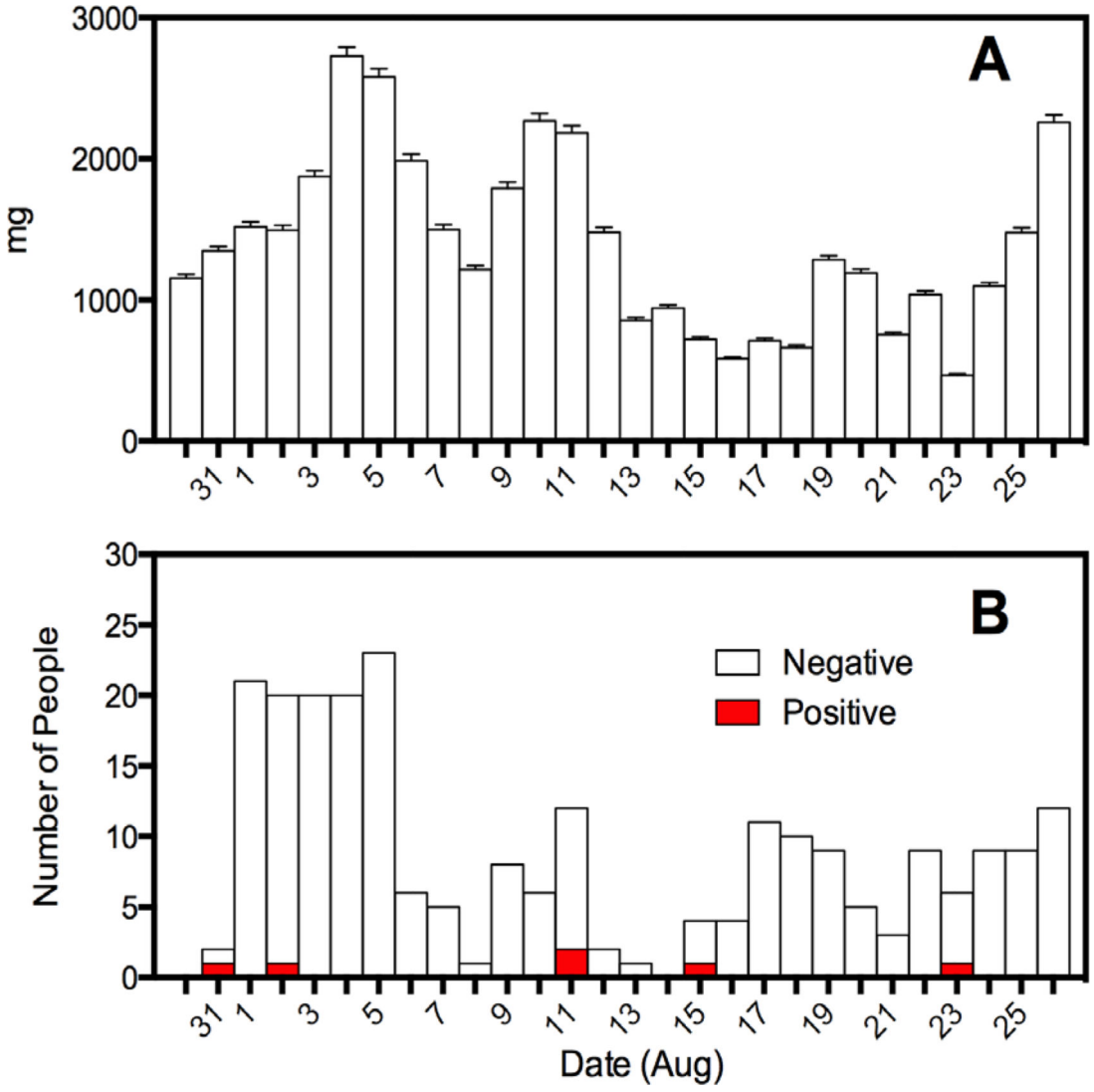

Figure 1.

Daily loads (mg) of methamphetamine (A) and number of positive and negative RUA results for methamphetamine (B) for July 30 to August 26. Error bars indicate 95% confidence interval. RUA, random urinalyses.

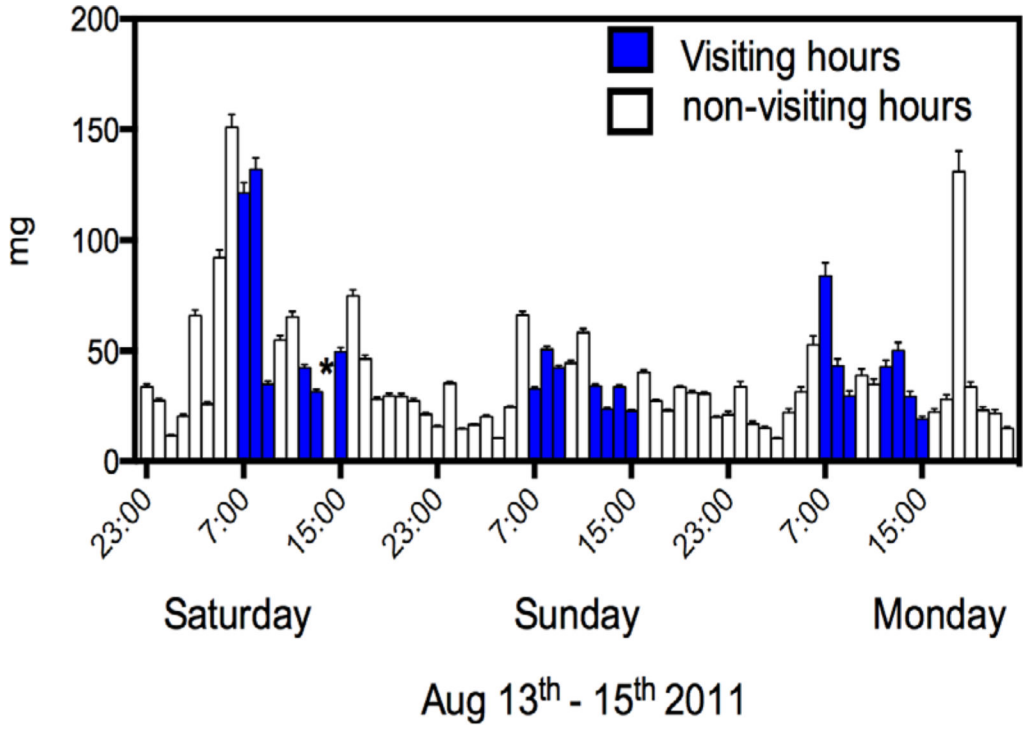

Figure 2.

Three days of hourly methamphetamine loads (mg) from 23:00 on August 12 to 23:00 August 15. Error bars indicate 95% confidence interval. * Indicates sample that was not analyzed.

Table 1

Frequency of cocaine and benzoylecgonine detections that were below the limit of detection (< LOD) or above the LOD but below the limit of quantification LOD<X<LOQ) for wastewater samples collected Monday-Thursday and Friday-Sunday.

Analyte	Detection Range	Monday-Thursday	Friday-Sunday
Cocaine	< LOD	8	7
	LOD<X<LOQ	8	5
Benzoylecgonine	< LOD	9	5
	LOD<X<LOQ	9	5