Wastewater Based Psychoactive Substance Monitoring

Findings from a Pilot Program in Boston, MA

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Background and Aims

Opioid-related overdose deaths increased by 12% in Boston from 2022-2023 despite a 10% decrease statewide in Massachusetts.*

Monitor psychoactive substance concentrations in wastewater in the City of Boston to potentially support outreach, intervention, and harm reduction efforts.

Measure concentrations of the following substances at 12 sewer maintenance hole sites across Boston: fentanyl, norfentanyl, xylazine, cocaine, benzoylecgonine (BZE), methamphetamine, p-hydroxymethamphetamine, naloxone, naloxone-3-D-glucuronide, and methadone.

Compare citywide wastewater data to real-time overdose data from the National Syndromic Surveillance Program (NSSP) to test for correlation.

Methods

Prioritized residential areas with no known contributions from healthcare facilities and priority areas for BPHC outreach during site selection.

Collected samples once weekly using ISCO GLS composite autosamplers - sample was a 24-hour time-weighted composite starting Sunday morning.

Obtained flow data using a combination of ISCO 2150 flow meters installed next to the autosamplers (n = 6 sites) and the Boston Water and Sewer Commission (BWSC)'s hydraulic and hydrologic (H&H) model (n = 6 sites).

Extracted analytes utilizing a solid-phase extraction (SPE) cartridge.

Conducted analysis using a Shimadzu High-Performance Liquid Chromatography (HPLC) system paired with a SCIEX LCMS 5500 mass spectrometer

Normalized measured wastewater values using flow data (actual and modeled) and catchment population with results aggregated at the city level.

Obtained real-time overdose data for Boston emergency departments from NSSP.

Normalized wastewater values and NSSP counts of overdose events were compared using Pearson correlation and cross correlation to assess lag between these datasets.

Generated heatmaps to highlight when the quantity of substances in the wastewater deviated by at least one standard deviation from their average.

**Health of Boston. Boston Public Health Commission. 2024 June.*

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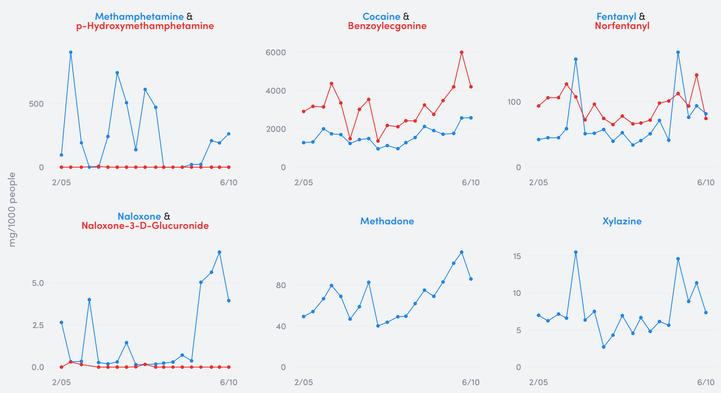
Results

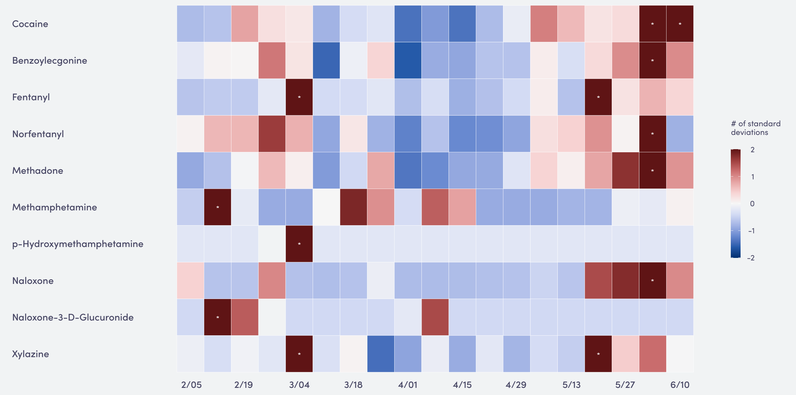
City average wastewater concentration

Average normalized analyte mass across all sites, weighted by population (mg/1000 people)



Data current as of 2024-08-06

City average analyte quantity difference from baseline



Each analyte's baseline is the population-weighted city average of the normalized analyte quantity across all 19 weekly collections. Colors represent the difference between baseline and the normalized analyte quantity each week, expressed in number of standard deviations. Outlying values beyond +/-2 standard deviations are marked with an asterisk (*).

The average level of Cocaine, BZE, Fentanyl, Naloxone, Methadone, and Xylazine measured in the last 4 weeks of the program was statistically higher than the average level detected during the first 15 weeks of the program ($P<0.05$)

Observed correlation between citywide norfentanyl and naloxone wastewater concentrations ($R^2=0.78$)

Xylazine was detected in 54% of samples with at least 1 detection in 11 of the 12 sampling locations

No correlation observed between weekly NSSP counts of overdose ED visits based on CDC syndromic definitions for cocaine and fentanyl and corresponding substances/metabolites (e.g. for cocaine overdoses R^2: cocaine = -0.104, BZE = -0.011; for fentanyl overdoses R^2: fentanyl = -0.071, norfentanyl = 0.039)

Lag adjustment did not improve the correlation between NSSP overdose-related ED visit and wastewater data

The methamphetamine isotope labeled internal standard could not be recovered from most (76%) samples

Discussion

This pilot study demonstrated the feasibility of conducting weekly wastewater testing for psychoactive substances at the neighborhood level in Boston.

Enabled cost efficient flow based normalization by leveraging an existing hydraulic model for the sewer network.

Measured levels of 6 out of 10 compounds increased during the last 4 weeks of the program (May to June). This aligns with existing research at the national level that suggests summer increases the risk of substance use initiation.*

An unknown component of the wastewater matrix prevented the extraction of some compounds, namely methamphetamine and its selected metabolite. This inhibition was not resolved by sample dilution. Future work should consider matrix specific assay validation.

Variations in the concentration of substances did not correspond to real-time NSSP data for cocaine and fentanyl overdoses.

NSSP data do not include overdoses that did not result in an ED visit and therefore are an incomplete count of overdose events.

This pilot program involved weekly data collection over a 19 week period; the duration of the pilot and the cadence of sampling may have impacted the lack of correlation to NSSP data.

Future work should investigate the correlation between wastewater measurements and other substance use data and continue to validate wastewater data with NSSP data and other real-time data sources.

**Palamar JJ, et al. Summer as a Risk Factor for Drug Initiation. J Gen Intern Med. 2020 Mar*